European Commission

Skills for Smart Industrial Specialisation and Digital Transformation

Final Report

Written by PwC
October 2019

Internal Market, Industry, Entrepreneurship and SMEs

EUROPEAN COMMISSION

Executive Agency for Small and Medium-sized Enterprises (EASME)
Department A – COSME, H2020 SMEs and EMFF

Unit A1 – COSME

Contacts:

André Richier
Policy Officer
DG for Internal Market, Industry, Entrepreneurship and SMEs
Unit for Advanced Technologies, Clusters and Social Economy
Rue des Nerviens, 105
B-1040 Brussels, Belgium
Tel: +32 2 29 69 110
Email: andre.richier@ec.europa.eu

Paola García Isaak
Project Adviser
Executive Agency for Small and Medium-sized Enterprises (EASME)
COSME Unit A1.5 Competitiveness
COV2 12/056
B-1049 Brussels/Belgium
Tel: +32 2 29 81816
Email: paola.garcia-isaak@ec.europa.eu

Skills for Smart Industrial Specialisation and Digital Transformation

Final Report

Europe Direct is a service to help you find answers to your questions about the European Union.

Freephone number (*)**:**

00 800 6 7 8 9 10 11

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

LEGAL NOTICE

Luxembourg: Publications Office of the European Union, 2019

EN PDF ISBN 978-92-9202-547-2 doi: 10.2826/550778 EA-01-19-570-EN-N

This study was carried out for the European Commission by

PwC EU Services EESV
Woluwe Garden
Woluwedal 18
BE-1932 Sint-Stevens-Woluwe
Belgium

For further information on this report, please contact the authors:

Laurent Probst
Engagement Partner
Office: +352 49 48 48 2199
Mobile: +352 621332199
Email: laurent.probst@pwc.com

Bertrand Pedersen
Project Manager
Office: +352 49 48 48 4365
Mobile: +352 621334365
Email: bertrand.pedersen@pwc.com

Jill Wenger
Senior Associate
Office: +352 49 48 48 2229
Mobile: +352 621332229
Email: jill.wenger@pwc.com

EXECUTIVE SUMMARY

Professionals with high-tech skills have a strong potential to serve the growing needs created by smart industrial specialisation and digital transformation. They offer a solid foundation for the work of the future. The competitiveness of the European industry is highly dependent on the knowledge, competencies and creativity of its workforce. Skills shortages and gaps combined with mismatches between labour supply and demand, harm investment. They are already quite significant and are likely to widen due to the major disruption the Fourth Industrial Revolution brings to the scale at which training efforts currently take place. The **skills for industry** initiative aims at developing a common vision and actions on skills for smart industrial specialisation and digital transformation with a view to increase the capacity of industry, trade unions, education and training organisations, and policymakers to shape the workforce transformation in Europe. It aims to help cities, regions and Member States in designing and implementing ambitious upskilling and reskilling policies.

Smart industrial specialisation and digital transformation

Smart industrial specialisation refers to the coordination within specific regions between industrial, governmental and academic players to develop a collective strategy for regional economic development by prioritising industrial sectors where the region has key competitive advantages. The concept emerged in conjunction with the smart specialisation strategy. In this process, the European cluster observatory has provided strong evidence by defining newly emerging industries and relevant sector-specific framework conditions needed for boosting their development. Thus, industry clusters have become one of the key catalysts in support of industrial specialisation. Given the need for critical mass in R&D and innovation, the **industrial modernisation platform**[1] has been launched to allow for cross-border and cross-sector partnerships all across the European Union (EU) and to establish a stronger industrial capability and specialisation for smart industrial specialisation. To this end, the European Commission launched the Vanguard initiative in 2015 and the European observatory for clusters and industrial change in 2018.

On the other hand, the digital transformation is one of the major trends that is affecting the economy and society. This brings the transformation of business activities/functions; processes; models; ecosystems; asset management; organisational culture; ecosystem and partnership models; as well as customer, worker and partner approaches[2]. As for the digital transformation of the EU industry, its importance is highlighted under the digitisation of EU industry strategy and the established digital innovation hubs under the **digitising European industry initiative**[3].

In terms of global competitiveness, the EU holds a remarkable global market share in automotive semiconductors (55%), followed by robotics (33%), embedded systems (30%), and semiconductor equipment and photonics components (20% each). The EU also holds the highest market share in

---

1 Smart Specialisation Platform. 2018. Industrial Modernisation. Available at: http://s3platform.jrc.ec.europa.eu/industrial-modernisation [Accessed 4 June 2019].

2 i-scoop. 2018. Digital transformation: online guide to digital business transformation. Available at: https://www.i-scoop.eu/digital-transformation/#Digital_business_transformation_8211_a_holistic_approach [Accessed 4 June 2019].

3 European Commission. 2018. Digitising European Industry. Available at: https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry [Accessed 4 June 2019].

enterprise wearables (40%) and scores second in 3D printing (28%) when compared among a group consisting of North America, Asia-Pacific and the rest of the world. However, artificial intelligence in the EU (15%) falls well behind North America (77.5%), while in advanced robotics, the EU (20%) falls well behind Asia-Pacific (63%).

Regarding the EU's competitive positioning on **readiness for future manufacturing**, the majority of Member States (Germany, Sweden, Austria, the Czech Republic, Ireland, Finland, France, Belgium, Italy, Poland, Slovenia, Spain, Estonia, Denmark and the Netherlands) fall into the 'leading countries' category worldwide, together with the US, Japan, South Korea, China, Singapore and Canada. However, Portugal, Lithuania, Slovakia, Romania, Hungary, Latvia, Bulgaria, Croatia, Greece and Cyprus are further behind, when using the World Economic Forum's measures. The generation of patents on advanced technologies is developed across most EU regions, while distribution is heterogeneous across the EU. Patents are focusing on advanced manufacturing systems, advanced materials, and micro and nano-electronics, while nanotech has the smallest share, as mentioned in 2015 in the report of the High-Level Group on key enabling technologies.

Major efforts are made to implement specialisation and digitisation strategies at city, regional, national and EU levels and industry-led initiatives appear to have been quite successful. Yet, despite significant efforts being made at all governance levels, a growing skills gap can be observed between the skills needed to strengthen industry in Europe, and the workforce currently available, emphasising the need for a comprehensive **skills for industry strategy**.

High-tech skills in Europe

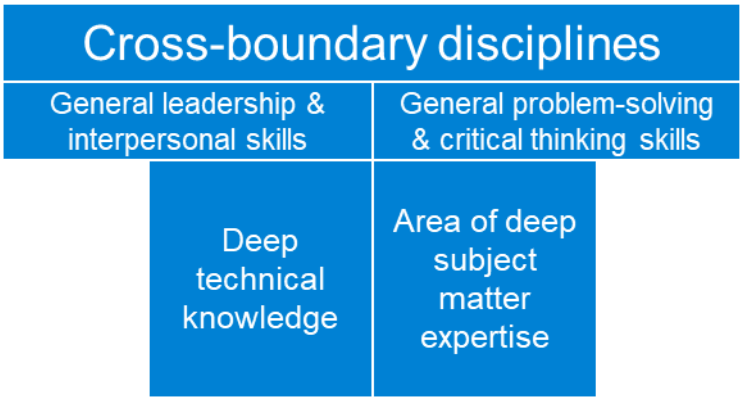
Behind current and future skills gaps lies a changing demand for various skills. CEDEFOP, the OECD and the World Economic Forum forecast that elementary work, manual, low-skilled jobs, and jobs consisting of routine tasks will decline, while non-manual, and highly skilled jobs will increase. At the same time, reports show that demand for jobs that include programming is growing 50% faster than the job market overall, and workers with skills that fit hybrid jobs are particularly sought after[4]. The skills requested by industry are not merely technical. Over the last decade, the concept of **T-shaped skills** has emerged, referring to a professional worker having a combination of both general skills across multiple domains and specialist skills within (at least) one domain. Facing the challenges of automation and artificial intelligence, future professionals are likely to be increasingly creative, innovative and entrepreneurial, capable of building relationships, advancing research and strengthening their organisations. They are characterised by both breadth and depth of their expertise. The breadth of the future professional reflects the individual's willingness and ability to collaborate across industries, sectors and disciplines. The depth of the future professional refers to the depth of the industry-related and sectoral skills and knowledge that the individual possesses.

As such, this report considers high-tech T-shaped skills an imperative for the EU's competitiveness. The conceptualisation of high-tech T-shaped skills primarily focuses on programmes, projects and curricula that combine high-tech skills with specific complementary skills, namely – technical skills in adjacent domains; skills related to quality, risk and safety; management, entrepreneurial and

[4] High-Tech Skills for Industry: Digital Organisational Frameworks and IT Professionalism, 2019

leadership skills; communication; innovation; emotional intelligence skills and the ability to consider ethical implications.

Figure 1. T-shaped skills model[5]



The category of technical skills relevant to smart industrial specialisation and digital transformation covers researching and developing production technologies (e.g. advanced materials), digital technologies (e.g. artificial intelligence), cyber-technologies, and digital technology skills. The stakeholder survey indicated that skills shortages are expected in all these domains, and to address them, new educational curricula and teaching methods will be needed across all educational levels – from vocational training and University programmes down to primary education.

The analysis of the state of play of current policy initiatives relevant to high-tech T-shaped skills has led to the following findings:

- The dominant focus is currently on co-developing educational initiatives and materials;
- Initiatives that introduce high-tech topics to children starting from an early age, and those that adapt University programmes to the human-capital needs of industry, are also common;
- Initiatives typically focus on technical aspects, while combinations of technical skills and managerial and entrepreneurial skills are also common, as of quality, risk and safety skills;
- Emotional intelligence as a skill type is not apparent in the initiatives that have been analysed;
- The systems-thinking aspect is also not apparent in the initiatives encountered so far.

Common features of initiatives relevant to high-tech and crosscutting skills include:

- Involving and mobilising industrial partners and local government;
- Targeted delivery methods of specific skills-development initiatives; and
- Sectoral coordination of policies and initiatives across Europe.

Digital transformation changes professions, occupations and job tasks throughout sectors and markets. Consequently, betting on upcoming graduates and prospective workers to fulfil labour

[5] PwC Analysis

demand in the coming years may not be enough. Considering the sheer numbers involved, retraining current workers may prove vital to preparing enough people for working both in new jobs and in new sectors. Subsequently, future-oriented education and training efforts will need to include current workers in the European labour force. Moreover, dual-track education is identified as a relevant system to develop high-tech T-shaped skills.

Comparison between US and EU

Several observations can be made regarding high-tech skills between the US and the EU. First, they face comparable skills challenges for similar technology domains, and the notion of skills gaps will require both precise definition and constant refinement. Second, in the US there are numerous initiatives focusing on the needs of the lower skilled, many of them launched separately by large IT companies, and there is nothing comparable to the EU Erasmus+ programme. Third, the US defence and security programmes matter a lot for investments in research, innovation and the subsequent development of high-tech skills. Finally, the US has been for a long time a magnet for gifted international students, entrepreneurs and high-tech talent.

The high-tech areas that receive significant policy attention are similar – especially domains that relate to information technology, advanced manufacturing, systems biology and life sciences, and innovative materials. The challenges that the US and EU share include: difficulty to fill positions, scarcity of young high-tech talent, gender and minorities issues, ageing high-tech workers, skills shortages, need for more academia-industry collaboration, and increasing industry demand for better-prepared graduates. Keeping (future) workers up with the demands of a fast changing economy through upskilling and reskilling is important. In some work fields and regions in the US, workers do not have the right skills for the available jobs. However, there is little evidence of a nationwide shortage in the science and engineering (STEM) workforce. In general, policy thinking will benefit from focused discussion on skills shortages, gaps and mismatches, as considering only the supply side of the market (workers needing to upskill or reskill) leads to a blinkered focus and may hinder effective policymaking. Instead, policymakers should consider all factors, including a decline in aggregate demand, regional market differences, and the role of labour-market intermediaries such as employment agencies or trade associations and employer relationships with technical colleges or other institutions. Overall, policymakers should focus on knitting together the supply and demand sides of the labour market as well as think about implementing the necessary financial and institutional mechanisms to stimulate both sides of the market.

The US policy landscape primarily focuses on the lower skilled. Both at federal level and at state level, public policy predominantly targets workers without a College degree. Key policy instruments such as Career Pathways and Cluster Skills Development are coordinated at the vocational post-secondary level by community colleges that work together with social service providers, economic development agencies, employers and labour unions, but not necessarily with Universities, high-tech companies or start-up communities. Large US information technology companies have a long tradition of launching their own digital skills initiatives (with variable geographic coverage, scale and duration), through a combination of free courses and training materials aiming at providing opportunities to socially disadvantaged groups. These contribute to demonstrate their corporate social responsibility and improve their image in the public. The largest IT companies' initiatives are also often rolled out globally to various part of the world for the same reasons.

Most importantly, the US defence and security industry is a catalyst for high-tech skills attainment. A major point of difference in the high-tech skills domain between the US and the EU can be found in the US defence and security ecosystem. For decades, the US military has invested heavily in the design, development and manufacture of weapons capabilities, and has had a stake in a steady supply of a local high-skilled workforce. At the same time, investments in defence-related research and development in Europe have not been as significant, and have been decided on at the Member State level. The US approach has resulted in a sizable labour-market footprint of their defence industry, which employs high-skilled high-tech workers, generates awareness of high-tech careers among students and prospective workers, and increasingly teaches T-shaped skills.

On the other hand, the EU can in the future develop a strong ecosystem by developing large-scale projects on climate change, in which high-tech skills will be required and potentially developed.

Good practices in Europe

Both state-of-play analyses provide multiple examples of initiatives and programmes that support both smart industrial specialisation and digital transformation and the development of high-tech T-shaped skills. Selected examples of good practices have been initiated by stakeholders at different levels: national authorities (e.g. Skillnet Ireland, Luxembourg Digital Skills Bridge), regional and city authorities (e.g., Allianz Industrie 4.0 Baden-Wurttemberg, Associazione Fabbrica Intelligente Lombardia, Building the Right Investments for Delivering a Growing Economy (Rotterdam), Business and Shared Services Centre (Fundao), 6Aika (Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu), Skills for Londoners strategy, and corporates (e.g. Airbus Engineer of the future, Bosch Centre of Artificial Intelligence, Cisco Networking Academy and IBM Skills Academy). Moreover, clusters (e.g. Brainport Development, Silicon Europe), non-profit organisations (e.g. Technofutur TIC ReDI School of Digital Integration) as well as academic institutions (e.g. IMEC Academy, PROMPT) have initiated programmes that proved to be successful. Alternatively, two main types of initiatives can be distinguished:

- Good practices that address the supply of skills, which refer to trainings and upskilling of the labour force (e.g. IMEC Academy, PROMPT, Technofutur), and
- Initiatives that target skills needs to further innovation and enhance the competitiveness of key sectors with a focus on SMEs (e.g. Silicon Europe, Brainport Development, and CNSP).

Both types of policy initiative help address the labour market challenges in a knitted approach of supply and demand.

The selected initiatives demonstrate that all stakeholders - public, private, academia, clusters and international organisations, need to be aware of the skills challenges. All the good practices analysed have proven the importance of cross-sectorial and cross-regional collaboration. They have also highlighted the need for transversal cooperation among public and private bodies as well as between different sectors and industries. In this sense, all parties need to undertake a concerted approach to addressing the problems at local, regional, national and EU-level. Special attention has been paid to selecting good practices that break with traditional silo organisational structures and encourage transversal activities. The coordination is necessary to make sure that all initiatives and policies are effective, complement each other and do not duplicate efforts. On the other hand,

comprehensive policies need to be implemented to support SME development. Lastly, more transversal flexible education and training systems are needed.

Skills for industry strategy

The insights from the analysis presented above, as well as from a series of expert workshops and stakeholder surveys, have informed the development of a common vision and recommendations resulting in a skills for industry strategy towards 2030 and beyond. This vision intends to foster the development of skills for excellence, prosperity and personal development. It aims to mobilise resources at the local, regional, national and EU level collectively to make skills an opportunity for everyone. It further aspires to raise momentum by inspiring key players to take part in designing and powerful skills strategies.

- By 2030, all Member States are implementing national skills strategies and have introduced the necessary mechanisms to ensure the continuous follow-up of high-tech skills needs;
- By 2030, the high-tech skills gap has been practically closed;
- By 2030, the basic digital skills gap has been more than halved;
- By 2030, two out of three adults upgrades their skills in any given year.

The vision aims to introduce a paradigm shift to the ecosystem of workforce planning, education and training provision for skills development. A major goal is to make lifelong learning a reality for all by empowering individuals and giving them greater autonomy and responsibility for their own skills development. All individuals should benefit from lifelong learning opportunities, as well as from agile and modern learning methods using tech-based tools and modern teaching methods. The key characteristics are illustrated below.

Figure 2. The nine characteristics of the high-tech skills vision[6]

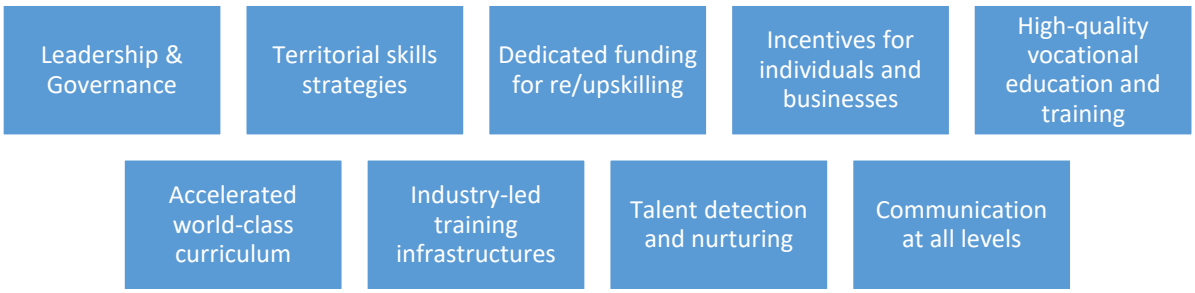
[6] PwC Analysis


1
REALISTIC
Leverage on already tested solutions and **success stories**
2
FEASIBLE
Funding Timing (i.e. short, medium and long term actions), **Incentives**
3
INCLUSIVE
Provision of **basic and advanced digital skills** for a **majority of EU citizens**
4
PARTICIPA-TORY
Consensus driven & collective by all relevant stakeholders
5
INSPIRING
To be **taken by all** to reach to world-class excellence and championship
6
RESPONSI-VE
Socially and culturally responsive to tackle societal challenges
7
ANTICIPA-TORY
Forward Looking based on foresights on emerging technologies and corresponding skill needs
8
EXCELLEN-CE
Supporting well-performing Cities and Regions to become **EU & Global Champions**
9
ETHICAL
Ethically responsible and encouraging the development of **ethical skills**

Recommendations for actions

To facilitate the operationalisation of the vision, a set of policy recommendations will guide different stakeholder groups on developing and implementing their own skill strategies in alignment with their industrial, R&D, innovation, education, training and RIS3 strategies. The recommendations encourage the development of forward-looking, dynamic, interactive, multi-stakeholder driven and agile upskilling initiatives that leverage on real-time AI-based labour market assessments and foresight tools for evidence-based decision-making. The recommendations have been grouped in nine modules, which are presented in detail by highlighting the key actions developed.

Figure 3. The nine modules for the operationalisation of the vision[7]



- **Leadership and governance.** The successful design and implementation of a skills for industry strategy requires the mobilisation of skills leaders/champions to coordinate efficiently activities at city, regional, national and EU-level (connecting academic, business, public and community leaders), resulting in strong partnerships, commitments and governance structure. Skills alliances should be set-up and tasked with the design and implementation of territorial re/upskilling strategies. Members of these alliances should include representatives from industry, from the traditional educational system, trade union spokespersons, as well as local cluster representatives. Business leaders have an important responsibility as the strategy must be based on current and anticipated skills and recruitment needs.

Bringing together all relevant stakeholders under a motivated leadership would facilitate the active implementation of scalable re/upskilling solutions with a sustainable and longer term perspective. The structures should remain agile and well resourced. The development and operationalisation of the strategies will require significant investments at all levels and the various funding programmes and instruments need to be mobilised and coordinated efficiently to contribute successfully to the EU skills for industry strategy.

- **Territorial skills strategies.** To strengthen the competitiveness of the industry and foster new jobs creation, efficient territorial re/upskilling strategies need to be developed and implemented consistently at all levels. Led by territorial skills alliances, these strategies should set clear objectives, measurable and achievable targets with a roadmap and strict deadlines to allow

[7] PwC Analysis

for timely implementation. They should be based on robust and reliable data, foresight and information that will allow policy makers to identify future skills trends and requirements.

Moreover, these strategies should be mindful of the latest developments in key technological areas (e.g. AI, robotics, nanotechnologies, advanced materials etc.) and fully align with clusters and research and innovation strategies for smart specialization (RIS3). Increased cross-border collaboration should be encouraged to build on synergies between regions and facilitate the implementation of skills strategies. Industries, value chains and areas of specialisation are not geographically bound. Greater collaboration on the provision of training across borders could reduce costs for regions while underlining a common skills vision in Europe.

- **Dedicated funding for re/upskilling.** The re/upskilling of the workforce will require significant financial support at all levels (city, regional, national and EU) and rely on both public and private sources[8]. Relevant European funding programmes and instruments should be promoted to enable the set-up and implementation of territorial re/upskilling strategies. Dedicated funding mechanisms should be introduced with the intention to support the effective lifelong learning of Europe's workforce. Furthermore, pre-financing mechanisms that will allow smaller businesses to re/upskill their workforce should be envisaged.

Given the diversity of funding schemes available, a one-stop-shop providing stakeholders with a clear view on all the funds available is highly recommended. To ensure the most efficient use of funds and foster a wider momentum, those interested in advancing the skills of the workforce require a clear view on the funds available, their target groups as well as on the rules and application criteria to respect (simplification and commonality is highly recommended). Simultaneously, a branding of the funds should be considered, and their benefits easily identifiable. So-called re/upskilling funds should be promoted at city, regional, national and EU-level and would regroup relevant funding mechanisms available under a dedicated logo and umbrella structure.

In the context of the new multi-annual funding framework (2021-2027), the financial support for the Blueprint for sectoral cooperation on skills should be expanded. At present, its pilot activities in key sectors are financially supported only at the EU-level. Yet, in conjunction with the skills for industry strategy, the cooperation framework of the Blueprint aims to expand and rollout its activities to the national, regional and city level, working directly with national, regional and local authorities as well as key industrial stakeholders. In addition, in line with the subsidiarity principle, the scope of activities supported at EU level could be more focused to the testing of highly innovative and thus more strategic re/upskilling initiatives than the much larger and more operational ones implemented at the other levels.

- **Incentives for individuals and businesses.** The strength of workers in the labour market is in their own skills, creativity, adaptability, efficiency and productivity. They constitute the core of their professional (human) capital and guarantee to a large extent their employability. When they leave an organisation, they take their skills with them. Workers should be supported in their efforts to acquire new skills during their professional life.

[8] Skills for Industry: Scaling up Best Practices and Re-focusing Funding Programmes and Incentives, 2019

One possible incentive scheme to contribute to make lifelong learning a reality for all, might represent the introduction of lifelong learning and skills insurance plans, which would adopt a similar framework to traditional capital insurance plans with a specific focus on the acquisition of skills by individuals in case they lose their job or want to transition to a new position/field. Simultaneously, individuals would be given the opportunity to build up a lump sum of money (e.g. individual learning accounts) that they could use to finance their trainings and continued education. At the same time, they would benefit from advantageous tax arrangements and an attractive return on investment. Lifelong learning and skills insurance plans could be introduced at national, individual or corporate level, depending on local conditions.

Another solution would be the introduction of corporate skills insurance plans that would allow business owners to invest in the future skills development of their employees. Similar to existing car fleet programmes, corporates could subscribe to corporate skills insurance programmes to ensure the continued re/upskilling of their workforce. To encourage the uptake of re/upskilling activities at the individual level, corporates could envision introducing a bonus system that would benefit those employees that regularly complete trainings/certifications offered at company level. Hand-in-hand with the corporate skills insurance plan, incentives encouraging the wider uptake of re/upskilling efforts should be highlighted. Employers should be encouraged to invest a certain percentage of their profit into dedicated Vocational Education and Training (VET) savings accounts that would serve the continued training of their employees.

In addition, governments could top-up the amounts committed to the lifelong learning of employees, facilitating individuals' and employers' investment into the continued acquisition of new skills. SMEs could benefit from dedicated assistance. Besides the financial contributions received, additional support should be offered in the form of advice on trainings and certificates needed or the optimised organisation of the workforce to allow for the inclusion of trainings into the work culture. In line with the introduction of individual accounts, private actors should be encouraged to share their corporate VET programmes with non-employees. Corporate academies should be opened to the wider public to encourage the exchange of knowledge among industries and facilitate the recruitment of available talent. Further financial incentives could be envisioned at EU, national or regional level to support these efforts.

- **High-quality vocational education and training.** Europe must aim at the highest quality standards in education and training. The relevance of the curricula offered should be compared to market needs and international best practices. VET curricula need to be reviewed to provide students with the knowledge and high-tech T-shaped skills necessary on the labour market; they need to be job-driven. In line with this review, a new set of quality criteria should be established to allow for the objective assessment of trainings (both on- and offline) offered. Quality criteria to be implemented need to be clearly defined and easily understandable to facilitate their integration.

End users should no longer face difficulty when searching the relevance and the quality of trainings offered (especially online training[9]). They should be able to integrate these quality criteria into their personal skills development plan. The relevance and quality of VET across the EU would

[9] Skills for Industry: Promoting Online Training Opportunities for the Workforce in Europe, 2019

further benefit from the strengthening of the European credit system for vocational education and training (ECVET)[10]. It would streamline the certification criteria across all Member States and would facilitate the mobility of skilled workers as well as the exchange of knowledge and trainings across borders.

- **Accelerated world-class curriculum.** As mentioned above, a review of curricula offered and their alignment to current industry/market needs should be envisioned. Each course offered should be set-up to target specific skills needs of industry. The introduction of AI tools assessing new skills and labour trends should be used to this advantage. Education and training providers should increase their cooperation with industry to adapt their curricula in line with industry needs. In line with the continuous adaptation of curricula, Universities and training providers need to be given the flexibility to change the structure and content of their courses more rapidly[11]. The application process to ensure the official recognition of the degrees/certificates provided thus needs to be accelerated, streamlined and when appropriate recognised EU-wide. This process should be mindful of the transformation of educational systems and thus need to remain open to innovation.

Private-public partnerships are becoming increasingly important to ensure that the courses and trainings offered are aligned with industry needs. Universities signing cooperation agreements with industry and including industry expert knowledge/input into their curricula could benefit from prioritised public funding to recognise their efforts. On the other hand, curricula with little impact on the employability of students should thus be progressively phased out.

The modernisation of education requires the re-invention of the teaching profession. Teachers, professors and trainers will have to be on boarded on this new vision of skills development. They need to be equipped to better understand the demands of labour markets and adopt new innovative teaching approaches and methodologies. They should collaborate with industry to give students the opportunity to learn directly from the best experts who are currently working in the field. Industry experts can teach learners not only the most relevant technical skills but also the soft skills to prepare them for the realities they will face on the real world.

- **Industry-led training infrastructures.** New partnership models between industry and education and training providers should be encouraged to develop new learning infrastructures. Together, new training methodologies can be established and the provision of curricula expanded. Industry leaders need to invest in the overall skills development of Europe's workforce to guarantee the sufficient availability of talent necessary to drive in-house innovation.

The support and networking at EU level of centres of VET excellence - strongly embedded in local innovation ecosystems - would enable to establish a world-class reference of centres sharing common interest in specific sectors or innovative approaches to tackle societal challenges. These would contribute to the provision of high-tech skills and competences leading to good quality jobs and career opportunities meeting the needs of an innovative and sustainable economy.

In line with the need for EU-wide high quality criteria for VET, the accreditation of industry-led training infrastructures and the trainings offered should be widely disseminated to facilitate the wider uptake of re/upskilling efforts. To ease the accreditation process and thus drive the

[10] https://ec.europa.eu/education/policies/eu-policy-in-the-field-of-vocational-education-and-training-vet_en
[11] Skills for Industry: Curriculum Guidelines 4.0 for key enabling technologies and advanced manufacturing, 2019

introduction of industry trainings, the processes and procedures of the European Cooperation for Accreditation to become an accredited training provider should be reviewed and, where possible, streamlined and strengthened.

- **Talent detection and nurturing.** A new approach to early talent detection in education as well as in corporate settings should be developed. A working group should be created at EU level to investigate new ways of detecting hidden talent at both an early and later stage, as well as on how best to support individuals that are highly gifted. In line with the development of a new talent detection and retention approach, best practices should be widely disseminated to encourage a broader up-take. By spreading information on innovative solutions and facilitating the exchange of new ideas, the talent detection and retention system developed would be continuously improved.

These efforts should pay special attention to women, migrants and youth not in employment, education or training, as they need to be better integrated into Europe's workforce of the future. These groups need to be given more opportunity to identify and nurture their talents. Female talent, especially, should be increasingly supported in its development of high-tech T-shaped skills. Actions dedicated to the detection of female high-tech talent should be introduced at an early stage to tap into this under developed high-tech talent pool.

- **Communication at all levels.** A communication campaign under a common branding should be envisioned in the EU. A high-level awareness raising campaign could be launched, highlighting wider trends and underlining the EU funding mechanisms available to support Member States, regions, cities, businesses and individuals in their re/upskilling journey. An interactive platform (linked to the one-stop-shop mentioned above) allowing for the widespread dissemination of tools, trainings and jobs available across Europe could be developed and launched in this context.

At the national, regional and local levels, the vision and tools developed should be widely communicated among the public and industry leaders to boost industrial modernisation, smart specialisation and digital transformation. In line with the campaign at EU level, national and regional communication activities should highlight local particularities and industries. National and regional skills trends should be underlined and territorial initiatives, funding mechanisms, trainings and open positions disseminated.

The vision and the recommendations presented above were discussed at a high-level European conference on Skills for Industry Strategy 2030 on 19-20 June 2019 in Brussels.

TABLE OF CONTENTS

SECTION I - INTRODUCTION

1. INTRODUCTION

The Final Report has been developed in the context of EASME's '**Skills for Smart Industrial Specialisation and Digital Transformation (SIS&DT)**' project. This two years long project was commissioned by the European Commission's DG Grow with an aim to present the **Skills for Industry Strategy 2030** and policy **recommendations** to guide different stakeholder groups to design and implement their own skill strategies needed for achieving SIS&DT. The final policy recommendations presented in this report have been developed based on two separate state-of-play analyses, a comparison of US and EU skills ecosystems, the best practices report as well as on expert consultations.

1.1. General objectives

Experts are well aware of the impact innovation and technological adoption have on the competitiveness of industry. At the same time, they know how important a workforce with the right knowledge, skills, competencies and creativity is to drive this innovation. Yet, the readiness of the current and future workforce to lead these changes has not been well defined and planned. A lack of knowledge, readiness, planning, coordination and collaboration between different stakeholders, as well as guidance on the transformation process, have resulted in growing skills gaps, mismatches and job losses.

The European Commission has noted the urgency of addressing this challenge and decided to launch the new 'Skills for Smart Industrial Specialisation and Digital Transformation (SIS&DT)' mission to complement existing EU initiatives such as the Blueprint for Sectoral Cooperation on Skills, Grand Coalition for Digital Jobs, Industrial Modernisation Platform.

The ultimate goal of this effort is to support Cities, Regions and Member States (MSs) in designing and implementing ambitious skills **Strategies/Policies/Initiatives (S/P/Is)** to successfully shape the workforce transformation in Europe and strengthen the competitiveness of its industry.

1.2. Specific objectives of the initiative

The first objective of this EU Initiative was to develop the Skills for Industry Strategy 2030 collectively with different stakeholder groups to define a common vision for high-tech t-shaped skills.

The second objective was to **develop concrete policy recommendations to facilitate the operationalisation of the Skills for Industry Strategy 2030** by corporates, cities, regions and Member States. The policy recommendations designed aim to guide different stakeholder groups in developing and implementing their own skill strategies in alignment with their Industrial, RDI, Education, and RIS3 Strategies. At its core, the policy recommendations encourage the development of forward-looking, dynamic, interactive, multi-stakeholder driven and agile upskilling initiatives that leverage on real-time AI-based labour market assessments and foresight tools for evidence-based decision-making.

Throughout the mission, a **holistic approach** has been adopted to assess the entire industrial ecosystem and to set-up the right framework conditions. Particular attention has been given to the skills needs of SMEs, mainly start-ups and scale-ups due to their innovative nature but limited capacities for up/reskilling. Another key point has been the creation of synergies between existing relevant initiatives and the recommendations made in order to avoid duplication of efforts and investments.

1.3. Specific objectives of this report

This report presents the final findings of the 'Skills for Smart Industrial Specialisation and Digital Transformation (SIS&DT)' project and the policy recommendations developed over the course of the mission.

Section II presents the EU 2030 High-Tech Skills Vision together with its key characteristics and objectives. It also argues the roles and responsibilities to be taken by Governments, Clusters, Corporates, Universities and Individuals for the operationalisation of the common vision.

Section III presents the key policy recommendations developed to facilitate the operationalisation of the EU 2030 High-Tech Skills Vision and forms together with the Vision developed the Skills for Industry Strategy 2030. The policy recommendations have been subdivided into 9 modules based on the focus areas identified during the mission. Best practices have been included where possible to encourage exchange between stakeholders and facilitate the implementation of dedicated regional/national skills strategies.

Section IV presents 20 diverse cases, ranging from initiatives at city, regional and national level, having been initiated by private and public actors have been selected. Despite their diverse scopes and targets, all best practices can be considered as having contributed to the development of SIS&DT.

Section V compares labour-market issues for high-tech T-shaped skills between the European Union and the United States. It discusses general trends in high-tech T-shaped skills challenges and responses that stakeholders from the public sector and the private sector have developed. It then describes and analyses the American policy discourse on skills shortages, and draws parallels in high-tech T-shaped skills issues in the United States and the EU. Subsequently, it describes notable differences in high-tech T-shaped skills issues in the United States and the EU.

Section VI presents an outlook on the deployment of industrial and digital technologies that are key for SIS&DT at the city, regional, national and EU levels together with the mapping of supportive S/P/Is in place for boosting the SIS&DT. It also provides an outlook to the competitive positioning of EU MSs within and against other third countries such as US, China, Japan.

The SoP on SIS&DT is mainly based on the desk research where key findings have been identified through the most recently published reports over 2017-18 under 'Digitisation of European Industry' Initiative, 'Digital Transformation Monitor', and Digital Progress Reports under Digital Single Market. In addition, for the identification of thematic focus areas, deployment of individual KET technologies as well as performance of MSs and Regions, a closer look is given to RIS3 at MS and Regional levels as well as to KETs Observatory. Furthermore, the participation of MSs and the Regions to most relevant EU initiatives (i.e. ETPs, S3-Industrial Modernisation Platform, Vanguard Initiative, c-PPPs, EIT-KICs, Digital Innovation Hubs etc.) have been checked for the identification of MSs and Regions taking a lead & participative roles as a proxy to determine National and Regional strengths under different KETs categories.

This SoP starts with key definitions together with the role of key industrial and digital technologies on SIS&DT and continues with the SIS&DT trends in EU and US. It provides an overview on the latest S/P/Is in support of SIS&DT implemented at EU, MS, regional and city levels; describes

specific strategy and measures lead by industry ; concludes with the mapping of specific efforts implemented at the EU, MS, regional and city levels specific to SMEs, start-ups and scale-ups.

Section VII presents the operationalisation of high-tech T-shaped skills together with the challenges faced. It continues with an overview on S/P/Is led by Industry, Governments, Academia, Hybrid and/or Triple-helix Initiatives focusing on high-tech T-shaped skills development. It also provides an outlook to efforts put in-place in US for developing transversal skills. The latest insights on funding programs for high-tech skills is explained. It concludes with preliminary conclusions on key focus areas and priorities, common features in design and implementation, key attributes of successful initiatives, scalability and transferability as well as key insights in mechanisms for high-tech T-shaped skills development.

SECTION II – EU 2030 HIGH-TECH SKILLS VISION

2. EU 2030 HIGH-TECH SKILLS VISION

2.1. The EU 2030 High-Tech Skills Vision

The **EU 2030 High-tech Skills Vision** aims **to mobilise resources** at the local, regional, national and EU level to make skills an opportunity for everyone. It further aspires **to raise widespread momentum** by inspiring all key players to take part in **collectively designing and implementing powerful skills strategies** and thus turn the potential challenges brought by digital transformation and industrial modernisation into opportunities.

The Vision is being accompanied by a set of policy recommendations subdivided into 9 modules to guide different stakeholder groups on developing and implementing their own **skill strategies aligned with their industrial, RD&I and education, as well as RIS3 strategies**. In its core, it will be **forward-looking, dynamic, interactive, multi-stakeholder driven, agile** and will leverage on **real-time AI-based labour market assessment and foresight tools** for evidence-based decision-making. This goal will also be strongly supported by the first-ever **Digital Europe programme**, which the EU Commission proposed in June 2018.

The EU 2030 High-tech Skills Vision wants to introduce **a paradigm shift** to the entire ecosystem of workforce planning, education and training provision for skills development; to revolutionise the way education and trainings have been provided. One of its main goals is therefore to encourage a switch from the 'Life Long Employment' towards the '**Life Long Employability'** concept by making individuals responsible for their own skills development. This can only be achieved by constantly staying tuned to the transformative trends in the global labor markets, identifying barriers to employment and understanding new needs of both employers and employees as they arise.

It calls for the active involvement of each and every stakeholder group including: policy makers responsible from Education, Training, Industry, Economy, Finance Digitalisation, RD&Innovation; Industry Players; Corporate Academies; Edtech Companies; Universities, Research & Excellence Centres; Vocational Education and Training (VET) Associations; KETs Associations; Cluster Organisations; Labour Unions; Industry Associations and Federations; Think Tanks; Existing EU/National/Regional level Skilling Initiatives/PPPs; Digital Innovation Hubs (DIH)s; and public private investors among others.

Competencies for 2030 will cover all **three sets of skills**: sector-specific, technology & digital skills in addition to transversal skills conceptualised in this report as **high-tech T-shaped skills.** In addition, **'Learn to Learn'** concepts should be injected into all education and training programs of all ages. **This will drive a major shift from classrooms towards learning factories, experience centres, and makerspaces** where participants will learn through solving issues in an open innovation ecosystem.

The vision will require a comprehensive **'rethinking of education and training'** for all individuals to benefit from **lifelong learning**. Trainings should be facilitated and provided by **collaborative initiatives led by private parties or PPPs,** and benefit from agile and modern education methods using tech based tools and modern teaching methods.

In the light of the insights gained through the state-of-play analysis complemented by stakeholder consultations through workshops, interviews and survey, the **key features of the Vision** can be illustrated as below:

Figure 4. Key features of the EU 2030 High-Tech Skills Vision

Source: PwC Analysis

Since the Vision has been developed **based on success stories**, future solutions/initiatives should be **realistic, feasible, participatory, inspiring, responsive, anticipatory and inclusive**. The overarching goal is to boost the emergence of **global champions** at the territorial level by intensifying the support measures in place. This will allow the EU to hold its global competitive position, in KET domains in particular, through champions. At the same time, **Skills Champions** at individual and/or institutional will be selected and supported to lead and drive the implementation of the Skills for Industry Strategy 2030 at the territorial level.

2.1.1. The Key Objectives of the EU 2030 High-tech Skills Vision

The core objective of the EU 2030 High-Tech Skills Vision is **to reinforce the competitiveness of the EU industry** and to ensure its **global leadership position among the rising competitors** in the realms of the 4th Industrial Revolution. This vision aims to support and **help the European industry to embrace new technological breakthroughs, to upscale its initiatives, and to leverage on the opportunities these technologies bring**. The key to capitalise on these new technical opportunities is a workforce that is capable and motivated to intensively work with them. Thus, corporates, governments and territories need to implement skills strategies according to their **contextual needs and circumstances**. This will empower and ensure skills development for excellence, prosperity and personal development. The following objectives in particular should be pursued in this respect:

- **Collaborative training programmes** – Creating and supporting joint training programmes between universities & research institutions, VETs and Industry.
- **World-class curriculum** – Ensuring world-class curricula, which are hands-on to required skills for operating rising technological advancements.
- **High quality single VET market across EU** – Creating a high quality single market for training in the EU and for specific adjustments of the university system according to industrial developments.

- **Smart education methodologies and technology based tools** – Increasing effectiveness and efficiency of conventional training programmes with rising smart education methodologies.
- **Dual track system** – Fostering a dual track training system in most industries, inspired by the German education system.

2.2. The Road for Key Stakeholders to High-Tech Skills in 2030

The implementation of the EU 2030 High-Tech Skills Vision and the accompanying recommendations will be highly collaborative at its core. It requires the involvement of all relevant stakeholders (cross sectors, cross borders and across the whole value chain) to co-develop the governance and implementation of the Skills for Industry Strategy 2030. The key stakeholders to be involved in developing the skills strategy at the territorial level are **governments**, **corporates and SMEs**, **universities and research organisations**, as well as **VET providers**. The following sections describe how these five pillars of the strategy can ensure a successful realisation of the EU 2030 High-Tech Skills Vision.

2.2.1. Governments

In this section, we describe the role of **local, regional and national governments** in skills development for smart industrial specialisation and digital transformation towards 2030. We discuss the importance of national governments, regional governments and city councils to provide an overarching vision on industry modernization, technological transformation and corresponding skills development. Subsequently, we describe the importance of the Skills for Industry Strategy 2030, the added value of data driven skills assessments for government policies and the coordinating role governments can play to create a market for skills development. Finally, we elaborate on government funding that can function as an important incentive to the development of high-tech skills and skills for digital transformation, the role governments can play to support stakeholders in communicating skills strategies, learning factories, and the importance of strategies to be able to adapt to changing market circumstances and leave room for territorial differences.

2.2.1.1. Leadership and Governance

The transition towards the fourth industrial revolution, driven by key enabling technologies and digitalisation, requires modernisation efforts to ensure that industry is well equipped to overcome the challenges it currently faces and to stay competitive in global markets. These challenges include the need to develop a truly digital entrepreneurial culture, to stimulate investments in new technologies, and to improve the market base for the commercialisation of KETs developed in Europe. National governments, regional governments and city councils will need to provide an overarching vision on industry modernisation, technological transformation and corresponding skills development. A vision towards 2030 needs will require a clear allocation of responsibilities allocation, a shared ambition, covering various sectors and technologies, with sectoral coordination, and with measurable objectives.

Clear responsibility allocation – It is recommended that one ministry, for instance the Ministry of Economy, takes a leading role. One important first step could be to appoint a steering group with representatives of other ministries (Ministry of Labour, Ministry of Education) and relevant stakeholders to draft shared ambitions.

Shared ambitions – It is important that all relevant stakeholders, including governments, industrial actors, labour unions, national education and training agencies, local development

organisations and community-based organisations, will have shared ambitions. This requires understanding their goals and priorities, as well as allowing them to benefit from their involvement.

Covering various sectors and technologies – Their ambitions should acknowledge the multidisciplinary character of high-tech T-shaped skills development for smart specialization and digital transformation. Subsequently, their ambitions should cover all relevant technologies and respective skills development, paying specific attention to links with applications in different sectors.

Sectoral coordination – Their ambitions need to pay special attention to stimulating sectoral coordination of policies and initiatives to encourage both the formation of new coordinating networks and alliances and the entrenchment and expansion of existing networks and alliances. This can help further conceptualising high-tech T-shaped skills and identify actors that can promote skills development.

Measurable objectives – The objectives on the horizon of 2030 have to be measurable in order to avoid inefficiency of any policy instruments and enabling the assessment of their performance. Policymakers always have responsibility to ask the question if public investments are spent effectively and to what extent this can be proven by evidence. In this context, effective monitoring and evaluation should be implemented to provide information to track developments and evaluate whether strategies and policies are implemented. Governments can set up a multi-stakeholder oversight body that reviews performance in light of objectives and ambitions.

2.2.1.2. 2030 Skills Strategy

The transition towards the Fourth Industrial Revolution, driven by digitalization and key enabling technologies, demands detailed EU, national and regional skills strategies in line with country, industrial and technological priorities to orientate the sourcing, and production of relevant skills in a sustainable matter. Consequently, government strategies should include the maintenance of necessary infrastructure, legal and regulatory environments and commitments to public funding. There is a need for continuity and alignment between all levels of government policy in order to have a positive impact on the growth of the technology sector.

Cities and regions are playing an increasingly important role in the smart industrial specialisation of Member States. The smart city concept is gaining momentum and cities and regions are continuing to grow. Cities and regions need to formulate a strategy to create the right environment to accelerate the digital transformation and high tech skills development and improve the ecosystem in which residents live and businesses succeed. As such, strategies should focus around both local and international sourcing of talent, upskilling of the existing workforce, dual-track education systems, and life-long learning policies.

Local and international sourcing – Governments need to consider European and national sourcing strategies. As part of the strategy development, a business case can be made to estimate the impact of using high quality European or national talent in comparison to other (more conventional) sourcing plans. Sourcing strategies should be aligned with upskilling and reskilling activities companies undertake, and may draw inspirations from the ways in which secondments and sabbaticals are organised, as these activities become increasingly popular as a means to internationalise professional occupations in Europe.

Upskilling – Upskilling of the existing workforce by paying particular attention to social inclusion as well as the preparation of the right framework to train the next generation of the workforce. It is also important to upskill job seekers, even if they have not taken part in formal education for

many years. This report provides a framework to train the workforce in skills that range from technical and academic skills to softer skills like problem-solving, multicultural openness, leadership, and managerial and interaction skills. The report proposes seven categories of skills development based on common patterns in KETs competences, and represent both the need for specialist (technical) skills and crosscutting skills. These categories are technical skills in an adjacent technology domain; skills related to quality, risk and safety skills; management, leadership and entrepreneurial skills, communication skills, innovations skills, emotional intelligence skills and ethical skills.

Dual track systems – The organisation of formal education in a way that combines in-school classroom-based education with workplace experience and on-the-job learning. Success depends on effective coordination between stakeholders, a wide recognition of resulting certifications and accreditations within the job market and education and training efforts shared by educators and employers across sectors and throughout the country.

Life-long learning policies – Future-oriented education and training efforts will need to include current workers in the European labour force. Therefore retraining current workers is vital to prepare enough people for working both in new jobs and in new sectors. Labour-market systems need to provide training and education throughout an individual's working life. Deliberate policy design may be required to stimulate the development and provision of educational curricula and policies should include targeted instruments that include specific arrangements for workers that are close to the retirement age.

2.2.1.3. Data-driven skills assessment

Government policies should be fact-driven and informed by the analysis of local economic developments at regional and city level. The need for skills development can be efficiently assessed by leveraging on Big Data and AI technologies. Data analysis could facilitate the identification of patterns and trends, accurate forecasting and producing relevant recommendations for skills development.

National and regional specialist bodies and taskforces can be responsible to build, progress, bring together and offer target groups tools, data and differentiated Big Data infrastructures, and support the creation of an ecosystem of data users, coders, and application developers. Collaborations with other interested parties can help to increase the datasets.

When data are collected and analysed, it is important that they be shared with the outside world, opening up the policymaking process. Governments can provide open data in searchable databases so that other parties can request, search and analyse this data. Possible beneficiaries of these data analyses could be HR-strategists, policy makers and people that compose curricula at educational institutions.

In order to pull meaning out of the collected data, responsible government agencies need to acquire the right talent, tools and systems. Governments need to develop the in-house skills to collect data, analyse it using the various tools, and interpret the results. When large amounts of data of citizens are collected, analysed and shared, oversight by national data protection authorities is essential to protect the privacy of the data subjects. The setting up of national and regional specialist bodies, the acquisition of the right talent, tool and systems and the collection and analysis of data can have impact on the medium term.

2.2.1.4. EU Single Market for VET

Governments can act as coordinators and enablers to create a market for skills development, which supports stakeholder engagement in workforce mobilisation. To create a single market, governments should focus their coordination and enabling role on stimulating demand, stimulating supply, creating online and physical marketplaces, coordinating accreditation and certification and ensuring their EU-wide recognition, and creating a common language around the development of high-tech T-shaped skills.

Stimulating demand – To stimulate demand for skills development, governments, on a national, regional and city level, should first gain insights in local skills needs and communicate insights to the relevant stakeholders. Governments can then organise events or round tables with responsible functionaries (ministers/majors/councillors) and industry leaders, where skills needs are collected and discussed and focus areas are nominated. Governments can stimulate private parties to allocate financial resources to skills development initiatives, for example by introducing tax incentives.

Stimulating supply – Educational institutions and research centres should be aware of employer's skills demands and stimulated to collaborate with private-sector actors to set-up education initiatives for lifelong learning and dual-track education for high-tech T-shaped skills relevant to smart industrial specialisation and digital transformation.

Create online and physical market places – One way to facilitate this process is to develop online matchmaking tools and real-world matchmaking events, which assist companies and research and educational facilities to search and explore new ways of collaboration and bringing supply and demand together. It helps companies to describe their demanded competencies in a structured way, and it helps research and educational facilities to identify missing competencies and find ways to team up with companies to compensate skills gaps.

Accreditation and certification – The European Commission can set up a list of recognised accreditation and certification bodies of training initiatives in the EU, and play a role ensuring that certificates (from schools, from apprenticeships, or from workplace training programmes) or accreditation of education are widely recognised throughout the European Union.

Create a common language/ nomenclature – The European Commission can kick-off and coordinate the creation of a shared nomenclature where names of trainings and demanded competences are the same throughout the European Union. This helps supply and demand of skills to find each other more easily.

Creating online and physical market places, setting up accreditation and certification and creating a common language/nomenclature can have an impact on the medium to long-term. Stimulating supply and demand getting insight in local skills needs and by collaboration between educational institutes and private parties can generate short-term results.

2.2.1.5. Finance and economics module

Government funding can function as an important incentive to the development of high-tech skills and skills for digital transformation. Governments could provide funding for development and first implementation of specific, in particular new and innovative, activities and initiatives. New financial incentives can be created, but some existing funding programmes (on an EU, national, regional or city level) could possibly be re-focused to initiatives on the acquisition of skills for smart industrial specialization and digitalization. Governments can choose between different funding mechanisms, including:

- Co-funding for industry in building and running dedicated vocational education centres;
- Co-funding for the co-creation by industry and academia of new courses and curricula;
- Co-funding for of new innovative and alternative teaching/learning systems;
- Co-funding excellence schemes with top universities to draw top academic talent and students;
- Co-funding SME vouchers for consulting contracts and knowledge transfer;
- Co-funding high tech apprenticeships/traineeships in industry;
- Co-funding the development of open education resources (OER, including MOOCs);
- Co-funding (lifelong) learners through vouchers, fiscal incentives and/or cost sharing;
- Co-funding upskilling/reskilling programmes for the workforce in particular sectors or regions.

Developing incentives for corporates and governments at regional and city level in designing and establishing vocational trainings for the workforce is particularly important as the job market requires students to acquire practical skills that can be applied in their (future) jobs, and the current workforce needs short-cycle qualifications aimed at reskilling or upskilling in technical or soft-skills domains.

In the design of vocational trainings, it is important to involve social partners, industry and research centres in an open approach allowing external stakeholders to participate in and contribute to the sharing of knowledge and experience, creating synergies and opportunities for lessons learned in the past to inform the curricula of the future. Governments can stimulate this process.

Stakeholders indicate that, on the regional level, to support creation of world class clusters especially in Central and Eastern Europe, it will be crucial for developing competitive companies and industries to have new tools for financing clusters in the beginning of their existence through top-down regional initiatives.

Government funding as an important incentive to the development of high-tech skills and skills for digital transformation can be expected to have an impact already on the short term.

2.2.1.6. Communication Module

When private sector parties, universities and other educational institutions develop training initiatives, (online) courses or dual-track education to meet future skills demand, it is important to support stakeholders in communicating and advertising these training initiatives.

In order to achieve large-scale effects, this support needs to take place within larger targeted communication strategies, developed in collaboration between governments and relevant stakeholders at multiple levels, and raising general awareness on the importance of skills development in high-tech cross cutting skills and digital transformation. Strategies should reach targeted audiences, including young people, teachers, public employment services and society in general.

Policy makers need to take a leading role in launching the initiatives and could outsource the development of the strategies to third parties. Moreover, it is essential that training initiatives in the different member states are collected and brought together on an EU wide portal, so that

audiences are aware of the supply. The European Commission could support the set-up of such a portal, where training suppliers can communicate and advertise their initiatives. Another more innovative instrument can be to encourage the set-up of pages on widely used social media platforms (such as Facebook, LinkedIn or Instagram) to communicate about training initiatives. Such support of stakeholders in communicating and advertising training initiatives can be expected to have impact already on the short term.

2.2.1.7. Industry-led Training Infrastructures

Governments can deploy a clear model for learning factories, such as in Baden-Württemberg with the "Learning Factories 4.0". In Germany, the State of Baden-Württemberg launched a network with the aim of sharing the resources and expertise of production, information and communication technologies to help businesses in their digital transformation process. The Learning Factories 4.0 are one of the most prominent and effective policies. The Learning Factories are a government-backed initiative to create learning factories to demonstrate the principles of digitally controlled production modules and teach students by providing real-life practice.

A clear model covers the establishment and tasks of a coordination centre, the creation of innovation-friendly conditions, support for young scientists and SMEs, support for selected core fields, funding of research institutes (universities and the non-university sector) and the support to individual projects. There needs to be close relationships with relevant stakeholders, and exchanges and dialogues need to be organised with experts on specific themes. Allocating clear responsibilities is essential between relevant stakeholders such as between ministries, chambers of industry and commerce, trade unions, clusters, networks and technology centres. Funding of learning factories needs to come from regional and city governments co-financed by private sector parties. All parts of a region need to take advantage of a learning factory approach. Therefore, learning factories not only need to be established close to renowned universities and research schools, but also in vocational schools throughout a region. The launching of an infrastructure for learning factories can be expected to have an impact on the medium term.

2.2.1.8. Agility

Government approaches for high-tech T-shaped skills development towards 2030 need to be able to adapt to the changing circumstances of new technology developments and labour-market requirements. Policies and programmes need to be flexible enough to allow for adjustments and revisions. Because the high-tech skills and digitalisation domain are in constant change, policy frameworks should give direction and action points, but also enable the scope and timescales to be easily changed, if necessary.

Disruptive technologies are changing industries rapidly. Several existing tools can be used to include the latest market insights in the vision, including insights from skills observatories and from technology foresight activities.

Insights from labour-market and skills observatories – Observatories analyse trends and challenges, collect examples of good practices, produce insights and recommendations on topical issues, organise public events and meetings, and stimulating discussions among institutions, socio-professional stakeholders, civil society and academia. These should all serve as input to adaptive policymaking at regional and city level on the topic of high-tech T-shaped skills for smart industrial specialisation and digital transformation.

Technology foresights – Technology foresight activities can produce input to policymakers on technological trends and forecasted developments. This can help determine what high-tech and

digital innovations will be relevant down to regional and city level, and can feed regional and company-level skills strategies and investment decisions.

Observatories and foresight studies can be financed by governments and by subscription fees of beneficiaries such as large companies, local policymakers and cluster organisations. The financing and development of tools to include the latest market insights in the 2030 vision and strategies can have impact on the short to medium term.

2.2.1.9. Autonomous territories

The vision must allow room for territorial differences and not impose an overarching one-fits-all concept upon all individual cases. The European Commission could formulate the vision in line with the EU's open method of coordination, which is a means of governance based on voluntary cooperation of member states. The vision should rest on a framework with guiding principles, stimulate the sharing of best practices, benchmarking and asking for reporting in EU review cycles.

A framework with guiding principles – The 2030 vision should contain guiding principles, and provide for enough flexibility that member states, cities and regions can modify a vision and strategy so that it suits the needs to the local markets and environments. Guiding principles can offer approaches and examples that can be translated into national, regional and city strategies.

Stimulate sharing of best practises – The European commission should stimulate the sharing of best practises of skills development across Member States, regions and cities.

Review cycle – The European Commission can monitor Member States' efforts towards the Skills for Industry Strategy 2030 at specific times throughout the year especially in the context of the European Semester. In similar fashion, the Commission can assesses regional skills strategies and provide region-specific recommendations. Regional and city governments can take policy decisions in light of the skills strategy in response to the specific recommendations, based on action they deem appropriate.

2.2.2. Clusters

Clusters can play an important role in the design of smart industrialisation and digital transformation strategies and in the implementation of these strategies. Clusters are a concentration of economic activities in groups of related industries (firms, institutions and other economic actors) that are connected through multiple linkages. The actors are located close to each other and they have reached a sufficient scale to develop specialized expertise, services, resources, suppliers and skills. Especially cluster organisations are important. They support the collaboration, networking and learning in innovation clusters, act as innovation support providers and facilitate strategic collaborating across clusters. In this section, we discuss the role clusters can play in defining and executing the skills strategy as active interface between industry, academia and governments. Subsequently, we elaborate on the role clusters can play in international partnership building and the strategies being responsive to the needs of workers and employers. Finally, we stress the importance to actively engage in in the provision of new skills for the key technology advancement and support stakeholders in communicating and advertising training initiatives for meeting future skills demand.

2.2.2.1. Active Interface of the Skills Strategy

Clusters, and specifically cluster organisations, can play a key role in defining and executing the skills strategy as active interface between the industry, academia and governments. In the defining of regional skills strategies, clusters should involve other relevant stakeholders such as businesses,

investors, academics and policy makers. In the implementation of the strategy, clusters need to promote implementation in all-important areas of regional cooperation, including R&D, skills development, education, marketing and improving innovation capacity. Cluster organisations can execute the strategy through different activities, including promotion and dissemination, lobbying and networking, sectorial regional analysis, design and implementation of training initiatives, and contributing to upgrading vocational training systems and university curricula.

Promotion and dissemination – Clusters may organise (networking) events and roundtables or promote dedicated websites to disseminate the national and regional skills strategies and present cluster activities to promote skills development and bring parties together. Networking events enable cluster members to look beyond their own field and get into contact with members of other clusters in order to develop new ideas, make new contacts and find possibilities for cooperation. At round tables, cluster organisations can bring together customers, researchers and companies to discuss the skills strategy and new technological opportunities in different industrial sectors. The cluster organisation can disseminate the strategy through its website and create a platform to bring supply and demand of skills together.

Lobbying and networking – Cluster organisations can liaise between private sector parties and regional and city authorities. They can collect input and perspectives from companies, especially from SME's, and present these perspectives in the strategy development process.

Sectoral and regional analysis and projection of skills needs – Clusters could analyse technology and business trends in the sectors relevant for the respective cluster. An analysis needs to be based on the understanding of the whole eco-system of related industries. Several analytical tools can be used, such as road mapping, foresight analyses or market analyses. Often used is road mapping, specifically providing a combination of competence mapping and foresight analysis. Clusters can also make use of insights from initiatives such as the European Cluster Observatory, a single access point for statistical information, analysis and mapping of clusters and cluster policy in Europe. Such observatories help Member States and regions in designing smart specialisation and cluster strategies to assist companies in developing new, globally competitive advantages in emerging industries through clusters.

Design and implementation of training initiatives – Clusters may contribute to the design and implementation of training initiatives through a collaborative, triple-helix, approach with universities, companies and governments. Especially cluster organisations can facilitate the interaction between universities, industry and governments to generate new ways of knowledge and skills development. They can stimulate the transfer of state-of-the-art knowledge between universities and private sector parties and help government funds to be allocated to skills development initiatives for high-tech crosscutting skills and digital transformation.

Contributing to upgrading vocational training systems and university curricula – Curricula must be dynamic and frequently updated in order for students to receive state-of-the-art education and training. There is a need develop curricula geared to high-tech T-shaped skills, in order to meet the job market which requires workers with a broader skills set. This can be achieved by including T-shaped skills in curricula (such as communication, ethics, or leadership skills), and include dual-track trainings in curricula in collaboration with industry.

Clusters should interact with other actors and stakeholders that play an important role in the definition and execution of the skills strategy, including government agencies, trade unions and vocational education training centres, educational institutions, public interest associations, consumer groups and private sector firms that may or may not be part of any cluster organisation.

Clusters playing a key role as active interface between the industry, academia and governments can have an impact on the short term.

2.2.2.2. International Partnership Building

Clusters can play an essential role as building blocks of designing regional and city-level skills strategies towards 2030, and as a means for executing them through international partnerships. International partnerships are essential for clusters to present themselves, to support European SMEs in global competition, share knowledge and resources and search for potential partners for transnational and interregional cooperation.

The European Commission launched already several cluster internationalisation initiatives aiming to promote international cluster cooperation by intensifying cluster and business network collaboration across borders and sectoral boundaries within and beyond Europe, such as the European Cluster Collaboration Platform (ECCP), International Cluster Matchmaking events and European Strategic Cluster Partnerships (ESCPs).

Of particular interest is the European Strategic Cluster Partnerships for Going International (ESCP-4i) that aims to develop and implement joint internationalisation strategies to support SME internationalisation towards third countries and aims to lead to cooperation in new areas, notably in emerging industries. In February 2018, a partnering event was organised, where 100 cluster representatives formulated recommendations. One of the key recommendations was to focus on establishing a partnership with complementary competences along the value chain rather than gathering partners only from the same sector.

The European Commission needs to make efforts to promote European Strategic partnerships for smart industrial specialisation and digital transformation, in order to facilitate new collaboration and innovation, boost investment in skills development towards 2030, and set priorities and help improve knowledge and awareness on funding possibilities.

Facilitate new collaboration and innovation – Collaboration is essential between educational and research institutes, companies and the public sector to develop T-shaped skills for smart industrial specialisation and digital transformation. Clusters can facilitate international cluster cooperation in new areas and emerging technologies and specific to non-EU markets, by organising get-togethers, events or workshops, business missions or networking visits, round-tables

Boost investment related to regional and city-level skills strategies – Cluster organisations can play an active role in stimulating private sector, cities, and regions to invest in skills development. Cluster organisations can formulate an ambition with local stakeholders, bring together knowledge and people to push forward initiatives in the region and connect ideas with funders and inventers with implementers. It is important to have a European and international focus and bring together, if relevant, ideas and funders across different countries.

Knowledge and awareness on funding possibilities – There are many funding programmes from government agencies that can be used by cluster participants in order to run programmes or start initiatives. Clusters need to continue communicating about these funding programmes on their website, and should focus on relevant funds for the 2030 skills strategy. Clusters should also call attention to interregional or international funding programmes when parties start a collaboration or partnership with other stakeholders. Clusters playing an active role in executing the 2030 skills strategy through international partnership building can have an impact on the short term.

2.2.2.3. Enhance Skills Provision Responsiveness

An effective skills development strategy needs to be responsive to the needs of workers and employers, and flexible enough to change according to fast changing labour-market demands. Therefore, clusters should collect and define requirements and skills gaps of companies at regional and city level, to enhance actively the skills provision from private sector and public sector stakeholders. To do so, cluster organisations can consider surveys, cluster mappings, development of data and knowledge platforms, and strategic monitoring and assessments.

Online surveys – Online surveys are a good way to monitor developments and collect skills requirements from companies in regions and cities across the EU, as well as from workers. These may be especially well received if they are brief, to the point, and can be answered through mobile devices.

Cluster mapping – Cluster mapping provides a fact-based analysis of local competitiveness and the concentration of economic activities. The result of cluster mapping is that priorities can be set and skills provision can be enhanced effectively. Moreover, key insights from skills observatories and technology foresight activities may be incorporated in cluster mapping efforts.

Data and knowledge platforms – Such platforms offer data and information in support of an evidence-based approach. They already exist on national, regional and European/international levels. When brought down to the regional and city level, these platforms can be used to develop cluster strategies, cluster policies and cluster management by organising workshops, courses and seminars. Examples of European platforms that offer data and information in support of more evidence-based approaches in cluster development are the European Cluster Observatory, the European Enterprise Network, the KETS Technologies Infrastructures and The Innovation Policy Platform.

Strategic monitoring and assessments – Monitoring and evaluation is often used as an 'external' assessment tool. Such efforts can be converted into a strategic intelligence tool that supports the analytical process of collecting skills gaps, and the implementation and improvement of policies and programmes. In this way, strategic monitoring and assessment can support stakeholder involvement in tracking developments, identifying priority areas and enhancing skills provision.

2.2.2.4. New Skills Provision

It is important for cluster organisations as well as stakeholders in clusters to also play a role in actual skills provision and generation, working together with educators in their region to develop and implement training activities relevant to the smart industrialisation of their region and to digital transformation developments within their regional economy. They can do so by a structural programme of workshopping new methods and ideas for actual skills development projects, piloting these projects, sharing best practices, and establish a network of actors for upscaling best practices throughout their city or region.

Workshopping new methods and ideas – Cluster organisations can take the lead to bring together HR strategists, leading educators, SME representatives and local policymakers in a workshop setting to think up and design skill development projects and activities that suit the needs and opportunities in their city or region. These workshops may benefit from structurally recurring, and can serve to translate regional skills strategies in to concrete projects, activities and events.

Piloting regional projects – When these multi-stakeholder workshops come up with relevant project ideas, these can be piloted within a city or region. An analysis may be conducted to identify specific organisations or institutions for which selected pilot projects can be particularly relevant. Cluster organisations can take the lead in developing and implementing these pilot projects, and monitoring their progress and results.

Sharing best practices – Successful pilot projects should be celebrated and disseminated throughout a region or city. Cluster organisations can work together with business hubs and local policymakers to promote successful pilot projects on websites, through social media, and other communication channels relevant to the city or region. Content should include what results were achieved, and how projects and activities generated these results in a way that can be copied by other organisations and stakeholders.

Networking for upscaling – Cluster organisations may take the lead in establishing and maintaining a network of local businesses, educators, policymakers and financiers that can work together to scale-up promising pilot projects and activities. This network can be called upon to push and promote especially skills development projects and activities that have proven to be able to generate tangible results, and to work together to implement these activities at a larger scale throughout a region or city.

2.2.2.5. Communication Module

Cluster organisations can play in important role in supporting stakeholders to communicate and advertise training initiatives for meeting future skills demand.

In order to achieve large-scale effects, this support needs to take place within larger targeted communication strategies, developed in collaboration between governments, private sector and relevant stakeholders at multiple levels, and raising general awareness on the importance of skills development in high-tech cross cutting skills and digital transformation. Strategies should reach targeted audiences, including young people, teachers, public employment services, SMEs and society in general.

Cluster organisations can take a role in launching initiatives such as organising (on-site) events at universities or companies or setting up online campaigns where stakeholders can present training initiatives and innovations. Facing international competition to attract people, jobs, firms and more, cities and regions are conducting branding strategies to promote their territory. Cluster organisations can make connections between stakeholders wanting to advertise and promote training initiatives and branding strategies from cities and regions

Support of stakeholders in communicating and advertising training initiatives can be expected to have impact on the short term.

2.2.3. Corporates

In this section, we describe the role of private-sector actors in the generation of high-tech, T-shaped professionals relevant to smart industrials specialisation and digital transformation. Specifically, we describe how corporate skill strategies may be defined, new university partnership models, innovative, data-driven skills assessment tools, the inclusion of SMEs, workforce mobilisation, third-party financing and innovative learning factories.

2.2.3.1. Define Corporate Skills Strategies

Private-sector actors will need to define their own, individual skills strategy. Especially for large employers in the high-tech and digital space, it is important to develop a skills strategy that suits

their needs for the middle and long term. These strategies should be tailored to the needs and requirements specific to the characteristics of individual companies, much like investment strategies in fixed capital or in intangible knowledge assets – one size will not fit all.

These corporate skill strategies in its essence are investment strategies and should be treated as such. It is very likely that costs associated to implementing these strategies will not be immediately recouped. These costs are an investment and returns will be generated over a period of years through human-capital gains. Human-capital investment strategies should cover:

Asset selection – Corporate skills strategies may benefit from analysing and determining what kind of human capital they may best invest in. This report provides skill categories, competency and knowledge areas, and specific skills that companies may value in their teams and in their individual employees. Also, this report provides a range of best practices for training and developing these skills. Based on a company's strategic outlook for the coming decade, these building blocks may help to define human capital needs and to make investment choices highly specific.

Financial allocation – After asset selection, corporate skills strategies may benefit from direct and committed allocation of company finances. As with every investment strategy, a skills strategy will require financial means to come about and to generate returns. As with most capital investments, the associated sums needed to invest in human capital for the technological and digital world of 2030 may be quite significant.

Performance assessment – When funds have been allocated to specific investment opportunities for human capital, it will be important to assess the performance of these investments and make any adjustments necessary for skill development and training to occur on the levels required. In this report, we describe innovative data-driven skills assessment tools that can help large employers assess human capital developments within their company and their sector.

Individual skills strategies for private-sector actors should focus both on hiring and recruitment of high-tech and digital talent, and on upskilling and retraining their existing employees. This report describes specific examples of in-company retraining and upskilling efforts, and in the section below, we describe the notion of workforce mobilisation in more detail.

To maximise the effectiveness and relevance of individual corporate skills strategies, companies can develop them to fit into regional skill strategies described above. This will benefit regional specialisation and allow for synergy between individual private-sector efforts to prepare their current and future staff for developments in labour demand.

The development and implementation of individual corporate skill strategies can be expected to have impact on the medium and long term. Specific modifications in hiring and retraining practices can generate short-term results.

2.2.3.2. New University Partnership Models for Corporate Academies

As part of their skill strategies, companies in the private sector should further engage in dialogues with higher-education providers, including universities and higher-vocational educators, to form partnerships that can deliver innovative educational programmes that respond to future skill needs. It may be particularly helpful to reach out to educators in their region or city. These partnership models can include two combined approaches:

Co-creating and developing educational materials and curricula – Companies can form structural partnerships with universities to jointly work on curriculum design and to co-author

educational materials. This will allow companies to help steer the scope and content of curricula to fit better with current and foreseen skill demand. It will also allow educators to enhance the level to which their curricula prepare their students for their first jobs. Co-creating educational content and structure will require substantial and well thought-out input from private-sector HR specialists. It will also require educators to find a balance between on the one hand short- and medium-term labour-market demand and on the other the need for strong, foundational education that can help graduates throughout their careers.

Reskilling workers together – Structural partnerships with universities can also be geared to focus on helping companies to reskill or upskill their employees. As part of a life-long learning effort, professionals in high-tech and digital domains can be enrolled in educational tracks throughout their career, tailored to their career phase and skills needs. This will require structural relations between universities and large companies, with intensive coordination on content and structure of the partnerships and of educational tracks. It will also require changes in how jobs are structured to facilitate continuous education, as well as changes in how educational tracks are developed, funded and appraised; the private sector might need to financially contribute to these tracks. This report described several initiatives that focus on reskilling current employees, which typically occurs at the middle-skill level and through industry-led initiatives.

The combination of industry involvement throughout the university years and academia's involvement throughout the professional career as part of a life-long learning can be expected to have impact on the medium and long term. On the short-term, intensifying existing partnerships will allow industrial partners the opportunity to pilot specific equipment, hardware and software solutions within an educational setting and will allow them the opportunity to spot talents early and cherry-pick their future hires. Also here, a balance will need to be found and guarded short-term labour-market demand and overall quality of higher education.

2.2.3.3. Apply Innovative Data Driven Skills Assessment Tools

Corporate skills strategies and forward-looking educational curricula can benefit greatly from data-driven skills assessments that forecast skill requirements in quantitative and qualitative terms. For widespread uptake, these assessments should offer high added value, be easily accessible, and be highly user-friendly. This may be achieved through digital skills assessment tools that leverage Big Data and Artificial Intelligence technologies.

High added value – Data-driven skills assessment tools can be of high added value to private-sector organisations. They should offer forward-looking analysis that helps companies gain more insight in their future skills needs, and that helps them understand with what organisations they can work to ensure the right talent with the right skills is available at the right time. These assessments should offer both quantitative insights (e.g. how many employees will be required in a specific high-tech domain for a specific sector) and qualitative insights (e.g. what type of skills and competencies will be required at what level for specific job clusters). T

These insights could be obtained through advanced artificial intelligence and machine learning applications that analysis on large volumes of structured data on labour market developments, developments in education and developments in (digital) technologies. Sets of Big Data could be generated by large online platforms of user-generated content that currently exist and are developing. Innovative assessment tools could plug into international online platforms such as LinkedIn, Indeed, Monster.com, and others.

Easily accessible – Wide update and implementation of innovative, data-driven skills assessment tools will be helped by easy accessibility. Accessibility can be enhanced through technological

solutions such as cloud hosting and cross-device compatibility, but also through solutions such as content availability over languages, straightforward sign-up and user acceptance policies, and clear positioning and dissemination throughout the online domain.

Highly user-friendly – In order for large numbers of relevant actors and stakeholders to use these assessment tools on a regular basis, they will need to be as intuitive and user-friendly as the most popular websites and mobile apps. This will require detailed analysis of user stories and their subsequent interactions, and a state-of-the art interaction and functional design.

Any success of these assessment tools will also rely on proper handling of privacy and security issues. The tools will need to be completely in line with data protection regulation and privacy law throughout the EU and perhaps even worldwide. Moreover, as big data sets become increasingly valuable, necessary precautions need to be taken to prevent data and insights on users, individuals, citizens and workers from being commodified beyond the direct needs of the skills assessments. One step may be to develop transparent and functioning financial models for these assessment tools, with clear payment flows and funding sources – e.g. paid for per use or through subscriptions, and by private-sector and government organisations.

2.2.3.4. Facilitating EU SME Inclusion

In 2016, SMEs accounted for 67 % of total employment in the EU-28 non-financial business sector, and 93 % of the SMEs were micro SMEs employing less than 10 persons.[12] As such, a large number of workers in Europe are employed by companies that can be expected to struggle with strategizing for long-term skill investments relevant to high-tech and digital developments. These companies cannot go it alone. Efforts need be made to facilitate SME inclusion in regional and company skill strategies, and to generate access to corporate academies and curricula, to develop financial mechanisms that help SMEs invest in long-term skills development, and to establish coordination across groups of SMEs at regional and city level.

Access to corporate academies and curricula – As large employers engage in new partnerships with educators to respond to future skill needs, it will be helpful to SMEs to have access to these partnerships and to the corporate academies and (online) curricula that can be part of the reskilling efforts of large companies and educators. Very likely, the content of educational tracks and modules geared to large employers is also relevant to SMEs. Organisational models for cooperation, partnership or licencing could be developed to allow SMEs to enrol their staff in educational programmes of large companies.

Financial mechanisms to help SMEs invest – Access to these academies and curricula need not be free. Our report describes in-company retraining programmes that cost about EUR 15,000 per trained worker. Moreover, it may very well be beyond the need of SMEs to invest in a skills strategy that suits their needs for the middle and long term and that includes both recruiting talent and reskilling existing workers. Consequently, they may benefit from financial mechanisms that will help them make these investments. Relevant and helpful financial mechanisms may include soft loans for reskilling efforts that have a measurable ROI. They may also include vouchers for participation in recruitment and upskilling programmes of large companies in their region or city. These vouchers may be funded directly by city or local government, or through an industry-led fund that pools the resources of large companies in a region, city or value chain. Large companies may even invite their SME suppliers to participate in their skills programmes and initiatives, and work any financial arrangements out in their overall commercial negotiations.

[12] European Commission, 2017, Annual Report On European SMEs 2016/2017

Sectoral coordination on regional and city level – While SMEs may not be able to make long-term skill investments by themselves; they may find a way to do so together. SMEs within the same sector in a city or region may make joint investments in constructing a strategic outlook that engages technological and digital developments. SMEs that share a similar strategic outlook may jointly invest in recruitment and reskilling programmes that serve their medium- and long-term human capital needs. These coordination efforts can be facilitated by regional cluster organisations, by local or city governments, or by large companies that want to strengthen the resilience of their supply chain.

This will require SMEs to be willing and able to cooperate and coordinate joint activities. It will also require local and city governments, cluster organisations or large companies to reach out to SMEs and help coordinate and get involved in strategies and initiatives in their city and region. These efforts may be expected to have impact on the medium and long term. Allowing SMEs access to current hiring and retraining practices of large companies in their vicinity may generate short-term results.

2.2.3.5. Workforce mobilisation

Individual workers have a substantial individual responsibility in their own lifelong skills journey. To put this responsibility to the fore, large employers can have a role in sensitising, mobilising and incentivising their workers to the reality and potential of continuous reskilling and upskilling, in facilitating widely recognised certification, and to organise reskilling and upskilling activities as close as possible to the workplace – both spatially and chronologically.

Sensitising, mobilising and incentivising – Employers can play an important role in reaching out to their workers and actively communicating and promoting the importance of continuous education and life-long learning through reskilling and upskilling activities. They can do this, for instance, through promotional campaigns and by making participation in reskilling and upskilling activities an every-day part of work scheduling, career planning and annual appraisals. Employers can also play an important role in incentivising their workers to participate in upskilling and reskilling activities. Incentives may include allowing employees to follow trainings during regular working hours, awarding bonuses or tying existing variable-pay elements to participation in upskilling and reskilling efforts, and organising upskilling and reskilling activities in a way that resembles secondments and sabbaticals – which appear to become increasingly popular in the professional occupations in Europe.

Reskilling and certification – In order for reskilling and upskilling activities to have as much value as possible both for individual workers and for labour markets overall, it is important for these activities to result in a certificate that is widely recognised. Preferably, such a certificate is recognised by employers across EU Member States and within several sectors for the knowledge and skills obtained are relevant. Such wide recognition increases the value of a certificate for individual workers, as with one certificate their labour-market value increases for several potential employers. Wide recognition also increases the relevance of a certificate for labour markets overall, as communicating and recognising the skills and experiences of potential workers becomes easier.

While they still have a job – To optimise the relevance of reskilling and upskilling activities, it can be important to conduct them while workers are still in employment. OECD statistics show that formal training and retraining of workers mostly happens on the job, where learning objectives can be tied to daily working practice and where learning outcomes directly can be applied to job tasks. Moreover, this report describes studies that show that employers appear to think attempts to reskill workers that are out of a job indicates low worker ability rather than the reverse.

As close as possible to the job – To organise reskilling and upskilling activities in a way that is efficient for individual workers and encourages high attendance, it can be important to host these activities as close as possible to where these workers do their job. This can mean to organise them on their working site or in close proximity to it, to organise them during or partly during regular working hours (or close to it), and in case of online courses to deliver them in an online environment that is specifically familiar to workers or that resembles one they are already familiar with.

This will require analysis of worker preferences and motivation in the area of reskilling and upskilling activities, establishment of accurate and widely recognised certificates and associated upskilling and reskilling standards, and innovative ways of organising continuous adult education. These efforts may be expected to have impact on the short term, especially where it concerns upskilling activities for current workers relevant to their job tasks. Sensitising, mobilising and incentivising workers may be expected to generate impact on the medium term, as these include social, psychological and organisational processes that will require some time to be adapted.

2.2.3.6. Third Party Financing

Financing projects and programmes for upskilling and reskilling large numbers of workers will require substantial sums over potentially long periods of time. Because of this, companies may consider attracting external funds from banks, angel investors, institutional investors and venture capitalists.

Bank loans – A rather straightforward way of attracting external funds for reskilling and upskilling programmes at companies is to loan money from a bank. This is particularly interesting for companies that do not have sufficient current assets to finance such programmes, yet do have the cash flow necessary to make periodic payments, and are sufficiently credit worthy.

Soft loans – For companies unable to shoulder interest payments or that are insufficiently credit worthy, government agencies and financial institutions may work together to generate soft loans for upskilling and reskilling activities.

Angel investors that revitalise micro companies – The current role of angel investors is to invest relatively modest sums in start-up companies, and to assist budding entrepreneurs through coaching and wisdom, oftentimes based on a successful business career. They can be envisaged to take on a similar role towards existing micro companies that face a skills challenge, by framing their skills challenge as an investment opportunity and counselling the owners and managers of micro businesses on how to recruit talent and reskill workers to prepare for the digital transformation of the European economy.

Institutional investors that reskill large companies – The large sums of money available to institutional investors, such as insurance companies and large-scale pension funds, can be invested in reskilling efforts of large companies and SMEs – provided a suitable ROI can be expected and at a very low risk. Especially large companies may benefit from exploring investment opportunities with their pension providers or insurers. The cost of specific company-wide reskilling efforts can be compared to expected productivity gains, and an analysis can be made on the foreseen return on investment. Moreover, as workers become more productive, their wages may increase and their pension contributions may rise accordingly, adding to pension fund solvency and future prosperity. SMEs may want to consider doing so in well-coordinated collaboration.

Venture capital involvement – If the productivity gains associated with reskilling and upskilling for high-tech and digital innovation are promising enough, venture capitalists may want to invest

in reskilling and upskilling programmes for medium-sized companies, and in reskilling and upskilling programmes for specific sites or departments of large companies.

These third-party financing solutions will require a method of calculating and forecasting the ROI on skills development investments. It may also require new management and governance models for skills development programmes that allow for involvement of and accountability to investors and financiers in the implementation and progress of upskilling and reskilling strategies. When these issues are addressed, third-party financing may be expected to generate impact already in the short term, freeing up much-needed financial resources for large-scale skill development programmes.

2.2.3.7. Innovative Learning Factory Infrastructures

Also as part of their skill strategies, companies can engage in collaborative efforts to develop high-tech learning infrastructures that allow students and workers to be trained, retrained and upskilled in actual high-tech environments. Innovative learning factories not only train technological skills relevant to advanced manufacturing and Industry 4.0, they also train communication, teamwork and management skills that are an important aspect of working as a T-shaped professional.

On top of providing excellent learning environments and preparing students and workers for future developments in high-tech and digital careers, this offers companies the opportunity to pilot specific equipment, hardware and software solutions, the opportunity to spot talents early and cherry-pick their future hires, and to draw individual participants into specific technology and innovation ecosystems.

These innovative learning factories will require substantial and continued investment, both in terms of time and in terms of funding. Together with regional and city governments, educators and cluster organisations, large companies in the high-tech and digital domain can form partnerships to develop, implement and invest in learning factory infrastructure. This may be expected to generate impact on the medium term.

2.2.4. Universities

In this section, we describe the role of universities in skills development for smart industrial specialization and digital transformation towards 2030. We describe the importance of universities to adapt their strategy to the skills strategies of cities and regions, and we discuss the importance of excellence in cooperative skills curricula facilitating the transition from theoretical knowledge to practical skills and the benefit of accelerated skills acquisition methodologies. Finally, we elaborate on the importance of the approach to be agile and of communicating the skills strategy.

2.2.4.1. Align with Territorial Skills Strategies

When governments, in collaboration with private sector parties and educational institutes, formulate 2030 skills strategies at the national, regional, and city level, universities will need to adapt their strategies to these territorial skills strategies. It will be important for universities to include the following elements in their strategy:

Adjusting research and education agendas – Universities should develop focused research agendas that are multi-disciplinarily and draw at the same time on the universities' vast expertise. Include research proposals that focus on a specific KETs and digital transformation related topic that cut across several disciplines. Universities should also adapt education agendas to the 2030 skills strategy and introduce high tech cross cutting skills development in the design of new

courses. Companies need to be involved in this process in order to adjust the agendas to employers' skills needs.

Experiment with curriculum and classroom education – Experiment with MOOCs, digital learning platforms and classroom sessions. Implement dual-track education so that students get workplace training next to their university courses. High-tech T-shaped skills education needs to be implemented trough cross-disciplinary curricula that combine different academic disciplines and stimulate collaboration between students from various backgrounds. In classroom laboratories, new teaching methods can be tested.

Educate 'the whole student' – Smart industrial specialisation and digital transformation demand for students with transferable and interdisciplinary skills. Universities should therefore adapt the curriculum to train these skills, in class or in a real-life working environment. This report provides a framework to train the workforce in skills that go from technical and academic skills to softer skills like problem-solving, multicultural openness, leadership, and managerial and interaction skills. The report proposes seven categories of skills development based on common patterns in KETs competences, and represent both the need for specialist (technical) skills and crosscutting skills.

These categories are technical skills in an adjacent technology domain; skills related to quality, risk and safety skills; management, leadership and entrepreneurial skills, communication skills, innovations skills, emotional intelligence skills and ethical skills. Students should also acquire so-called system knowledge, which are all knowledge areas pertaining to societal challenges that are facing Europe in the years to come. Top-of-mind societal challenges are areas such as the environment, energy, mobility, health and wellbeing, food and nutrition, security, privacy, and inclusion and equality.

Provide educational curricula relevant to workers in their 30s, 40s and 50s – This report highlights the importance of continuous education for working adults in an economy undergoing digital transformation and for technology domains relevant to smart industrial specialisation and Industry 4.0. It will be important for regional skills strategies to outline how this will be organised at the regional or city level. Subsequently, universities will need to provide educational curricula tailored to local needs of people already in work. This entails designing curricula that are both relevant in terms of content and structured in a way that fits with working life. Cooperation and dialogue between HR specialists and educators should result in clear insights in modular education that is relevant and practical for people in their 30s (who are often in the rush hour of life), 40s (who are typically disinclined to engage in intensive, multi-year programmes), and 50s (some of whom may be mentally preparing for retirement rather than reskilling).

Develop innovative ways to gain income – Universities should explore innovative ways to gain income in collaboration with companies and regional or municipal governments, and make this part of territorial skills strategies. When skills training initiatives are co-financed by companies and/or governments special attention should be paid to preserving academic freedom and the continuation of fundamental research.

Adopt flexibility in the curriculum – Universities should design programmes, curricula and courses in a business-friendly and flexible manner, in line with skills strategies and able to adjust to possible changes and updates in skills strategies or companies' skills need change over time. When curricula are changed to the needs of companies, special attention should be paid to preserving academic freedom and the continuation of fundamental research.

2.2.4.2. Cooperative world-class skills curricula

Some skills are difficult to develop in a classroom environment. This report describes that especially non-technical skills (e.g. communication skills and teamwork skills) can best be trained in real-world working situations. Therefore, on the job training is essential to facilitate the transition from theoretical knowledge to practical skills. To achieve this, universities should consider involving industrial partners, introduce dual-track education for transversal skills, enabling continuous education and retraining of the workforce and promote wide recognition of certificates.

Involving industrial partners –Universities can form partnerships with companies in the region or city to work jointly on curriculum and course design. This will allow universities to enhance the level to which their curricula prepare students for their first job.

Introducing dual-track education for transversal skills – Universities should introduce dual-track education, combining in-school classroom based education with workplace experience and on-the-job learning. This report describes the relevance of dual-track education to the transversal nature of high-tech crosscutting skills. Students can train non-technical skills (e.g. communication skills and teamwork skills) in real-work situations at companies where they are directly required. As the this report notes, dual track can take different shapes such as fully fledged apprenticeships, apprenticeships as a parallel track to other forms of VET, strong elements of work-based learning in school-based programmes and fully school-based VET. Universities can play a role in taking away preconceptions parents can have of dual-track systems, worrying that VET-tracks consign their kids to blue-collar jobs with limited prestige.

Enabling continuous education and retraining the workforce – World-class curricula that aim for reskilling and upskilling of highly educated workers will need to be structured in a way that makes attendance and participation practically feasible for working individuals in different career phases. This may well require an intricate combination of online learning opportunities, in-company training sessions, and university lectures. Consequently, design of such curricula will require close consultation between HR specialists, employers, trade unions and educators, to analyse which workers could benefit from what type of education, and how specific educational modules may be organised and implemented.

Promoting wide recognition – To prevent complexities around the mutual recognition of diplomas and certificates, universities should strive for improving EU-wide recognition. Universities could set up working groups, together with companies to set-up a pragmatic approach to recognition issues in the EU.

2.2.4.3. Accelerated Skills Acquisition Methodology

Young people entering universities are digital natives, meaning they were born and brought up during the age of digital technology. They think and process information differently from earlier generations and are used to other methods on how to learn and collaborate with the use of digital technologies. Therefore, it is recommended that universities experiment with innovative approaches for digitally enhanced learning. Digitally enhanced learning strategies need to focus on online curricula, new technologies in classrooms and adaptive learning.

Online curricula – The student experience will change in the coming years, as workers in their 30s, 40s and 50s will need to follow upskilling and reskilling courses, Universities should therefore work on cutting edge technology to provide for online curricula, enabling long-distance and flexible learning. These online curricula can take several shapes, for example, as Massive Open Online Courses (MOOCs) that are widely popular online (interactive) courses. Other methods to provide

for online curricula are filmed lectures, online readings, online learning environments and e-learnings. In the creation of online curricula, universities should closely interact with companies in order to design personalised and adapted courses or training programs to fit the exact skill shortage in companies.

New technologies in classrooms – Universities can experiment with new technologies in classrooms. Several new technologies will have on the shorter or longer term an impact on learning. On the short term, technologies such as enhanced simulation and games using virtual reality and 3D imaging can be introduced in classrooms. 3D imaging is for example already used in classrooms for anatomy education of first-year medical students where images are based on 3D reconstructions from actual patient data. Other technologies that can have an influence on education include artificial intelligence and machine learning that can generate new ways of assessing and supporting learners, using adaptive learning systems and automated assessment. An example of artificial intelligence implementation in a classroom is an existing app, used in some classrooms in the USA, which blends real math curriculum with a personalized teaching style.

Adaptive learning – Universities can start pilots with adaptive learning methods, which are methods adapting the content to the learner's needs for example by letting a digital platform adjust information based on a learner's previous responses. Adaptive learning gives learners their own personalized course, made specifically for their strengths, weaknesses and goals. Courses can be adapted in real-time to a learner's activity and adjusted to his performance and interest level.

Creating digitally enhanced learning requires universities to form multi-disciplinary teams, featuring faculty members and instructors as subject matter experts, as instructional designers, and as technology advisors. Universities should make use of available open educational resources with proven track records and prevent creating everything unnecessarily from scratch. To achieve this, universities can agree with international university partners on baselines for skills development.

2.2.4.4. Agility tool

As the World Bank concludes in a paper on how world-class universities apply their funds to retain their high status, world-class universities are constantly engaged in educational innovation. This means that, the approach towards the EU 2030 Vision must innovative and be able to adapt to the changing circumstances of new technology developments by deploying an agility tool. This includes promoting an innovative university culture, promoting an open university culture, monitoring company developments and needs, preventing fragmentation between faculties and departments within the university and develop responsive education.

Promote an innovative university culture – Universities need to stimulate the development of new and innovative teaching methods such as digitally enhanced learning, adjust curricula and stimulate teachers to acquire innovative teaching methods. This may impact teaching and testing methods, evaluation and reward systems for teaching staff, and accreditation of faculties and institutions.

Promote an open university culture – In order to maximise the potential for talent development, teaching high-tech T-shaped skills, upskilling and reskilling current workers, and preparing generations of high-tech workers for labour-markets in constant flux, universities will need to promote a university culture that is open to a highly diverse group of students and participants. This includes openness in terms of race, gender identity and sexual orientation, but also includes adopting communication techniques and pedagogical approaches and attitudes that

reflect the changes in current and future student populations – especially if current workers and professionals enrol in reskilling and upskilling programmes.

Monitor company developments and needs – Universities need to be aware of private sector developments and monitor closely the latest technological developments. Universities should closely monitor the insights from observatories and involve representatives from companies in the development of curricula and training initiatives. In order to provide for world-class curricula universities should analyse data to know what skills are needed for continuous education and upskilling and reskilling of the workforce and promote wide recognition of certificates. When universities collect large amounts of data of companies, students and other citizens, oversight by national data protection authorities is essential to protect the privacy of the data subjects

Prevent fragmentation between faculties and departments with the university – Faculties and departments within universities tend to operate independently. The creation of multi-disciplinary education needs to be improved, especially by stimulating collaboration and alignment between technology and non-technology faculties. Universities could develop a tool to map how faculties and curricula influence each other on skills development.

Develop responsive education – Education needs to be designed in a flexible manner to adopt to business needs and new technological developments, in line with skills strategies and be able to adjust to possible changes and updates in skills strategies or companies' skills need that change over time. Universities should further apply accelerated skills acquisition methodologies as new 'digital native' generations are used to other ways of processing and analysing information.

2.2.4.5. Communication

Universities can play an important role in communicating the national and regional skills strategies and align with all university members and raising general awareness on the importance of skills development in high-tech cross cutting skills and digital transformation.

In order to achieve large-scale effects, communication of the skills strategy needs to take place within larger targeted communication strategies, developed in collaboration with private sector parties and relevant stakeholders at multiple levels. Strategies should reach targeted audiences, including young people, parents, teachers, and society in general.

Universities can organise events at the university on key enabling technologies and other new technologies relevant to smart industrial specialisation and digital transformation. They can also need to set up campaigns to attract young people for studies and training in the technological domain, paying special attention to girls. Universities can support companies in advertising on-the-job training initiatives and job vacancies.

Communicating skills strategies, raising general awareness on the importance of high tech cross cutting skills development and advertising training initiatives can be expected to have impact on the short term.

2.2.5. Individuals

Individuals have agency when it comes to choices that impact their careers. Throughout this report, we have analysed structural factors and the role of stakeholders at multiple levels in the development of high-tech T-shaped skills for smart industrial specialisation and digital transformation. In this section, we focus on individual workers, describing how individual responsibility can be promoted, how opportunities can be created for worker mobility, how reward

systems can motivate workers to engage in adult education, and how credentialed world-class curricula can become a thing to aspire too for individuals.

2.2.5.1. Individual Responsibility

In order to engage individuals to do their part in identifying reskilling and upskilling opportunities and enrolling in educational tracks relevant to smart industrial specialisation and digital transformation, it is important to promote the roles and responsibilities that individual EU citizens and workers have in their own lifelong upskilling journey.

Raising awareness – Promoting the roles and responsibilities at the individual level can be done through targeted communication strategies that raise awareness on the rapid developments in high-tech and digital fields, how these impact economies at the regional and city level, what this means for current and future jobs, and how individual workers can anticipate on these changes. Expert communication agencies can be assigned to develop and implement communication strategies using both traditional mass media and online social media to raise this awareness.

Options and opportunities – Beyond raising awareness, it will also be important to communicate options and opportunities. To this end, dedicated websites can highlight educational pathways within a city or region for upskilling and reskilling in specific sectors and at specific levels. Individuals can use these websites to browse educational tracks and enrol or sign up. Also, these websites can host or direct to MOOCs and other online e-learning modules.

These activities may be expected to generate impact in the medium term, as influencing the behaviour and outlook of individual EU workers and citizens takes time and continued effort across stakeholder groups.

2.2.5.2. Internal and External Mobility

For individuals to pursue opportunities for upskilling and reskilling, they will need to be empowered to do so by their employers. This does not only mean allowing employees to follow trainings during regular working hours, awarding bonuses or tying existing variable-pay elements to participation in upskilling and reskilling efforts. It also entails organising upskilling and reskilling activities in a way that resembles secondments and sabbaticals – which appear to become increasingly popular in the professional occupations in Europe.

Similar to the European Commission's Erasmus student exchange programme, large employers and city and regional governments throughout Europe can work together to develop pan-European worker exchange programmes. Within such a programme, workers would be able to go on secondment, effectively being temporarily reassigned to a different company (externally) or a different department within a large company (internally), with upskilling as the main goal.

The outline of such a programme would best be developed in tandem with regional skill strategies and corporate skills strategies. Cluster organisations may play a coordinating role in bringing together key actors from the public and private sector at the regional level, and in liaising with other regions throughout Europe to identify exchange opportunities and facilitate temporary reassignments. This interaction with regional and company-specific skills strategies entails that impact from these mobility mechanisms may be expected at the medium term.

2.2.5.3. Reward Systems

For EU citizens and workers to become enthusiastic about upskilling and reskilling and take on their roles and responsibilities as actors with agency, in charge of their own working life and career progression, it important to ensure that upskilling and reskilling indeed is rewarding. To this end,

credible and well-targeted reward systems should be in place throughout European labour markets, so that an individual's reskilling and upskilling efforts pay off. These reward systems may be implemented at company level, or at regional or city level.

Credibility at company level – To build and maintain credibility at company level, it will be important for upskilling and reskilling activities to be organised (partly) during regular working hours. This directly sends the message that employers also believe this is time well spent. To make upskilling and reskilling activities appear rewarding, employers may consider designing variable-pay elements for participation in upskilling and reskilling efforts. Most important of all is that successfully completing upskilling and reskilling activities is translated into tangible career improvements.

Tax facilities at regional and city level – At the regional and city level, upskilling and reskilling can be made rewarding through tax facilities that promote and encourage enrolment in educational tracks for upskilling and reskilling in areas relevant to smart industrial specialisation and digital transformation. To make sure that the coverage and scope of these facilities is defined accurately, these facilities should be coherent with regional skills strategies. Specifically, these tax facilities may cover:

- Tuition and/or enrolment fees;
- Cost of educational materials (e.g. specific software licenses, reading materials, or hardware);
- Costs for travel to and from educational sites (e.g. for visits to a regional learning factory)';
- Costs for child-care services during hours directly attributable to training activities.

Having credible and well-targeted reward systems may directly on the short term stimulate EU workers and citizens to actively seek out upskilling and reskilling opportunities that are highly relevant to the changing European economy.

2.2.5.4. World-class curricula

Another vital precondition for motivating EU citizens and workers to commit time and energy for intensive reskilling and upskilling, is to make sure that sufficient and adequate supply exists in world-class reskilling and upskilling programmes, and that they have the tools to communicate the value of having completed these programmes to potential future employers.

Sufficient and adequate supply – Steps will need to be taken to ensure that individuals looking for upskilling and reskilling opportunities can find high-quality educational providers that are capable of translating state-of-the art theoretical knowledge to practical skills that can be applied to job tasks. This has a qualitative dimension, which challenges educators, regional and city government, and large employers to design and develop well thought-out curricula. This has also a quantitative dimension, which challenges these stakeholders to ensure supply can meet demand without waiting lists or periods (which can cause frustration and reduce motivation), and without over-crowded educational tracks (which can significantly reduce quality).

Certification and credentials – As described earlier in this report, certification of upskilling and reskilling activities in a manner that is broadly recognised effectively increases the value of these activities, both for individual workers and for labour markets on the whole. In practical sense, it helps individuals communicate their upskilling and reskilling results to their current employer and to any potential future employers. Moreover, as certificates and credentials become better known

and higher valued, they become something to aspire too, to make savings for and to invest in personally and individually.

Combined with well-targeted reward systems, generating sufficient supply of world-class reskilling and upskilling programmes may generate results in the short term. Still, considering the amount of work still to be done and effort still to be committed to the real-world realisation hereof, serious impact may be expected on the medium and long term.

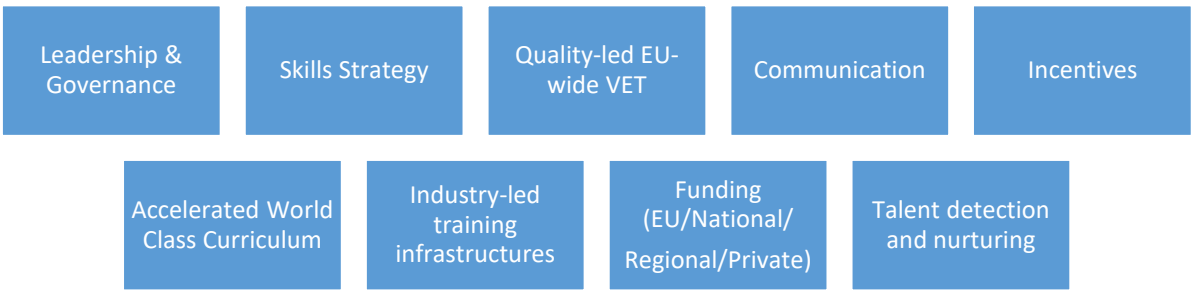
SECTION III – POLICY RECOMMENDATIONS

3. POLICY RECOMMENDATIONS

3.1. Introduction

This section of the Final Report will present a set of policy recommendations subdivided into 9 modules to **facilitate the implementation of the Skills for Industry Strategy 2030** as it has been developed over the course of the skills for smart industrialisation specialisation and digital transformation mission.

Figure 5. The policy recommendation modules



Source: PwC Analysis

The recommendations have been build following an in-depth analysis of the current state-of-play on strategies, policies and initiatives smart industrialisation and digital transformation in Europe, the state-of-play on strategies, policies and initiatives on high-tech t-shaped skills in Europe, the best practices report as well as the comparison of the high-tech skills situation between USA and EU. Furthermore, all recommendations have been discussed with experts from the field through the Expert Workshops organised.

The policy recommendations proposed encourage the **development of forward-looking, dynamic, interactive, multi-stakeholder driven and agile upskilling initiatives** that leverage on **real-time AI-based labour market assessments** and foresight tools for **evidence-based decision-making**. They underline the need for a data and technology driven industry strategy and highlight the need for motivated and engaged leadership.

The modules developed further serve to **guide** different stakeholder groups on developing **and implementing their own skill strategies aligned with their industrial, research and innovation strategies for smart specialisation initiatives**. They offer food-for-thought and aim to encourage a wider debate on Europe's growing skills gap and how to meet the industry's need for workers with the necessary high-tech skills to drive innovation.

Overall, the following three key recommendations should be consulted with the greatest attention and should build the foundation for future debates and efforts on the implementation of the Skills for Industry Strategy 2030:

- A **multi-level motivated leadership** needs to be defined at European, national, regional and city level to allow for a most promising environment for the development of territorial skills strategies.
- The **clear identification of territorial strategies** will be crucial for the alignment of re/upskilling initiatives and will facilitate the allocation of funding/investments necessary.
- The re/upskilling of Europe's workforce will require **significant investments**. The urgency and importance of revolutionising Europe's skills system to ensure Europe's competitiveness needs to be widely understood and the necessary investments made.

The implementation of the Skills for Industry Strategy 2030 requires the active engagement of all stakeholders and will introduce a paradigm shift from 'lifelong employment' to **'lifelong employability'**. The education and training ecosystem will have to be fundamentally revised and the public actively included in the re/upskilling of Europe's workforce. Only by tackling Europe's growing skills gap, can the competitiveness of Europe's industry be strengthened and secured.

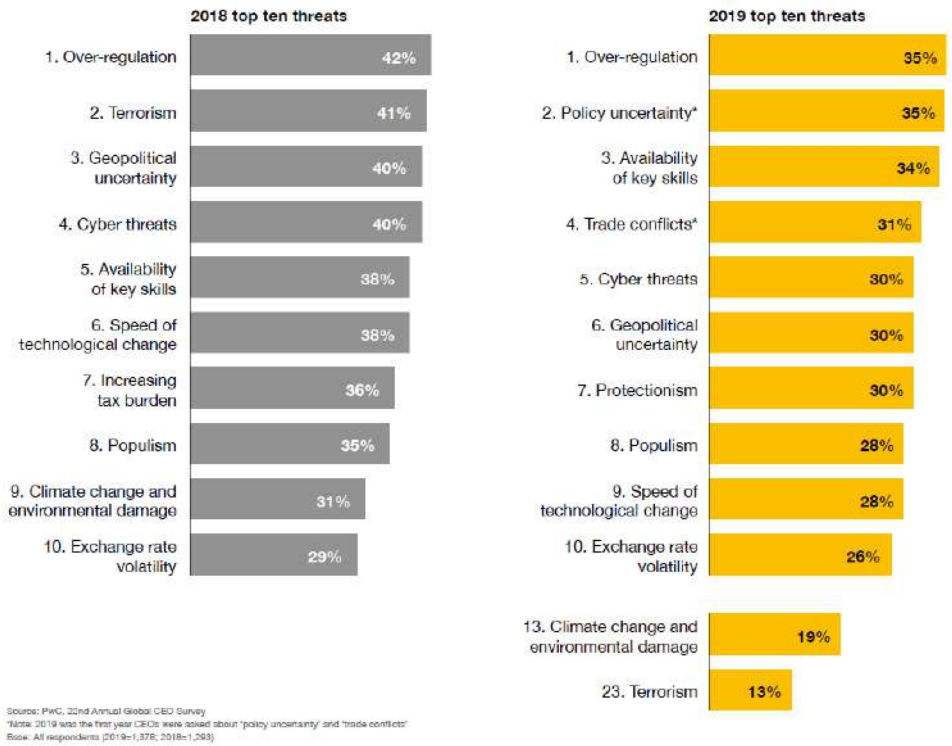
3.2. Recommendations per Module

This section of the report will discuss each module in detail and highlight the key recommendations developed over the duration of the programme. Each module was developed in close collaboration with key stakeholders in the field in line with the collaborative and inclusive design approach set out in the Skills for Industry Strategy 2030.

3.2.1. Module 1 – Leadership and Governance

Member States often **lack 'Skills Champions'** that could lead them in the definition and implementation of their territorial skills strategies. The speed with which new technologies emerge and affect the way we work and live is unprecedented. CEOs and industry leaders are well aware of the risk the growing skills gap poses for the continued competitiveness of their businesses. In fact, the availability of key skills ranks among the **top ten global threats identified by business owners to their organisation's growth**. Yet, 46% of C-suite executives lack knowledge of what skills will be needed in the future[13]. Member States may find it even more difficult to develop comprehensive skills strategies as they struggle to assess the needs of the workforce and labour market.

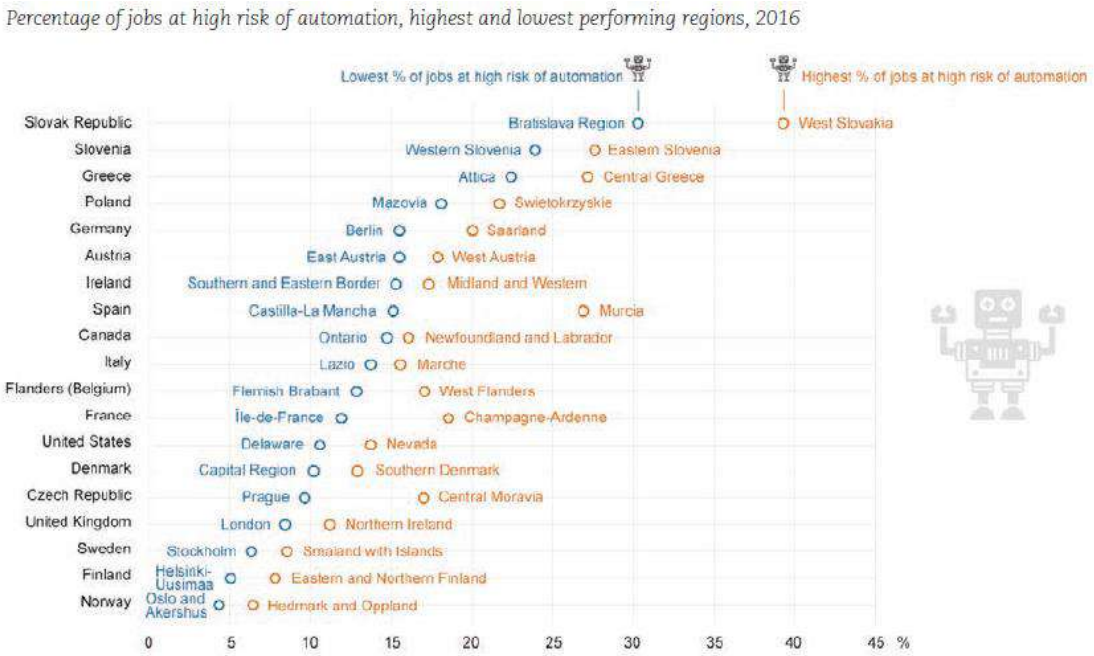
Figure 6. Top 10 threats to business growth



[13] https://www2.deloitte.com/content/dam/insights/us/articles/GLOB1948_Success-personified-4th-ind-rev/DI_Success-personified-fourth-industrial-revolution.pdf

Each territory/region faces specific skills challenges and gaps based on the demographic of its population, its industrial base as well as its historical specialisations. As stated by the OECD (2018), the risk of job loss due to automation can vary over nine-fold depending on the regions or local communities assessed[14]. Even within-country variations between regions are common. Some regions are better at shifting their workforce towards jobs at lower risk of automation than others, which can further enhance existing inequalities.

Figure 7. Share of jobs at high risk of automation across OECD regions[15]

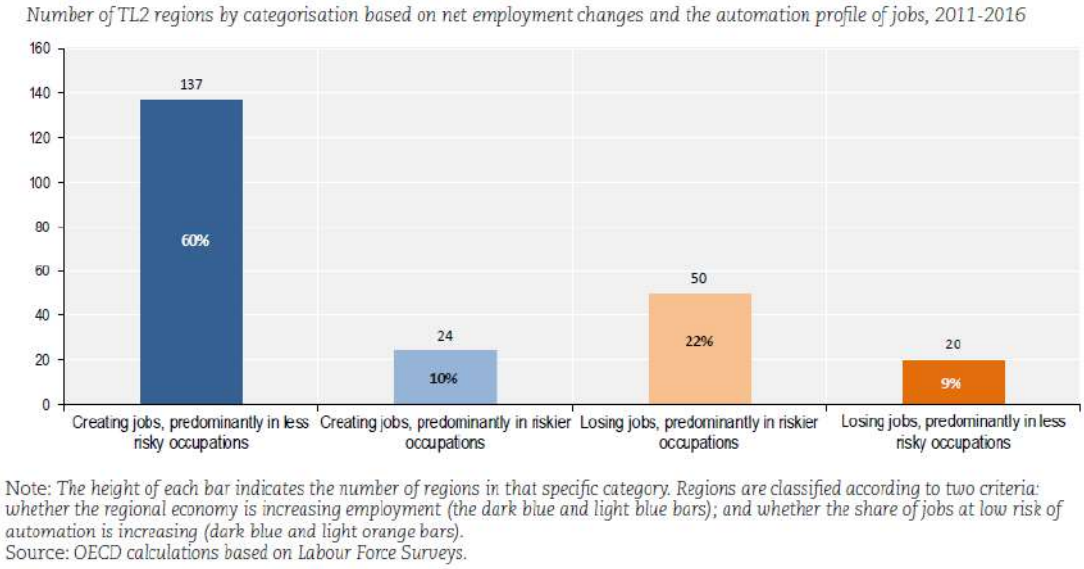


Note: OECD TL2 regions in selected OECD countries. High risk of automation refers to jobs with over 70% of risk of being automated.
Source: OECD calculations based on Labour Force Surveys.

Stakeholders of different industries, regions or nations often tend to address the challenges identified irrespective of the efforts of others in the field, as they try to find a solution to their daily struggles. This leads to conflicting or misaligned initiatives that focus on short-term gains rather than long-term sustainable skills solutions. These mismatches ultimately lead to deeper divisions between stakeholders and tend to exasperate the skills gaps identified.

[14] http://www.oecd.org/cfe/leed/LEED-Flagship-Policy-Highlights.pdf
[15] http://www.oecd.org/cfe/leed/LEED-Flagship-Policy-Highlights.pdf

Figure 8. Differences in how regions shift towards jobs at lower risk of automation[16]



3.2.1.1. Definition of Skills Leaders

The successful implementation of the Skills for Industry Strategy 2030 requires **motivated leadership and a clear governance structure**. All actors involved at the city, regional, national and EU-level need to be assigned a **distinct set of roles and responsibilities** to assure the execution of comprehensive skills strategies.

This report suggests the definition of the following 3 key roles:

- Vice-President for Skills of the European Commission
- National Minister for Skills
- Regional Skills Leader

The ***Vice-President for Skills of the European Commission*** would be tasked with the development and execution of the EU's overarching skills strategy. The Vice-President, in collaboration with a dedicated team of experts, would define the high-level skills priorities of leading EU industries and ensure the analysis of corresponding market trends and skills gaps. The data collected using high-performing state-of-the-art AI tools, will be key for the development of territorial skills strategies and will allow for the broader assessment of workforce and labour market trends in Europe. Activities at the European level should further concentrate on supporting the growth of leading skills hubs and/or best practices to encourage the development of key skills and world-renown areas of expertise.

At the national level, a dedicated ***Skills Minister*** should be defined. The introduction of a Ministry of skills represents a shift in paradigm from lifelong employment to lifelong employability. In Ireland, for example, the Department of Education and Skills supports individuals along their learning journey with the aim of helping them achieve their full potential and thus contribute to Ireland's social, cultural and economic development. To achieve its mission, the department developed the National Skills Strategy 2025 – Ireland's Future. A further example of motivated skills leadership at national level can be seen in the case of the Luxembourg Digital Skills Bridge programme that was introduced by the Ministry of Labour, Employment and the Social and Solidary Economy. Following the consultation of national employers, trade unions, and numerous chambers,

[16] http://www.oecd.org/cfe/leed/LEED-Flagship-Policy-Highlights.pdf

a comprehensive upskilling programme was developed and tested to facilitate the continuous re/upskilling of the local workforce and fulfil the skills needs of local industries.

Box 1. Ireland's Department of Education and Skills and its National Skills Strategy 2025[17]

As part of the Action Plan for Jobs 2015, the Department of Education and Skills has developed a new National Skills Strategy 2025 – Ireland's Future.

The strategy was developed in the context of significant reform in the education and training sector to ensure a more dynamic, responsive and high quality system that provides all learners with the knowledge and skills they need to participate fully in society and the economy.

The skills strategy is complemented by a national and regional skills architecture that enables collaboration and effective implementation. Robust intelligence will underpin the Strategy's implementation and inform resourcing allocations. Prioritisation of skills needs will be overseen by the new National Skills Council. The new Regional Skills Fora will facilitate ongoing employer-educator dialogue to match identified needs with sustainable provision in each region, thereby optimising the return on Irish investment in education and training.

Initiatives will be monitored by existing mechanisms and regular impact evaluations. These will be complemented through the tracking of identified key national and international skills indicators.

The cumulative intent is to ensure that Ireland's people develop and use their skills to their maximum potential through sustainable employment and civic participation.

The National Skills Council and the Regional Skills Fora will be supported by The Department of Education and Skills, which will oversee the implementation and collaboration between different governance levels. This initiative is a good practice for a proactive Ministerial body that pushes the national skills agenda forward, including through the formulated strategy.

Source: National Skills Strategy 2025 Report

As these cases demonstrate, traditional education and labour ministries have to be reimagined and their activities re-aligned to allow for the active implementation of territorial skills strategies. Ideally, the Prime Minister should be identified as the Skills Minister to underline the centrality of this centre of activity to the wider national priorities and strategies. Skills represent the key factor influencing the future prosperity and competitiveness of Europe's industry and should thus be at the heart of political activity.

[17] For more information, please refer to: Department of Education and Skills, 2016, *Ireland's National Skills Strategy 2025,* Department of Education and Skills , accessed 04 June, <https://www.education.ie/en/Publications/Policy-Reports/pub_national_skills_strategy_2025.pdf>

Box 2. Luxembourg Digital Skills Bridge[18]

The Ministry of Labour, Employment and the Social and Solidarity Economy launched the Luxembourg Digital Skills Bridge programme in 2018, a pilot project aimed at employees whose positions are changing or at risk due to digital transformation.

The programme strives to anticipate the impact technological developments will have on the skills of employees and employment in general. Following an in depth strategic workforce planning exercise, companies and their employees are accompanied through the required upskilling efforts. The current skills of employees are assessed and the existing skills gap evaluated. Then the newest state-of-the-art trainings are selected to help the employee bridge the skills gap between their current and future position.

To further ensure the successful completion of the upskilling journey, specialised advisors accompany the employees throughout the process to ensure they fully understand the philosophy of the programme and to encourage a shift in mind-set in line with the upskilling process.

In 2018, 20 companies applied to the programme, with 11 being selected to participate to the pilot. Businesses of all sizes and from various sectors were accepted and are currently undergoing the upskilling process. Of these participating companies, 9 businesses will upskill their employees for internal mobility exclusively, demonstrating their need for skilled talent as well as the value of retaining the knowledge these employees already have of the business within the company. At the end of the pilot over 300 employees will have been upskilled.

As a key takeaway, governments should assume a leading role in encouraging companies, especially SMEs, to invest in the skills of their employees and to adopt a pro-active upskilling approach. Corresponding incentives should be developed and implemented.

For more information, please refer to the Best Practices section.

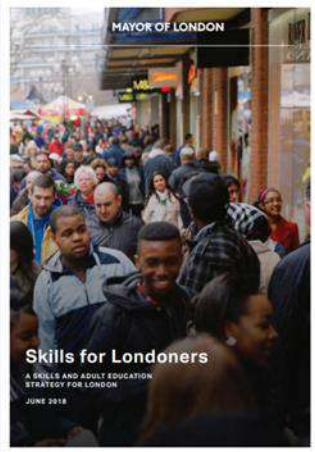
To facilitate the implementation of national skills strategies, **regional skills leaders** should be named to ensure the adaptation of the activities/initiatives developed to local needs and priorities.

Skills gaps vary depending on the industries, specialisations and demographics present in each region. Local actors have a deep understanding of the challenges and needs faced by their population and will be able to ensure the introduction of territorial skills strategies that best meet all requirements. Sadiq Khan, the current mayor of London, set out a dedicated skills vision for a skills system that is tailored to the exact needs of London's businesses and population. Closely linked to the Economic Development Strategy of the city, the city of London aims to strengthen the competitiveness of its local industry, upskill its resident workforce and ensure the continued growth of the city. The continued efforts being made to the reform of the local training and education system underline the positive effect a dedicated local leadership can have on the advancement of territorial skills strategies.

By identifying skills leaders at each governance level, top-down as well as bottom-up skills initiatives can be easily introduced, aligned and promoted. Motivated leaders are crucial to driving the review of Europe's skills system and to implement the Skills for Industry Strategy 2030.

[18] For more information, please also refer to: Skills Bridge, 2019, Le Gouvernment du Grand-Duché du Luxembourg, accessed 04 June, <https://www.skillsbridge.lu/>

Box 3. Skills for Londoners Strategy[19]



Source: Skills for Londoners Report

The Skills for Londoners Strategy aims to create a single, integrated skills and adult education offer for London that delivers a comprehensive and strategic post-16 education training strategy.

Three key priorities stand at the heart of this effort – the need: (1) to empower all Londoners to access the education and skills to participate in society and progress in education and work; (2) to meet the needs of London's economy and employers now and in the future; and (3) to deliver a strategic city-wide technical skills and adult education offer.

To support the active implementation of the strategy, a Skills for Londoners Framework was published in 2018. It outlines how the objectives of the strategy will be delivered through the devolution of the Adult Education Budget (AEB) in London to the Mayor from the academic year 2019-20, transferring responsibility from the Department for Education for the delivery of adult education provision to London's residents.

In general, the Strategy has been defined and will be implemented under the leadership of the Mayor of London, who essentially acts as a regional skills leader, aware of the local specificities and close enough to implement the solutions.

For more information, please refer to the Best Practices section.

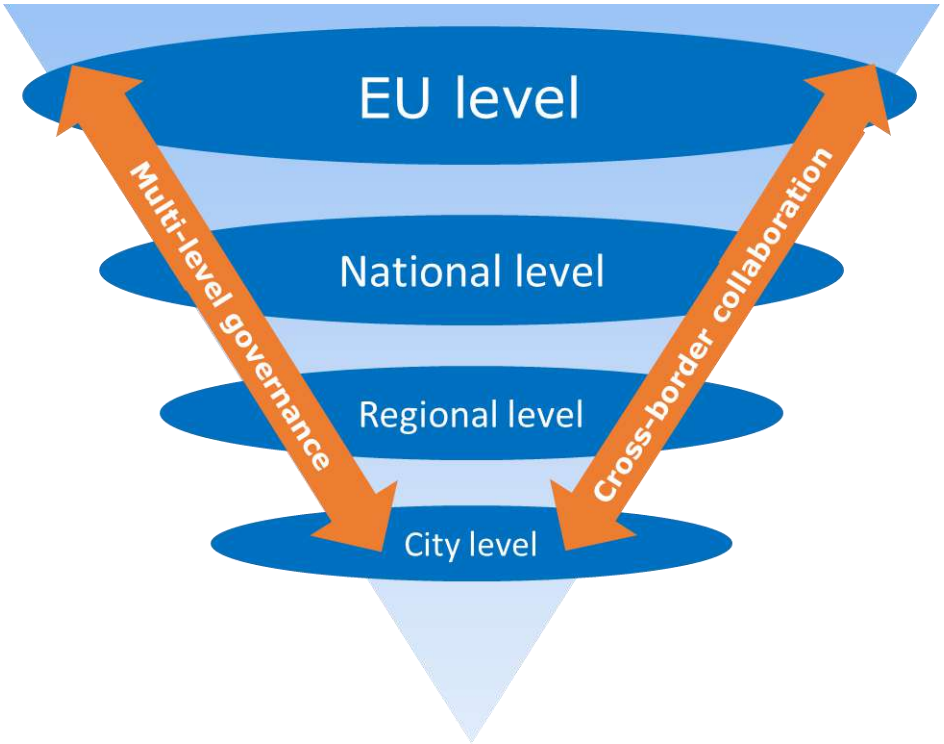
3.2.1.2. Set-up of Territorial Skills Councils

To facilitate collaboration between regional skills leaders, skills ministers and the Vice President for Skills of the European Commission, **Territorial Skills Councils** could be introduced. The main objective of the Territorial Skills Councils would be align the efforts of all leaders involved to ensure the development and implementation of a comprehensive and holistic **Territorial Skills Strategy**. The Territorial Skills Council would actively **facilitate the implementation of short-, medium- and long-term upskilling initiatives**.

Members of the Territorial Skills Councils should include industry representatives, representatives from the educational system, trade union spokespersons, as well as local cluster representatives. Simultaneously, the structures defined should remain **agile, independent** and **well financed**. The development and operationalisation of territorial skills strategies will require significant investments and the necessary funds need to be made available to allow the Territorial Skills Councils to actively contribute to Europe's skills development plan. By bringing together all stakeholders concerned under a clear motivated leadership, Territorial Skills Councils will facilitate the implementation of the Skills for Industry Strategy 2030.

[19] For more information, please also refer to: Mayor of London, 2018, *Skills for Londoners - a skills and adult education strategy for London*, Greater London Authority, accessed 04 June, <https://www.london.gov.uk/sites/default/files/sfl_strategy_final_june_20186.pdf>

Figure 9. Envisioned governance structure



Source: PwC Analysis

3.2.2. Module 2 – Territorial Skills Strategy

"In our rapidly digitalising world, skills make the difference between staying ahead of the wave and falling behind…..To help people, governments will need to find the right balance between policies fostering flexibility, labour mobility and job stability. Businesses have also a key role to play in ensuring that employees upskill and reskill, adapting to the changing demands of the labour market. By improving our skills systems, we can ensure that today's technological revolution will improve lives for all. – OECD Secretary-General Angel Gurría"[20]

As mentioned above, many Member States **miss comprehensive Territorial Skills Strategies,** as their leadership is unaware of the growing skills gap marking Europe's labour market or do not possess the means to assess the skills needs of their local industries.

Some underestimate the impact disruptive technologies will have on existing business models and manufacturing services across the value chain. Connected vehicles and autonomous driving, for example, have emerged as major driving factors of automotive digitalisation. Yet, Europe is lagging behind the US regarding the introduction of digital platforms crucial to managing and controlling the vast amounts of client data collected.

Others lack guidance on how to develop comprehensive skills strategies or would like clear common guidelines at EU-level on how to proceed. According to the *2019 OECD Skills Outlook*[21], very few countries are prepared to reap the benefits of digitalisation fully, lacking the skills and lifelong learning systems necessary to allow their population to thrive in the digital world. Their analysis finds that only a few countries, including Belgium, Denmark, Finland, the Netherlands, Norway and Sweden, have made the necessary investments to strengthen their population's skills portfolio and provide them with sufficient opportunities to continuously upskill their competences. Most Member States thus miss sufficiently developed skills strategies to drive their workforce's future development and strengthen its competitiveness.

Furthermore, data-driven AI-tools that would allow for the continuous assessment of market/skills developments are widely missing and are required for evidence-based decision-making. Member States need to be able to access real-time data on the European skills trends as well as national/regional developments to continuously adapt their re/upskilling efforts. The implementation of skills strategies in line with industry needs requires the **continuous adjustment of the trainings offered** to **ensure that the workforce remains sufficiently trained to drive innovation** and possesses knowledge of the latest state-of-the-art technologies/services.

3.2.2.1. Definition and implementation of Territorial Skills Strategies

Member States should be encouraged to develop comprehensive **Territorial Skills Strategies** to ensure the continued competitiveness of Europe's industry. Europe's workforce needs to be equipped with the right skills and given access to cutting-edge trainings to be able to drive innovation across Europe.

Led by the Territorial Skills Councils presented above, the skills strategies developed should set **clear, measurable and achievable objectives with strict deadlines** to allow for timely

[20] http://www.oecd.org/skills/governments-should-step-up-their-efforts-to-give-people-skills-to-seize-opportunities-in-a-digital-world.htm
[21] https://read.oecd-ilibrary.org/education/oecd-skills-outlook-2019_df80bc12-en#page20

implementation. They should be based on **concrete data and information** that will allow policy makers to assess future skills trends in the next 3, 5, 10 years.

Furthermore, all strategies developed should be mindful of the latest **developments in key technological areas** (e.g. AI, robotics, nanotechnologies etc.) and align with the RIS3 strategies previously identified. Local actors need to be given the right tools and advice to upskill their workforce. Additionally, facilitators should be identified to assist businesses in developing their own corresponding internal skills strategies.

Box 4. Smart Specialisation Strategy[22]

Smart specialisation is an innovative approach that aims to boost growth and jobs in Europe, by enabling each region to identify and develop its own competitive advantages.

Through its partnership and bottom-up approach, smart specialisation brings together local authorities, academia, business spheres and the civil society, working for the implementation of long-term growth strategies supported by EU funds.

It aims to be:

Smart – place-based approach to identify the region's own strengths and comparative assets;

Specialised – Prioritise research and innovation investment in competitive areas;

Strategic – Define a shared vision for regional innovation as well as a sound monitoring and evaluation system.

Source: European Comission, Strengthening innovation in Europe's regions factsheet

As showcased by the Portuguese National Skills Strategy, the successful development and implementation of territorial skills strategies requires cross-ministerial collaboration, the close consultation of stakeholders, and a strategic approach to skills policies as introduced by an OECD support team. A quadruple helix model as adopted in the case of Finland's 6 Aika might serve as further inspiration regarding the definition and implementation of territorial skills strategies through the joint efforts of multiple stakeholders and across cities/regions.

[22] For more information, please refer to: Smart Specialisation Platform, 2018, European Commission, accessed 04 June, < http://s3platform.jrc.ec.europa.eu/home>

Box 5. Portugal – Building a National Skills Strategy[23]

REPÚBLICA PORTUGUESA
EDUCAÇÃO

The Portuguese National Skills Strategy, developed by the cross-ministerial Portuguese National Project Team with the support of the OECD, is built on the in-depth analysis of the existing education system and the skills gaps noted.

The OECD Skills Strategy initiative provides a strategic approach to skills policies to strengthen countries' skills strategies through the coherent development, activation and effective use of skills. Its objective is to promote economic prosperity and social cohesion, reflecting a strong focus on 'lifetime employability'.

The Portuguese project started in 2014 with a diagnostic phase that included numerous workshops and stakeholder consultations, and resulted in the 2015 Diagnostic Report that identified key challenges to be addressed by Portuguese policy-makers.

The key challenges identified for Portugal and which are critical to an effective skills system were around:

- Developing relevant skills;
- Activating the supply of skills;
- Using skills effectively;
- Enabling conditions.

In line with this initiative, the Portuguese government launched a number of concrete actionable programmes between 2014 and 2018, which resulted in the reduction of school dropouts in basic and early education and decreased the number of students leaving education early. Furthermore, a significant decrease of youth unemployment, an increasing number of adults in qualification programmes (20,000 to 110,000), and an increase in students entering higher education could be noted.

For more information, please refer to the Best Practices section.

Lastly, the Territorial Skills Strategies should be aligned to the key characteristics defined in the Skills for Industry Strategy 2030 and address the following themes in particular:

- The development of new world class curricula allowing students to gain the skills required by industry ;
- The review and modernization of VET available to encourage innovative thinking ;
- The development of territorial methodologies/systems/infrastructures to facilitate the detection and nurturing of talent ;
- The increased introduction of industry-led training infrastructures and their opening to the wider public to facilitate the sharing of knowledge ;
- The introduction of programmes targeting the needs of specific demographics (e.g. women, NEETs, elderly, migrants etc.)
- The continuous assessment of the effect major external factors such as Global Warming, economic downturns and technological revolutions will have on the skills required by the workforce.

[23] For more information, please also refer to: OECD Skills Studies, 2018, *Skills Strategy Implementation Guidance for Portugal,* OECD, accessed 04 June, <https://www.oecd.org/publications/skills-strategy-implementation-guidance-for-portugal-9789264298705-en.htm>

Box 6. 6Aika – The six city strategy [24]

6Aika - open and intelligent services - is a flagship joint development strategy focused on the sustainable urban development of the six largest cities of Finland which are home to almost 30% of Finland's overall population (Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu). The strategy covers the period 2014-2020 and aims to create new competences, businesses and jobs in Finland.

The strategy is based on co-operation between municipalities, companies, citizens, and universities in a quadruple helix model. A joint management team and steering group have been set up, consisting of directors from the six cities, to coordinate and monitor the strategy, while the implementation is conducted by the Six Cities Strategy Office which includes city-specific coordinators.

Given the broad scope of developed projects in urban development, four training and education-related projects have been approved, with a specific focus on smart learning solutions and training citizens in innovative sectors. With schools acting as platforms for innovation and experimentation, a strong collaboration can lead to better products and, in turn, better learning outcomes.

Moreover, teachers actively participate in the pilot projects, and can offer valuable input, while pupils can familiarise themselves with the new technologies.

The other three projects, called Digipore, Game Time and PoraKONE, are pilot initiatives trying to increase employment and improve the skills in the technology, gaming industry and engineering industries, respectively. All three projects offer trainings and career advice based on company needs, as well as acting as platforms for more ongoing discussion.

For more information, please refer to the Best Practices section.

Source: Retrieved from <https://6aika.fi/in-english/>

3.2.2.2. Increased cross-border collaboration

Increased cross-border collaboration is necessary to **expand on existing synergies between regions** and facilitate the active implementation of Territorial Skills Strategies. Industries and areas of specialisation are not geographically bound and increased collaboration on the provision of trainings and VET across borders should be encouraged.

As demonstrated by the introduction of EU-level clusters (e.g. Silicon Europe), the exchange of knowledge and best practices can be highly beneficial to local industries. The same concept applies to the development and implementation of skills strategies. Industrial needs might align cross-border and should be tackled in a collaborative manner. The territorial skills strategies developed by the corresponding Territorial Skills Councils should therefore include common initiatives or programmes. Smaller regions especially might benefit from the set-up of a close collaborative relationship with their neighbouring Territorial Skills Councils to facilitate the provision of programmes and allow for the shared split of costs.

[24] For more information, please also refer to: 6Aika, 2019, accessed 04 June, < https://6aika.fi/in-english/>

Box 7. Silicon Europe[25]

Silicon Europe is an alliance of twelve European clusters that unites the most advanced technologies and expertise in all fields of the electronics and software value chain.

The established meta-cluster has the goal to support Europe's objective to become the world's leading centre for innovative electronics and software technologies. It is the platform and brand under which the leading European electronics and digitisation clusters in different EU countries collaborate to represent, support and promote primarily SMEs and the organisations of their regional business networks at European and global levels.

The alliance operates along the following five main themes, formulated in the Joint Action Plan (2016-2018):

- Knowledge and technology transfer – organise fairs, map knowledge sources, support human capital development, and encourage SMEs to use existing and new platforms/labs;
- Smart specialisation – support the creation of regional field labs, develop new approaches to build interregional value chains, establish a platform for best practice exchange, and support cross-regional cooperation;
- SME funding – act as an intermediary between SMEs and financing opportunities, organise events to attract investors, support SMEs and investors in assessing risks and needs, identify accelerator, and contribute to designing SME financing schemes;
- International business development – support primarily SMEs in foreign market entries (focus on the US and Taiwan), and attract foreign capital not present in Europe.
- Promotion of micro- and nanoelectronics – create case studies promoting the role and the entire value chain, encourage companies to explain their role to a broader audience, and communicate the strengths of the European semiconductor industry.

For more information, please refer to the Best Practices section.

Source: Retrieved from <https://www.silicon-europe.eu/home/>

3.2.3. Module 3 – Dedicated funding for re/upskilling

The continued re/upskilling of the European workforce will require significant financial support at all levels (EU, national, regional and city) and rely on public as well as private initiatives. An estimated **20% of the European workforce** will have to be upskilled in the coming years, costing between **EUR 500M. and EUR 1T. over the next 5 years**. To finance these upskilling efforts, existing funding schemes will need to be reviewed and new funding solutions developed.

At present, general **limited awareness of existing EU funds** and on how to leverage on them for re/upskilling efforts hinders the accelerated uptake of upskilling solutions. At the same time, many different schemes with varying purposes and eligibility criteria exist. Yet they often lack a clear entry door that would ensure their widespread utilisation.

In other instances, the accompanying **guidelines and criteria to respect** might be **too restrictive** to allow for their use by innovative approaches. Often regional leaders, clusters, and

[25] For more information, please also refer to: Silicon Europe, 2019, accessed 04 June, < https://www.silicon-europe.eu/home/>

business owners struggle to find the information they need to apply for the funding schemes available or do not possess sufficient resources to complete the entire application process.

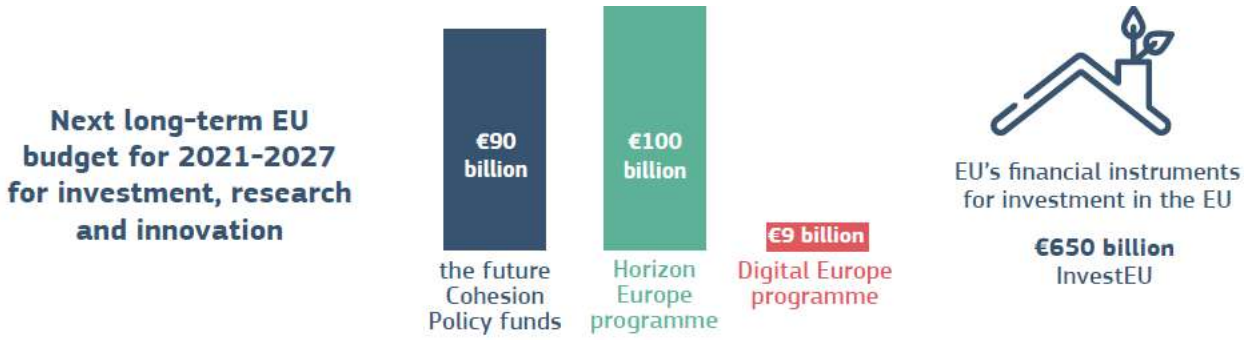
Pre-financing mechanisms are often missing and private funding needs to be leveraged on. Finally, the general public still considers skills an 'intangible asset' that cannot be invested in or does not offer a clear return on investment (ROI). A shift in the way society sees skills and their centrality to the continued competitiveness of Europe's industry thus needs to be encouraged and facilitated.

3.2.3.1. Review and expansion of existing European and national funding schemes to support upskilling and lifelong employability

The European Commission is strongly committed to securing the continued employability of the European workforce and thus strengthen the competitiveness and growth of Europe's industry. To this end, the Commission continues to make large sums available to support measures, initiatives, activities and projects aiming at developing the education system, up/reskilling the workforce and strengthening the labour market.

In its proposal for the next long-term EU budget for 2021-2017, the Commission also foresees to invest heavily in industrial innovation. It proposed to increase funding for investment, research and innovation significantly as shown in the below figure.

Figure 10. EU Investment geared at industrial innovation[26]



An increasing number of funding schemes have thus been developed to tackle the European skills gap. However, these initiatives are often led by different actors, which results in a number of activities with similar objectives and differing structures.

Existing investment tools need to be reviewed to allow for the successful set-up and implementation of Territorial Skills Strategies. **Dedicated upskilling funding programmes** should be set-up and used with the sole intention to support the upskilling and lifelong employability of Europe's workforce. The development and rollout of new skills strategies and programmes will require the provision of dedicated funds and investment tools that will allow regions, industry-leaders as well as individuals to invest in their skills and ensure the adoption of the lifelong learning mind-set. Finally, **new pre-financing mechanisms** that will allow smaller businesses and SMEs in particular to upskill their workforce should be established.

To align efforts and thus improve the efficient use of funds available, a **dedicated working group** should be set up, representing each fund and directorate generate (DG) involved in the existing framework. This working group would review the structure of the funds in place, align target

[26] https://ec.europa.eu/commission/sites/beta-political/files/euco-sibiu-eu_industry_fit_for_the_future.pdf

groups, as well as ensure currently existing funding gaps are covered. Additionally, regional leaders should encourage the review of regional funding schemes and their eligibility criteria.

Box 8. Available EU funding schemes[27]

The European Social Fund - The ESF is Europe's main instrument for supporting jobs, helping people get better jobs and ensuring fairer job opportunities for all EU citizens. It works by investing in Europe's human capital – its workers, its young people and all those seeking a job. ESF financing of EUR 10 billion a year is improving job prospects for millions of Europeans, in particular those who find it difficult to get work.

The Youth Employment Initiative – The Youth Employment Initiative exclusively supports young people who are not in education, employment or training (NEETs), including the long-term unemployed or those not registered as job-seekers. It ensures that in parts of Europe where the challenges are most acute, young people can receive targeted support. Typically, the YEI funds the provision of apprenticeships traineeships job placements further education leading to a qualification

Erasmus+ – the EU's programme to support education, training, youth and sport in Europe. Its budget of EUR 14.7 billion will provide opportunities for over 4 million Europeans to study, train, and gain experience abroad. Set to last until 2020, Erasmus+ doesn't just have opportunities for students. Merging seven prior programmes, it has opportunities for a wide variety of individuals and organisations.

Expected changes in the new Multiannual Framework 2021-2027[28]:

- ESF+ will merge the current ESF, YEI, the Fund for Aid to the Most Deprived (FEAD), the EU Programme for Employment and Social Innovation (EaSI) and the EU Health programme under one umbrella structure with a rationalised number of objectives.
- The new fund has a provisional budget of EUR 101.2 billion, which represents a *de facto* decrease in financing.

3.2.3.2. Set-up of a one-stop-shop

With the rising number of funding schemes available, the **introduction of a one-stop-shop,** providing stakeholders with a clear view on all the funds available for their skilling needs is recommended. To ensure the rightful use of funds offered and encourage a wider upskilling movement, those interested in advancing the upskilling of the European workforce require a clear view on the funds available, their target groups as well as on the application criteria to respect. By introducing one-stop-shops at the regional, national and EU-level, resources for the scaling up of successful programmes/initiatives and massive reskilling efforts can be easily combined and their provision centralised.

Clusters might play an enabling role in this regard. Acting as an interface between industry, academia and governments, cluster organisations are well positioned to assume an enabling role in the definition and execution of skills strategies. They can serve as an initial point of contact between all actors (e.g. public authorities, industry representatives, training providers, individuals) and provide them with an overview of all the funding schemes available. Their promotion, lobbying

[27] For more information, please refer to: European Social Fund 2018, European Commission, accessed 05 June, <http://ec.europa.eu/esf/main.jsp?catId=35&langId=en>; Youth Employment Initiative 2018, European Commission, accessed 05 June, <https://ec.europa.eu/social/main.jsp?catId=1176>; Erasmus+ 2019, European Commission, accessed 05 June, <https://ec.europa.eu/programmes/erasmus-plus/node_en>

[28] For more information, please refer to: Multiannual financial framework for 2021-2027: negotiations, European Council, accessed 05 June, <https://www.consilium.europa.eu/en/policies/eu-budgetary-system/multiannual-financial-framework/mff-negotiations/>

and networking activities would allow for the widespread dissemination of information available on the funding mechanisms available. At the same time, they would be well suited to assist stakeholders with the assessment of their funding needs and the accompanying submission of financial support applications due to their deep knowledge of the industries/sectors in questions.

A further key actor to promote the set-up of one-stop-shops might be **regional bodies** such as the ESF Agency Flanders. The ESF Agency Flanders has been actively supporting local businesses in defining their digital strategy and encouraging employers to upskill their workforce. It has been working closely with local industry leaders and businesses to build a strong community and become their main point of contact for all questions on the availability of funds.

Box 9. ESF Agency Flanders[29]

The Portuguese National Skills Strategy, developed by the cross-ministerial Portuguese National Project Team with the support of the OECD, is built on the in-depth analysis of the existing education system and the skills gaps noted.

The OECD Skills Strategy initiative provides a strategic approach to skills policies to strengthen countries' skills strategies through the coherent development, activation and effective use of skills. Its objective is to promote economic prosperity and social cohesion, reflecting a strong focus on 'lifetime employability'.

The Portuguese project started in 2014 with a diagnostic phase that included numerous workshops and stakeholder consultations, and resulted in the 2015 Diagnostic Report that identified key challenges to be addressed by Portuguese policy-makers.

The key challenges identified for Portugal and which are critical to an effective skills system were around:

- Developing relevant skills;
- Activating the supply of skills;
- Using skills effectively;
- Enabling conditions.

In line with this initiative, the Portuguese government launched a number of concrete actionable programmes between 2014 and 2018, which resulted in the reduction of school dropouts in basic and early education and decreased the number of students leaving education early. Furthermore, a significant decrease of youth unemployment, an increasing number of adults in qualification programmes (20,000 to 110,000), and an increase in students entering higher education could be noted.

3.2.3.3. Development of a new skills funding branding

Simultaneously a **rebranding of the funds available** should be considered. Funding schemes should be clearly branded as such and their target audiences easily identifiable. These '**Skills Funds'** would be introduced at the regional, national and EU-level and would regroup the funding mechanisms available under a dedicated umbrella structure.

The regrouping of the funds available would, on one hand, facilitate the communication of skills funding available and, on the other hand, allow industry-leaders as well as individuals to clearly identify the funding mechanisms they might be eligible for.

The ultimate aim of this rebranding effort should be to facilitate the uptake of upskilling initiatives by making it easier for industry-leaders and individuals to assess the funding options available and the accompanying eligibility criteria.

[29] For more information, please refer to: ESF Vlaanderen, 2019, accessed 04 June, <https://www.esf-vlaanderen.be/>

3.2.3.4. Expanding the use of the Blueprint for sectoral cooperation on skills

In line with the reform of the existing EU funds, **the financial framework for the Blueprint for sectoral cooperation on skills** could be expanded.

Part of the New Skills Agenda (2016), the Blueprint offers a new framework for strategic cooperation in a given economic sector between key stakeholders (e.g. business, research, trade unions, education and research institutions, public authorities, clusters). The Blueprint supports EU sectoral skills alliances with the development of a sectoral skills strategy. Partners of the sectoral skills alliances analyse major trends in the sector that are likely to affect jobs as well as the skills needed and based on their findings identify the main priorities to address in the years to come. Each sectoral skills strategy aims to bridge the existing skills gaps and support the overall growth strategy of the sector. By developing concrete solutions such as the updating of curricula and qualifications in line with the needs of industry, the blueprint supports the development and execution of defined sustainable up/reskilling solutions.

Figure 11. How does the Blueprint work?[30]

Source: European Commission, Blueprint for Sectoral Cooperation on Skills In a Nutshell.

At present, the activities of the Blueprint are limited to the European-level. Yet, in line with the Skills for Industry Strategy 2030, the cooperation framework aims to **progressively expand its activities to the national and regional level,** working directly with national and regional authorities as well as key industrial stakeholders in the target areas. This expansion would increase

[30] https://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=8164&type=2&furtherPubs=yes

the potential impact of the Blueprint's activities and encourage a comprehensive sectoral skills review at all levels of governance.

In a further instance, the scope of activities supported by the Blueprint could be restricted to the **testing of highly innovative** and thus **more risky upskilling initiatives**. By focusing on the financing of upskilling champions at the EU-level, the Blueprint would give these inspiring initiatives a platform to test the successful implementation of their upskilling visions while limiting the risks taken at the national and regional level. These efforts would naturally require the set-up of a dedicated financial scheme.

3.2.4. Module 4 – Incentives for individuals and businesses

The shift from the lifelong employment to the lifelong employability paradigm will require a significant change in the way we see education and employment. To encourage the widespread adoption of this shift in society, **human-centric incentives facilitating job creation and integration need to be proposed**. Industry-leaders, employees, training providers and traditional academic institutions will need to be encouraged to change the ways they work. They need to collaborate on developing a highly competitive skilled European workforce.

While the availability of funding mechanisms will significantly affect the uptake of re/upskilling solutions, further efforts are needed to reach the wider public and facilitate the comprehensive revision of the existing skilling ecosystem. Individuals and employers need to be held responsible for the development of the skills of the workforce and upskilling requalification schemes highlighted.

At present, the **incentives offered do not align with the needs of employees and employers**, leading to a **slow uptake of re/upskilling solutions and programmes**. Individuals are not being sufficiently encouraged to invest in the development of their skills to ensure their lifelong employability. Many are still reticent to pro-actively learn new skills and to expand their knowledge to fields of interest beyond their chosen specialisation/trade. This lack of willingness to invest time and effort into one's personal development is often linked to the still limited awareness of the wider population on the skills trends marking Europe's workforce and the trainings offered. Others, however, might lack sufficient incentives to do so outside of work.

Similar trends can be observed among employers. Many are still unaware of the changes affecting the market place as they focus on managing their everyday activities. Others simply lack the funds or incentives to invest in the continuous specialisation of their workforce. SMEs especially often struggle with training their employees during working hours while simultaneously ensuring the running of their daily activities. Therefore, a revised set of incentives will need to be introduced targeting the various stakeholders involved in this comprehensive change of the European workforce.

3.2.4.1. Introducing the Lifelong Learning and Skills Insurance Plan

One possible incentive might represent the **introduction of *lifelong learning and skills insurance plans*.** A first iteration of this concept was introduced at the Skandia Competence Insurance Conference on November 30, 1995 and might serve as inspiration to the introduction of similar models.

The "lifelong learning and skills insurance plan" would be based on a similar framework to traditional capital insurance plans with a specific focus on the **acquisition of skills by individuals, in case they lose their job or want to transition** to a new position/field.

Individuals would be given the opportunity to progressively build up a lump sum of money that they could use to finance their trainings and continued education. At the same time, individuals would benefit from advantageous tax arrangements and an attractive return on investment. "Lifelong learning and skills insurance plans" could be introduced at the national, individual or corporate level, depending on local conditions.

3.2.4.2. Introducing the Corporate Skills Insurance Plan

A similar solution could represent the **introduction of "corporate skills insurance plans**" that would allow business owners to invest in the future skills development of their employees.

Industrial leaders have been investing significantly in the skills development of their employees over the past years and have been continuously assessing the skills they will require in the future.

Airbus, for example, reviews the company's skills needs on a yearly basis and works closely with its global university partners to ensure a comprehensive review of their training programme.

Other companies invest in the set-up of R&D centres that drive innovation and support talent development. Both cases demonstrate the motivation of industry leaders to invest in the skills development of the employees. They also suggest that multinational companies might find it easier to dedicate the required amounts of funding to invest in dedicated upskilling initiatives. Smaller businesses often struggle to liberate the means required. "Corporate skills insurance plans" might facilitate these investments and provide business owners with interesting incentives.

Box 10. Airbus Engineer of the future & AGUPP [31]

Airbus' Engineer of the Future is a yearly evolving whitepaper started in 2014 by the Airbus Global University Partner Programme (AGUPP). Its purpose is to capture key points from the ongoing dialogue among AGUPP stakeholders about the skills and competencies needed by future Airbus engineers, and how Airbus can work together with universities to develop them.

It is developed and shared within the AGUPP community to provide insights and inspiration, and Airbus employees participate in the programme development structure of each partner university.

In its essence, the whitepaper defines the skills needs of the company in the short to medium-term. It is a mechanism by which Airbus articulates a clear vision of the graduate engineering skills it needs, partner universities remain informed of this vision, and Airbus and partner universities work effectively together to develop and realise this vision on an ongoing basis.

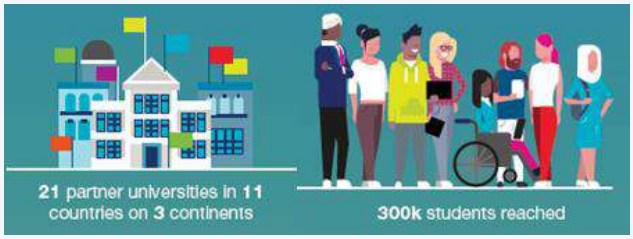
It is both a recognition that the skills and competencies required by Airbus are changing faster than the systems in place to provide those skills and competencies, and a platform for facilitating communication and collaboration with universities to mitigate the skills gap and talent shortages.

Airbus' vision of the future engineer is based on four pillars: (1) technical skills; (2) transversal disciplines; (3) generic disciplines; and (4) soft skills. As such, the traditional 'T-shaped' engineer is becoming a 'Pi-shaped' engineer, with the extension to the 'π' shape representing an engineer's transferable skills and commercial awareness.

In this regard, soft transferrable skills are of great significance, given the need to work together in flatter, more complex environments, with an emphasis on inter-personal, teamwork, as well as cross-cultural skills.

Moreover, in response to the digitalisation of engineering, the vision emphasises the need for digital skills attainment, such as advanced analytics, entrepreneurial thinking, and cybersecurity skills.

For more information, please refer to the Best Practices section.



Source: Airbus, 2017 Annual Report AGUPP.

Similar to existing "car fleet programmes", companies could subscribe to corporate skills insurance programmes to ensure the continued upskilling of their workforce. To further encourage the uptake of these upskilling activities at the individual level, corporates could envision introducing a bonus system that would benefit those employees that regularly complete trainings/certifications offered at company level. The more skills an individual acquires, the higher the bonus or additional benefits

[31] For more information, please also refer to: AGUPP - Airbus Global University Partner Programme, 2019, Airbus, accessed 04 June, < https://www.airbus.com/careers/partnerships-and-competitions/airbus-global-university-partner-programme.html>

received would be. The business, on the other hand, could reduce the insurance rates to pay given the highly skilled profiles of its workforce.

Box 11. Bosch Center for Artificial Intelligence [32]

Bosch Center for Artificial Intelligence (BCAI) is a multinational programme with locations in Germany, USA, Israel and India to advance the usability of Artificial Intelligence (AI) across multiple products and services. Next to advancing the state-of-the-art of AI research and making AI more robust, secure, safe and explainable, this programme creates a short way from R&D to adoption and offers in-house consulting, training and support in applying AI in all Bosch entities.

Bosch has partnered with Carnegie Mellon University in the US, with Technion in Israel, with the University of Amsterdam and University of Freiburg in Europe. The collaboration between researchers delivers findings that are published in leading academic conferences and journals.

In terms of skills and talent development, the programme supports the development of experts on AI, as these PhD students benefit by working with both academia and industry to advance their research.

Moreover, from Bosch's side, the employees also have the opportunity to develop their skills and expertise in AI, contributing to a lifelong learning aspect. This creates a basis for forming more experts on AI and machine learning on both sides.

For more information, please refer to the Best Practices section.

Source: Retrieved from <https://www.bosch-ai.com/>

3.2.4.3. Incentivise VET Upskilling

Hand-in-hand with the "corporate skills insurance plan", incentives **encouraging the wider uptake of VET upskilling efforts** should be highlighted. The UK Apprenticeship Levy incites businesses to offer new apprenticeships and boost the development of vocational training. France, on the other hand, introduced personal training accounts that put the individual at the centre of his/her re/upskilling journey and dedicate a fixed budget to their future skills development. Both programmes underline the need to incentivise VET upskilling and encourage the active participation of both individuals, employees and training providers.

[32] For more information, please also refer to: Bosch Center for Artificial Intelligence, 2019, Bosch, accessed 04 June, <https://www.bosch-ai.com/>

Box 12. UK Apprenticeship levy [33]

Education & Skills Funding Agency

The Apprenticeship Levy is a levy on UK employers to fund new apprenticeships. The levy is charged at a rate of 0.5% of an employer's paybill. Each employer receives an allowance of £15,000 to offset against their levy payment. Only companies with annual paybills in excess of £3 million are required to pay it, which means that less than 2% of UK employers are charged.

The levy helps deliver new apprenticeships and it supports quality training by putting employers at the centre of the system. Employers who are committed to training are able to get back more than they put in by training sufficient numbers of apprentices.

The levy is co-financed by the government and a monthly is made available for companies to use for offering trainings. For non-levy paying firms, the co-investment rate is set at 5% of the available funds, stimulating trainings especially in SMEs.

Companies can also share funds between each other, allowing transfers of up to 25% of the annual value of the paid funds.

Therefore, this report suggests that employers should be encouraged to invest a certain percentage of their profit into dedicated **VET savings accounts** that would serve the later continued training of their employees. Governments could top-up the amounts committed to the lifelong employability of employees, facilitating employers' investment into the continued training of their workforce. SMEs, on the other hand, could benefit from additional funding and support. Besides the financial contributions received, additional support could be offered in the form of advice on trainings needed or the optimised organisation of the workforce to allow for the inclusion of trainings into the company's work culture.

Box 13. Personal Training Accounts, France [34]

The personal training account is an initiative of the French government, enacted by the Act for the future to choose one's future career from 5 September 2018, which gives every citizen new trainings rights and tools for reskilling, upskilling and professional development.

The service is beneficiary-centered and offered to any employee when entering the labour market. Everyone is entitled to a personal account that is financed mainly by employers through social contributions and is available throughout the entire career, facilitating labour mobility as well as security. The training account is credited with 24 hours per year up to 120 hours, and then with 15 hours until the threshold of 150.

In monetary terms, an individual account is credited with EUR 500/year up to EUR 5,000 and EUR 800/year up to 8,000€ for low-qualified persons.

Currently 7.5 million personal training accounts have been opened. The programme will be extended in October 2010 via a new online platform.

Source: Moncompteactivite.gouv.fr platform

[33] For more information, please refer to: Guidance Apprenticeship funding: how it works, 2019, Education & Skills Funding Agency, accessed 04 June, < https://www.gov.uk/government/publications/apprenticeship-levy-how-it-will-work/apprenticeship-levy-how-it-will-work>

[34] For more information, please refer to: Bosch Center for Artificial Intelligence, 2019, Bosch, accessed 04 June, <https://www.bosch-ai.com/>

3.2.4.4. Encourage companies to share their industry VET programmes, infrastructures and content with the wider community

In line with the introduction of individual VET savings accounts, private actors should be increasingly encouraged to share their corporate VET programmes with non-employees. **Corporate academies should be opened to the wider public** to encourage the exchange of knowledge among industries and facilitate the recruitment of available talent. Dedicated financial incentives could be envisioned at the European, national or regional level to support these efforts. The set-up and maintenance of industry-led training infrastructures especially requires significant investments that could be alleviated by additional funding.

While staying mindful of the non-disclosure of confidential procedures/systems, many of the trainings offered could be opened to the wider public without endangering the competitive advantage a certain company might have.

The Cisco Networking Academy, for example, is an IT skills and career development programme open to individuals and education institutions worldwide. The internal knowledge of the business is thus being share with the wider public while continuing to drive internal skills development. The materials offered are continuously reviewed as new methodologies and systems are developed. The Business and Shared Services Centre, an innovation incubator based in Fundão, further strengthens the positive effect collaborative working spaces have on community skills development.

Box 14. Cisco Networking Academy [35]

The Cisco Networking Academy is an IT skills and career-building programme for learning institutions and individuals worldwide, providing education, technical training and career mentorship services. Currently present in all 28 Member States, the programme is a pillar of Cisco's corporate social responsibility policy, and delivers classroom instruction, online teaching materials, interactive tools and hands-on learning to students from all socioeconomic backgrounds. The main themes covered by the courses are networking, programming, IoT, cybersecurity, operating systems & IT, and packet tracer.

Since its inception in 1997, over 8 million students in 180 countries have been through the programme, with about 1.3 million in Europe alone. While online content and courses are also available, the majority of content is delivered in person through affiliated education institutions in local communities, of which there are 2,799 courses and 6000 educators in Europe.

The total in-kind contribution in Europe amounts to €492 million.

Despite its small start in 1997, the academy has now developed into an organisation that creates a community of all relevant stakeholders: other companies (e.g. IBM and Verizon), universities, government agencies and educators, and has set ambitious targets: bring the benefits of digitisation to 1 billion people by 2025.

In the EU, Cisco has pledged to train 200,000 students in the period 2017-2020. For instance, Cisco has joined the European Commission partnership Grand Coalition for Digital Jobs. The programme has also built an extensive network of instructor training centres, training not only students but also teachers.

For more information, please refer to the Best Practices subsection.


Networking


IoT


Programming


Cybersecurity

OS&IT

Packet tracer

By opening their doors and training contents to all, the overall quality of VET trainings will be raised as companies will publish their latest state-of-the-art knowledge plans. Furthermore, participants will be allowed to test their newly gained skills in save and cutting-edge facilities, providing them with the best opportunities available to gain new skills and knowledge. Participating companies will thus directly contribute to the re/upskilling of Europe's workforce and thus the continued competitiveness of its workforce.

[35] For more information, please also refer to: Cisco Networking Academy, 2019, Cisco, accessed 04 June, < https://www.netacad.com/>

Box 15. The Business and Shared Services Centre in Fundão

The Business and Shared Services Centre is a business centre project in Fundão, in the central rural region of Portugal. Initiated by the city municipality in collaboration with all relevant stakeholders, the centre provides technical infrastructure and skills for smart, sustainable businesses, with a focus on information and communication technologies for education (TICE).

The centre acts as an innovation incubator by providing office space to companies and freelancers. It further offers support to entrepreneurs and organises trainings in digital skills to contribute to the upskilling of the workforce in the region. The sectors under focus are related to the emerging digital age, such as software development, robotics and business services, and aim to modernise the regional business environment.

The technical infrastructure and facilities include a training centre, a digital fabrication lab, an open-source IoT centre, a plant biotechnology facility and a software validation and certification. By sharing these facilities, companies, especially SMEs, can cut costs and become more financially sustainable.

The centre has been established by accessing ERDF funds in excess of €2 million. The training centre focuses on digital skills and trains also unemployed people. Around 240 unemployed persons, out of which 50% without higher education have participated in the trainings and 97% found a job afterwards.

The courses in turn are funded by the participants or the companies.

The centre has attracted 14 specialist companies and created 500 jobs in a relatively small city. The created ecosystem has facilitated the start-up of 68 companies and offered support to over 200 private funding projects, with a special focus on R&D and skills development.

The initiative has initiated strong network effects, which led to a rehabilitation of the region, materialised through a decrease in unemployment, increased demand for real estate and the launch of other innovation projects. The project has received several accolades, such as the European Enterprise Promotion Awards in 2015, the Municipality of the Year award in 2016 and the RegioStars award of the European Commission in 2018.

For more information, please refer to the Best Practices subsection.

Source: Retrieved from https://ec.europa.eu/regional_policy/en/regio-stars-awards/

3.2.5. Module 5 – High-quality vocational education and training

At present, Europe is missing a commonly recognised and harmonised VET system focused on the provision of high-tech t-shaped skills. While industry leaders design their own VET trainings to respond to company needs, these trainings are often not widely shared and focus on the particular needs of a designated company. They can thus not be easily adapted to the wider needs of the public workforce.

Simultaneously, the design of independent VET trainings leads to varying quality standards and certification systems. VETs completed in one industry or Member State might not be recognised in different locations or fields of activity.

Lastly, information on the trainings offered is not widely available, leading to a limited uptake of VET development paths. Europe's VET system thus needs to be fundamentally revised and restructured.

3.2.5.1. Check the relevance of VET curricula compared to market needs

In a first instance, **the relevance of the VET curricula offered needs to be compared to market needs**. VET education faces similar struggles to the traditional educational system. Many of the trainings currently offered do not respond to actual market needs. VET curricula need to be reviewed to provide students with the skills necessary to remain competitive. The BRIDGE programme presented in detail below, offers students from the city of Rotterdam a career start guarantee if they have completed curricula in line with market needs. Industry leaders and regional/national representatives have thus started actively pushing for the review of existing VET curricula.

Box 16. Building the Right Investments for Delivering a Growing Economy [36]

The initiative "Building the Right Investments for Delivering a Growing Economy" (BRIDGE) is a project carried out by the city of Rotterdam in close collaboration with industry partners and education institutions. It aims to prepare students in vocational education from the South of Rotterdam region for the future labour market, with a focus on stimulating the following career paths - engineering, healthcare, maritime, food, construction and logistics.

The programme directly targets the Green Digital Economy and the opportunities created in major growth sectors. It provides a regional skills agenda, and serves as a call to action to reform the vocational education system.

Furthermore, by having a finite timeline (2016-2019), the initiative's main role is to experiment on the most effective ways to connect with students and to encourage a deeper collaboration between employers and schools, especially concerning the promotion of available career choices to youth.

The career and talent orientation programme starts in primary school (age 9) and ends with the students' entry to the labour market. BRIDGE targets that by 2020, 600 pupils per year in Rotterdam Zuid following vocational education choose a specialisation in technology sectors (35%) and health (15%), and that those pupils have a guaranteed job after graduating.

In fact, employers will offer 600 pupils per year a Career Start guarantee (420 for technology sectors and 180 for healthcare) the moment they enter secondary vocational education. If the pupil chooses the trainings required to meet labour market needs, an employer will commit in advance to that individual with a guaranteed career start after graduation.

Students will thus be encouraged at an early stage to acquire the skills required by industry while employers will be given the opportunity to become actively involved in the continuous skilling of their employees.

For more information, please refer to the Best Practices section.

Innovative VET curricula should incorporate technologies of the future and keep an eye on emerging trends. They should be market driven (i.e. meet current industry needs), have high impact (i.e. facilitate job transition) and allow individuals to improve their self-learning autonomy.

Closer collaboration between industry leaders and VET training providers needs to be assured to allow for the development of trainings that directly meet market demands and allow for the growth of a competitive labour force. At the same time, the way in which the trainings are provided should be reviewed to allow for the best balance of practical and technical education.

Finally, the Skills for Industry Strategy 2030 should align with the Vision for the Future of VET, which DG EMPL has been developing over the past months.

[36] For more information, please also refer to: BRIDGE - Building the Right Investments for Delivering a Growing Economy, 2019, Urban Innovative Actions, accessed 05 June, <https://www.uia-initiative.eu/en/uia-cities/rotterdam>

Figure 12. Vision for the future VET by 2030[37]

A vision for the future Vocational Education and Training by 2030

Excellent, inclusive and lifelong VET

European VET systems by 2030 should aim to deliver excellent and inclusive education and training that offer opportunities for both economic and social cohesion, support competitiveness and growth and smart, inclusive and sustainable development, and foster democratic citizenship and European values - thus helping all individuals to develop their full potential in a lifelong learning continuum. They are defined by three core elements:

- They foster acquisition of skills, competences and qualifications which ensure employability, adaptability, personal development and active citizenship of individuals
- They provide accessible, attractive, valued and innovative quality assured provision for all
- They are integrated, responsive, diversified and quality assured and they are underpinned by governance, funding and guidance which foster excellence, inclusion, effectiveness and shared responsibility

3.2.5.2. Develop a new set of quality criteria for VET in line with market needs

In line with the review of the relevance of the VET curricula offered, a **new set of quality criteria should be established to allow for the objective assessment of VET trainings offered**. VET education needs to be of high standard to allow for the acquisition of innovative high-tech t-shaped skills. Employers and individuals often struggle with selecting the best trainings to meet their needs and would benefit from an EU-wide set of standards that would facilitate the selection of high quality trainings. The European Quality Assurance in Vocational Education and Training (EQAVET) has been very active in this context and can offer some interesting insights on how to develop a new set of quality criteria for VET.

The quality criteria to be implemented need be **clearly defined and easily understandable** to facilitate their integration into the VET curricula offered. The end user should face little difficulty when assessing the quality of trainings offered and should be able to easily integrate the quality criteria defined into their personal skills development plan. Lastly, the quality of VET curricula should be directly linked to the **impact** they have on the individual trained and his skills portfolio.

37 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwiw8JrPqtLiAhXDbVAKHYiPD04QFjABegQIBRAC&url=https%3A%2F%2Fec.europa.eu%2Fsocial%2FBlobServlet%3FdocId%3D20479%26langId%3Den&usg=AOvVaw12qK08rKuWB8v00P-0nSI6

Box 17. European Quality Assurance in Vocational Education and Training [38]

European Quality Assurance in Vocational Education and Training (EQAVET) brings together the EU Member States, the Social Partners and the European Commission to develop and improve quality assurance in European VET systems within the context of the implementation of the European Quality Assurance Reference Framework by:

- Assisting the Member States in developing effective approaches to support the implementation of the Reference Framework;
- Developing a culture of quality, to be embedded at European level and other levels with the help of the Quality Assurance National Reference Points and other Network members;
- Supporting the Member States and the European Commission in the monitoring and implementation of the Reference Framework within the context of the Education and Training 2020 Strategy;
- Supporting the quality assurance dimension of work in EQF and ECVET.

Source: Retrieved from https://www.eqavet.eu/About-Us/Mission.

3.2.5.3. Build a stronger ECVET as an established certification entity for all players in the VET system

The harmonisation of VET education across the EU would further benefit from **the expansion and reinforcement of the European Credit System for Vocational Education and Training (ECVET)**. Dedicated communication efforts to reinforcing awareness on ECVET and its functioning could be envisioned as well as a review of its processes.

This would not only streamline the certification criteria to be respected across all Member States but would also facilitate the mobility of skilled workers across Europe as well as the exchange of knowledge and trainings across borders.

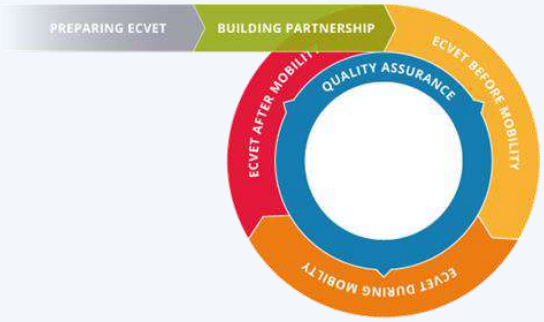
[38] For more information, please refer to: EQAVET, 2019, accessed 05 June, <https://www.eqavet.eu/>

Box 18. European Credit System for Vocational Education and Training[39]

The European Credit System for Vocational Education and Training, often referred to as ECVET, is a technical framework for the transfer, recognition and (where appropriate) accumulation of individuals' learning outcomes with a view to achieving a qualification. ECVET relies on the description of qualifications in units of learning outcomes, on transfer, recognition and accumulation processes and on a series of complementary documents such as a Memorandum of Understanding and Learning Agreement.

ECVET is intended to facilitate the recognition of learning outcomes in accordance with national legislation, in the framework of mobility, for the purpose of achieving a qualification.

- ECVET aims to support the mobility of European citizens, facilitating lifelong learning - achieved in formal, non-formal and informal settings - and providing greater transparency in relation to individual learning experiences, making it more attractive to move between different countries and different learning environments;
- At a systems level, ECVET aims towards greater compatibility between the different vocational education and training (VET) systems in place across Europe, and their qualifications.
- From a geographical mobility perspective, ECVET aims at facilitating the validation, recognition and accumulation of knowledge and skills acquired during a stay in another country, with a view to ensuring that such achievements can contribute to the achievement of vocational qualifications.



Source: Retrieved from http://www.ecvet-toolkit.eu/ecvet-toolkit/ecvet-toolkit

[39] For more information, please refer to: The European Credit system for Vocational Education and Training (ECVET), 2019, European Commission, accessed 05 June, <https://ec.europa.eu/education/resources-and-tools/the-european-credit-system-for-vocational-education-and-training-ecvet_en>

3.2.6. Module 6 – Accelerated World Class Curriculum

Traditional education and training providers currently lack a sufficient understanding of the high-tech t-shaped skills required by industry. This leads to a lack of alignment between existing curricula and the skills required by industry, ultimately resulting in a growing skills gap. Curriculums need to be continuously and seamlessly adapted to the changing needs of industry to assure the comprehensive re/upskilling of Europe's workforce.

3.2.6.1. Adapt curricula offered to market needs to ensure employment

In a first instance, a **comprehensive review of curricula offered and their alignment to current industry/market needs** should be envisioned. Each course/degree offered should be set-up to target specific skills needs of industry and the general labour market. The introduction of comprehensive AI tools assessing market and labour trends could be used to this advantage.

Furthermore, **traditional education and training providers should work increasingly with industry leaders** to directly exchange on the adaptation of curricula in line with market needs. The Territorial Skills Councils mentioned above might serve as a first point of reference to facilitate public private collaboration in the educational system. The Brainport Development programme presented below further underlines the need to introduce hybrid-learning environments.

In line with the development of new curricula, their **impact on the employability of students** should be reviewed and assessed. Data on the time before employment, their retention rate as well as their continued learning could be envisioned. Universities could also request employers to provide information on the profiles recruited from the respective curricula and the alignment of skills the students possess with regards to those required for their active contribution to the business' development.

Box 19. Brainport Development [40]

Brainport Development is the regional economic development organisation of the Brainport Eindhoven economic region working with industry, research institutions and public authorities in a Triple Helix model.
The agency has the mission to strengthen the region's competitiveness at a global level, which is a key area for the Dutch and even the European economy, mainly due to its successful concentration of companies in the high-tech systems & materials industry, food, health, mobility and design industries.
In its essence, the organisation creates knowledge sharing networks, offers business advice and support, and implements projects that aim to solve company-wide issues. The agency thus divides its roles and activities in five sectors: (1) strategy; (2) projects and programmes; (3) communication; (4) business services; and (5) SME services.

In terms of developing networks, Brainport Development develops clusters and business incubators for a group of companies in need of a strong collaboration.

Brainport Development focuses on the setup and emerging stages of cluster development, with the successful ones spinning off and becoming self-sustainable organisations.

Besides the extensive work done on developing clusters and supporting companies, Brainport Development has also developed a strategy to address the education and labour market challenges of the region, which are considered crucial in maintaining the leading position of the region.

Therefore, the National Action Agenda formulated by the agency focuses on creating an action plan for the region's stakeholders. The key points are: (1) increase availability of tech and IT (inter) national talent; (2) future skills and education innovation; (3) hybrid learning environments; and (4) lifelong development. This agenda has been supported by joint agreements that ensures the stakeholders' commitment to these points.

For more information, please refer to the Best Practices section.

3.2.6.2. Empower universities to review and their curricula rapidly and easily

In line with the continuous adaptation of curricula, universities and training providers need to be given the opportunity to **easily and rapidly change the structure and content of the courses offered**.

The application process to ensure the official recognition of the degrees/certifications provided needs to be streamlined and recognised EU-wide. The quality criteria to be respected need to be easily understood and their application supervised by a dedicated body/institution. At the same time, the criteria defined should be mindful of the changing educational system and thus need to remain highly flexible and open to innovation.

3.2.6.3. Prioritise public funding to private-public collaborations

Private-public collaborations are becoming increasingly important to ensure the courses/trainings offered align with industry needs. By directly cooperating with industry leaders and experts in the field, academic institutions and training providers can adapt the courses/trainings offered to respond to concrete needs market needs. The IBM Skills Academy, for example, works closely together with universities to offer training and courses to students on the newest technologies developed. These programmes offer a great opportunity to support universities in their R&D efforts while allowing students to gain hands-on insights on developments in the industry of their interest.

[40] For more information, please also refer to: Brainport Eindhoven, 2019, accessed 05 June, < https://brainporteindhoven.com/>

Universities that sign collaboration frameworks with industry leaders and directly include industry knowledge/input into their curricula could benefit from prioritised public funding to recognise the efforts made. Curricula with little impact on the continued employability of students should be slowly phased out and discouraged.

Box 20. IBM Skills Academy Poland [41]

IBM Skills Academy is a private initiative launched by IBM that offers trainings to students enrolled in universities. The programme assists universities in filling the gap between academia and business, improves student learning through hands-on experiences with the latest technologies, and helps connect students to the job market.

Through partnerships with universities, students and educators in IT or IT-related fields can participate in 11 'career tracks' that range from data scientist to predictive analytics modeler. Each career track has a number of distinct skill-focused learning objectives that are based on market research and in line with high-demand jobs in the IT market.

The teaching is done through a blended learning module that is partly web-based (roughly 80%) and partly classroom based (roughly 20%). Upon successful completion of a career track, a student receives two IBM certificates – Explorer Badge and Master Badge.

The Skills Academy started as a pilot in a number of African countries, but has now expanded to different regions, including Asia, the Pacific, and the United States.

Last year, the first Skills Academy launched in Poland, similar to the already existing partnerships in other countries. The partner organisations are currently EITT, a company offering trainings and coaching, and the Wroclaw University of Science and Technology, while other universities have already presented the programme to their students.

The aim of the initiative is to have partnerships with hundreds of universities across Europe. By making use of its wide network of university partnerships, since 2014, the year of the launch, 35,000 university students participated in the IBM Skills Academy programme, and 9000 students received Open Badges. These students came from 10 different countries and studied at 150 different universities. Of the students that attended a course, 60% now have a job.

For more information, please refer to the Best Practices section.

Source: Retrieved from <https://www-03.ibm.com/services/weblectures/dlv/Gate.wss?handler=Information&sequence=1&customer=meap&offering=meai&action=customer&content=Careers&language=en&origin=us>

[41] For more information, please refer to: IBM Skills Academy, 2019, IBM, accessed 04 June, < https://www-03.ibm.com/services/weblectures/dlv/Gate.wss?handler=Login&action=index&customer=meap&offering=meai&origin=us&allow_login=no&from=short_url>

3.2.6.4. Upskill academic teachers and include more professionals in the provision of education

The modernisation of traditional education requires the **re-imagination of the entire educational profession**. Teachers and professors will have to be on boarded on this new vision of education and skills development. They will have to be upskilled to better understand the demands of the market and adopt new training methodologies.

The active support of the teacher body is required to ensure the successful operationalisation of the Skills for Industry Strategy 2030. The expertise developed by decades of academic excellence should not be rejected but needs to be translated into concrete applications to ensure the comprehensive review of students' skills development plans.

Traditional educators should collaborate with industry professionals to give their students the opportunity to learn directly from those that are currently working in the field and can teach them not only the technical skills required but can also prepare them for the realities they will face on the market place. Professionals can provide student with invaluable knowledge on the day-to-day application of the knowledge they have gained but also on the transversal skills they will require to progress in their respective careers. Codecool presented below even based its entire educational system on the provision of hands-on trainings by professionals. The knowledge gained from these exchanges will provide students with a better understanding of the skills needed, the trends marking industry, as well as an elevated understanding of the importance of lifelong learning.

Innovative education leaders should further be recognised to encourage the widespread review of curricula offered. An **"innovative educator" award** could be introduced at EU-level to recognise the efforts being made to revolutionise the education sector and give those innovation drivers a platform to exchange on best practices and new learning methodologies. Possible synergies with the VET Excellence Award mentioned above could be envisioned in this regard.

Box 21. Codecool [42]

Codecool is a private company which aims to bridge the gap between the accelerating digital transformation and the lack of digital skills.

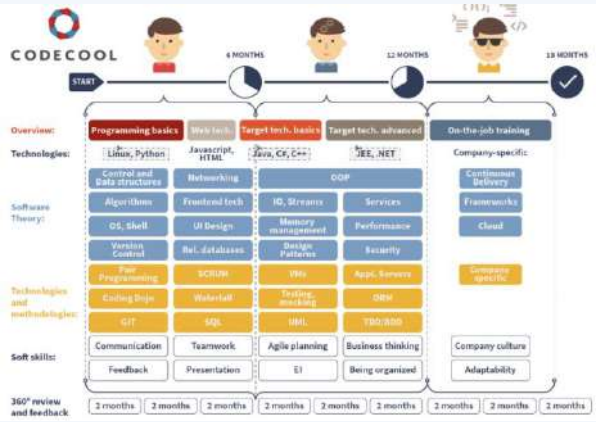
On the one hand, bootcamps that offer trainings are usually too short to develop the necessary competencies and require an upfront payment.

On the other hand, academic degrees are too long and often provide little practical knowledge.

As such, Codecool acts as an organisation between schools and the workplace, where industry experts act as mentors who are able to also offer business insights. The 1-year course thus focuses on skills that are needed on the job, while being based on projects and peer learning.

The company offers a post paid model, in which trainees pay the course after 18 months and only if they have been hired full-time, ensuring that the organisation is truly inclusive.

Codecool currently has five campuses across Hungary, Poland and Romania and is looking to expand from 450 students per year to 5000 graduates by 2023.



Source: Retrieved from https://codecool.com/en/about-courses/

[42] For more information, please refer to: Codecool, 2019, accessed 05 June, <https://codecool.com/en/>

3.2.7. Module 7 – Industry-led Training Infrastructures

Traditional training infrastructures were designed in a pre-digital world. Yet, students need to have the opportunity to acquire the latest skills and knowledge on cutting-edge innovative systems/technologies in an environment that enables them to do so. They need to be able to experiment with the newest technologies /systems in a safe environment.

Both industry leaders and local authorities need to work closely together to drive the review of existing training infrastructures and encourage greater collaboration between all actors involved in the education field.

While existing industry-led training infrastructures often boast state-of-the-art equipment and thus facilitate the acquisition of new skills, the scope of these activities often remains limited to the immediate workforce of companies. Innovative training infrastructures should be made available to the wider industrial workforce.

Box 22. Allianz Industrie 4.0 – Learning Factories 4.0 [43]

Allianz Industrie 4.0, launched by the State of Baden-Württemberg, is an organisation with the aim to share resources and know-how of production, information and communication technologies to help businesses in their digital transformation process.

Allianz offers a platform to promote partnerships. The objectives of this platform are to: (1) provide advice and support to SMEs to find their own way into the industrial future, (2) to strengthen innovation processes, as well as (3) to encourage collaboration between industries and technological sectors.

Within the Allianz Industrie 4.0, Learning Factories 4.0 is one of the most prominent and effective initiatives. In the context of digital transformation and the subsequent skills gap, the Learning Factories are government-backed labs implemented in vocational schools. They have two objectives: (1) to teach students and train employees by providing real-life practice opportunities; (2) to act as a research factory for demonstrating and testing new technologies and approaches.

The learning factories have simplified systems, are cost effective and have a smaller footprint. They have been established in 16 training centre projects in vocational schools across Baden-Wurttemberg, involving 30 vocational schools and 250 companies and industrial organisations.

The regional government of the land supports the investment costs, the expenses related to teacher trainings, and other associated costs. The estimated budget of the initiative is around EUR 6.8 million.

A second call of the development programme was announced in 2018, and as a result a further 21 project have been started in February 2019. By autumn 2021, they will be integrated into the corresponding education and training programmes of the schools. Business enterprises, universities and other institutions as well as business organisations have participated in the individual concepts and supported the learning factories.

For the training part, the learning factories cover three categories of skills: (1) technical skills, such as automation, control and programming; (2) transformation skills; and (3) social skills.

For more information, please refer to the Best Practices section.

Source: Lernfabrik 4.0 Karsluhe. Retrieved from https://www.lernfabrik.karlsruhe.de/

[43] For more information, please refer to: Allianz Industrie 4.0, 2019, accessed 04 June, < https://www.i40-bw.de/en/>

3.2.7.1. Develop new partnership models

New partnership models between industry leaders, SMES and education providers need to be encouraged to develop and build new learning infrastructures. Together, new trainings methodologies can be established and the provision of curricula expanded. Industry-leaders need to invest in the overall skills development of Europe's workforce to guarantee the sufficient availability of talent necessary to drive in-house innovation.

Industry-led training infrastructures provide students with the opportunity to gain new skills through practical exercises and the active testing of new technologies/systems. They mobilise industry leaders to become active drivers of the transformation of the training ecosystem.

At the same time, students need to be given the freedom to train with the right equipment in a highly innovative environment. By working with other businesses, employers can facilitate exchange of knowledge, skills and expertise while reducing overall costs for continued education.

Both the Learning Factories 4.0 and the business skills networks developed by Skillnet Ireland offer great examples of the benefits greater collaboration between business owner and training providers can have on the development of dedicated skills strategies and training curricula.

Box 23. Skillnet Ireland [44]

Skillnet Ireland is a flagship national agency responsible for the promotion and facilitation of enterprise-led workforce training. The aim of the organisation is to sustain Ireland's national competitiveness by contributing to the learning and upskilling of the working population.

The agency supports and funds the creation of sector-specific learning networks of firms, which eventually become self-sustaining through the active participation of the members and the founding industry association or steering group.

This approach ensures that the programmes delivered by Skillnet are relevant for industry, while providing a flexible and informative model for member firms. To this day, 65 learning networks operate across sectors such as ICT, pharma, financial services, agriculture, retail and transport.

In 2017, 94% of the network members were SMEs. Skillnet Ireland therefore also supports activities related to enhancing SME productivity, through driven programmes spanning multiple industry sectors, and both accredited and non-accredited learning.

Skillnet Ireland is partly state-funded and partly derives its financing from network members' contributions. It finances the steering organisation that leads the learning networks thus decreasing the costs of trainings.

Since 1999, Skillnet Ireland has facilitated over 70,000 Irish enterprises, in over 400 networks to improve the range, scope and quality of training and allowed over 300,000 employees to upskill and meet their work related training needs. Moreover, the participating companies all report high satisfaction levels for addressing their skills gaps.

For more information, please refer to the Best Practices section.

3.2.7.2. Strengthen the efforts of the European Cooperation for Accreditation (EA)

In line with the need for EU-wide quality criteria for VET, **the accreditation of industry-led training infrastructures and the trainings offered should be widely disseminated** to facilitate the wider uptake of re/upskilling efforts.

The European Cooperation for Accreditation (EA) is enshrined in EU regulation 765/2008 and counts national accreditation bodies as its members. It oversees accredited bodies that give

[44] For more information, please refer to: Skillnet Ireland, 2019, accessed 05 June, < https://www.skillnetireland.ie/>

certifications to persons and is thus directly involved in the control the quality of industry trainings provided.

To further facilitate the accreditation process and thus drive the introduction of industry trainings, the processes and procedures to respect to become an accredited training provider should be reviewed and where possible streamlined.

Box 24. Europe Cooperation for Accreditation [45]

EA, the European co-operation for Accreditation, is a not-for-profit association, registered in the Netherlands. It is formally appointed by the European Commission in Regulation (EC) No 765/2008 to develop and maintain a multilateral agreement of mutual recognition, the EA MLA, based on a harmonized accreditation infrastructure.

The EA MLA exists to facilitate fair trade, ensure product and service quality and reduce technical barriers to trade.

The EA currently has 50 Members. They are National Accreditation Bodies (NAB) that are officially recognized by their national governments to assess and verify – against international standards – organizations that carry out conformity assessment activities such as certification, verification, inspection, testing and calibration.

Organisations that check conformity and compliance against standards must have the technical competence and integrity to carry out these assessment services. EA evaluates its National Accreditation Body (NAB) Members which assess certification and inspection bodies, testing, medical and calibration laboratories as well as validation and verification bodies.

In its essence, EA is the organisation enabling National Accreditation Body (NAB) Members to share and build a common body of knowledge to develop a sound and harmonized approach to accreditation which is required to ensure that Conformity Assessment Bodies have the technical capacity to perform their task.

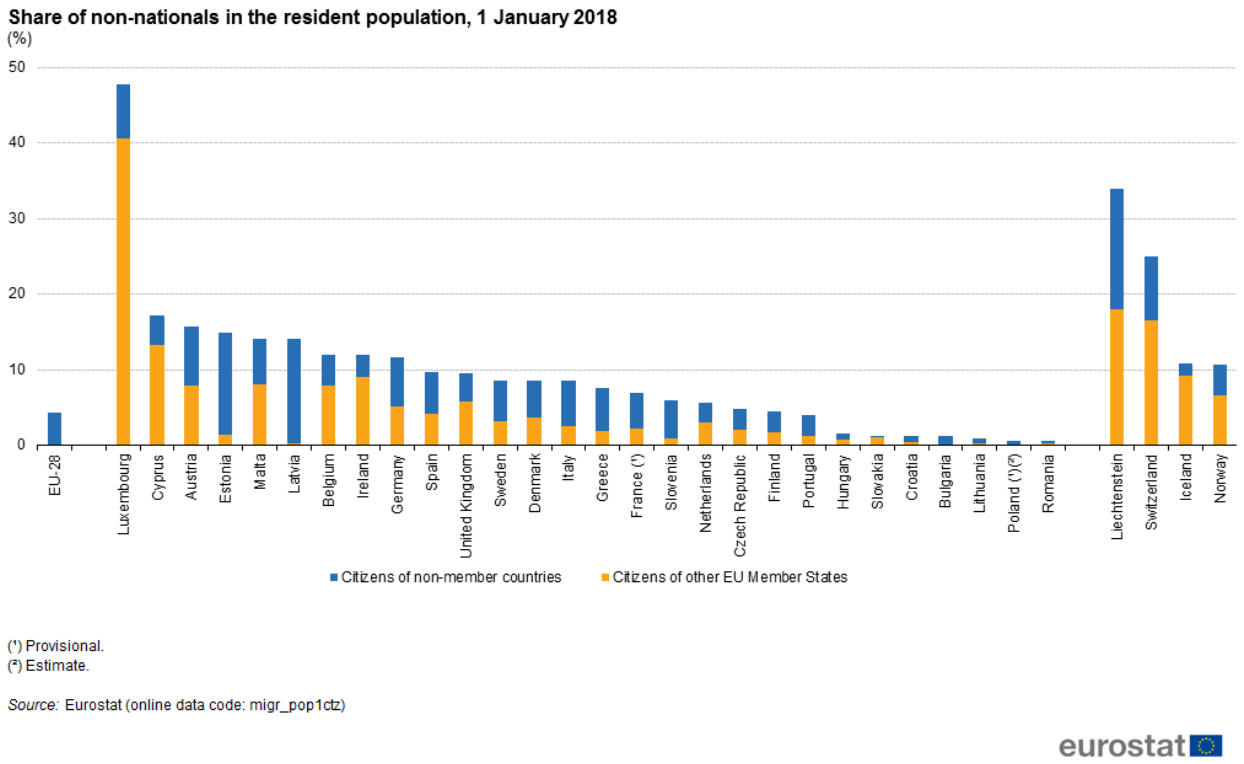
[45] For more information, please refer to: European Accreditation, 2019, accessed 07 June, < https://european-accreditation.org/>

3.2.8. Module 8 – Talent Detection and Nurturing

To ensure the development of a strong talent pool in Europe, talent needs to be nurtured and encouraged once detected. Both young as well as experienced talent needs to be identified and its future development supported. Furthermore, untapped talent pools such as women, migrants and youth not in employment, education or training (NEET) need to be increasingly integrated into Europe's workforce of the future. These populations can significantly contribute to bridging Europe's skills gap and driving industrial innovation.

On 1 January 2018, 22.3 million non-EU citizens were living in the EU, representing 4.4. % of the EU 28 population[46]. The largest numbers of non-nationals living in the EU Member States were found in Germany (9.7 million persons), the United Kingdom (6.3 million), Italy (5.1 million), France (4.7 million) and Spain (4.6 million), representing 76% of the total number of non-national living in all EU Member States. This represents a significant pool of talent that should be further assessed and included in future re/upskilling efforts.

Figure 13. Share of non-nationals in the resident EU population



To ensure the detection and nurturing of talent, flexible and tailored education/training programmes are necessary to allow advanced talents to progress at a faster pace and to ensure their continued growth. At the same time, individuals need to be exposed to different environments and industries to be able to realise their talent and become engaged in a field.

3.2.8.1. Develop a new approach to talent detection and career progression

At present, teachers often find themselves with limited to no support regarding the identification of early talent and the best ways to encourage their further development. Similarly, employers often lack sufficient knowledge on how best to retain and continuously challenge the talents they have acquired. **A new approach to both early talent detection in traditional education as**

[46] https://ec.europa.eu/eurostat/statistics-explained/index.php/Migration_and_migrant_population_statistics#Migrant_population:_22.3_million_non-EU_citizens_living_in_the_EU_on_1_January_2018

well as in corporate settings needs to be developed and implemented. A **dedicated working group should be created at EU level** to investigate new ways of detecting talent at both an early and later stage, as well as on how best to support these individuals that are highly gifted.

An important point to underline in this respect concerns the **retention of elderly talent**. While their jobs might be changing and they might be forced to acquire a completely new set of skills, the experience they have acquired over the years should not be disregarded. The transversal skills they have gained often highlight elderly individuals as highly talented in the organisation and motivation of their team members. They also tend to possess in-depth knowledge on the functioning of the company, the decisions made in the past and their main motivators. Their departure thus represents a significant loss to the working environment in given businesses.

Employers will need to be given the right tools to keep these individuals, to upskill them so they acquire the new skills required, while allowing them to continue sharing their knowledge gained from experience with their younger colleagues. The Professional Master in Software (PROMPT) might offer an interesting framework in this regard, as it focuses on the continued upskilling of current professionals and academics that want to grow their skills in specific tech areas. The trainings are entirely web-based allowing individuals to gain new skills while working. This, on the other hand, facilitates the retention of elderly talent as the individual can be upskilled while working and then be transferred from a disappearing position to a newly emerging one.

Box 25. Professional Master in Software [47]

The PROMPT (Professional Master in Software) initiative aims to ensure a steady and high-quality supply of advanced software competencies and innovativeness that benefits both Swedish industry and higher education. It is an education initiative created by academic parties and leading industrial companies that promotes lifelong learning.

PROMPT develops advanced, master-level courses in web-based format tailored to the skill development needs of current professional engineers and software developers.

The courses are designed for participants with a professional and/or academic background in software development and who need to combine work and studies. Currently, PROMPT offers 21 courses that fit within five subject-related areas. The courses are based on existing courses taught at different universities, and adapted with industry input.

The programme is managed using the Triple Helix model. As such, Mälardalen University leads the PROMPT initiative in cooperation with education institutions (Blekinge Institute of Technology, Chalmers, the University of Gothenburg and RISE SICS) and dozens of industry partners. Industry partners include but are not limited to Ericsson, Fujitsu, Schneider Electric, Bombardier, Scania, and Volvo.

The contents of the courses are then designed by the two parties to make the contents highly relevant and focused on emerging topics.

The third stakeholder in the initiative is the government. PROMPT is fully financed by the Swedish Knowledge Foundation's (KKS) Expertise for Innovation programme, which supports mid-sized universities, and which aims to promote cooperation between academia and industry.

Funding runs from 2011 until 2020, with talks about the extension of the programme ongoing. The ultimate goal is to include the courses in the ordinary university curricula. Thousands of professionals from 300+ different companies and organisations have participated in PROMPT courses since 2015.

For more information, please refer to the Best Practices section.

Source: Retrieved from http://www.promptedu.se/

Moreover, as mentioned above, **refugees and migrants need to be given the opportunity to identify and nurture their talents** to become thriving members of Europe's community and drive the competitiveness of its industry. The ReDI School of Digital Integration represents an interesting best practice in this regard. The NGO developed a dedicated training programme for migrants, refugees and asylum seekers to acquire the digital skills required to enter the European labour market. Proposing a blended learning approach including workshops, company visits and hackathons, the school facilitates the integration of non-nationals into the local community. Similar programmes could be introduces across those Member States with high levels of migrants and refugees that struggle to enter the labour market.

[47] For more information, please refer to: PROMPT, 2019, accessed 05 June, <http://www.promptedu.se/>

Box 26. ReDI School of Digital Integration[48]

ReDI School of Digital Integration is a non-profit digital school for tech-interested locals and newcomers in Germany, offering trainings in English and German. The school has the aim to offer students valuable digital skills and a strong network of tech leaders, students and alumni to help create new opportunities for all.

The organisation offers IT and programming courses, workshops, company visits as well as hackathons to primarily migrants, refugees and asylum seekers. Special courses are dedicated to women that have little background in IT.

Moreover, the NGO provides career counselling as well as employment matchmaking, thus not only training students, but actively helping them enter the workforce. This ensures the successful integration of migrants, refugees and asylum seekers into the German labour market and society.

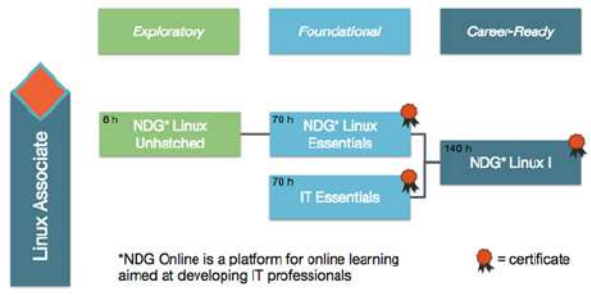
The programme offers three levels of training: beginner, intermediate and advanced. In addition, trainees develop their IT core competencies (presentation skills, agile project management, and development), soft skills and professional network by participating in conferences and company visits.

Teachers are usually volunteers from the tech industry who while teaching technical skills also share important insights on the industry and the practical applications of theory.

With around 500 students, the school can take a personal approach and help each individual find a job according to his/her skills and interests.

An example of a career path is illustrated below.

For more information, please refer to the Best Practices section.



Source: Retrieved from https://www.redi-school.org/online-courses

3.2.8.2. Encourage the dissemination of best practices

In line with the development of a new talent detection and retention methodology/system, **identified best practices in the field** (e.g. TechnofuturTIC) **should be widely disseminated to encourage the broader up-take of talent detection and retention practices**.

Best practices should be clearly highlighted in the upskilling promotion campaign introduced above. By spreading information on innovative solutions and facilitating the exchange of new ideas, the talent detection and retention system developed will be continuously challenged and improved.

[48] For more information, please also refer to: ReDI School of Digital Integration, 2019, accessed 05 June, <https://www.redi-school.org/>

Box 27. Technofutur TIC [49]

Technofutur TIC is a non-profit organisation which offers trainings on IT skills for four target groups (i.e. employed trainees, educators, students and jobseekers).

The organisation currently offers on-site and online trainings in Software Development, IT management, Business IT and digital marketing. All trainings are offered either by training companies and experts from partner universities or companies, which are invited by Technofutur TIC. The courses are offered at three levels of IT readiness: basic, advanced and expert. The latter specifically focuses on cross-functional skills acquirement in order to enable jobseekers to enter the labour market for the medium and long term.

Moreover, new courses are developed in collaboration with employers to reflect emerging trends in industry. In this context, Technofutur TIC also provides trainings in resume writing and digital identity, as well as offering job interview simulations. The programmes usually last from six to eight months and might end with an internship of four to six weeks as well as a recommendation to obtain formal education.

Technofutur TIC provides trainings to around 350 jobseekers per year and in 2018, 74% of the jobseekers have reintegrated into the workforce. The success of the initiative is based on a partnership model between (1) the local employment agency, FOREM, which mainly funds the action and offers additional support to the unemployed, (2) sector federation Agoria, which relays the needs of employers, (3) two Universities (UC Louvain, ULB), which guarantee the scientific content of the training programs and (4) the Unions (Setca, CNE), which support the overall initiative from a worker perspective.

For more information, please refer to the Best Practices section.

3.2.8.3. Encourage talent development and detection among women

EU, national and regional efforts should pay special attention to targeting demographics that until today have received less support. **Female talent**, especially, **should be increasingly encouraged and supported in its development of high-tech t-shaped skills**. Currently, women outnumber men by 10 to 7 in occupations with high risk of automation[50]. Simultaneously, men outnumber women in high digitalisation jobs and the female employment share in IT occupations continuous to fall.

Moreover, based on the latest data available from LinkedIn, the WEF further assessed that only 22% of AI professionals globally are female, compared to 78% that are male. This represents a gender gap of close to 72%[51]. While slight variations can be noted across the countries assessed, female representation in AI does not surpass 28% in the best case (e.g. Italy, Singapore, and South Africa). Sadly, the gender gaps noted in the AI field reflect broader gender gaps within specialisations in Science, Technology, Engineering and Mathematics (STEM).

Programmes dedicated to the detection of female high-tech talent thus need to be introduced to tap into this under developed talent pool. **Women in STEM need to be given the opportunity to continuously expand their knowledge and to keep expanding their talents**. Dedicated talent detection and retention systems should thus be envisioned and implemented.

[49] For more information, please also refer to: Technofutur TIC, 2019, accessed 05 June, <http://www.technofuturtic.be/ >
[50] https://iwpr.org/publications/women-automation-future-of-work/
[51] https://www.weforum.org/reports/the-global-gender-gap-report-2018

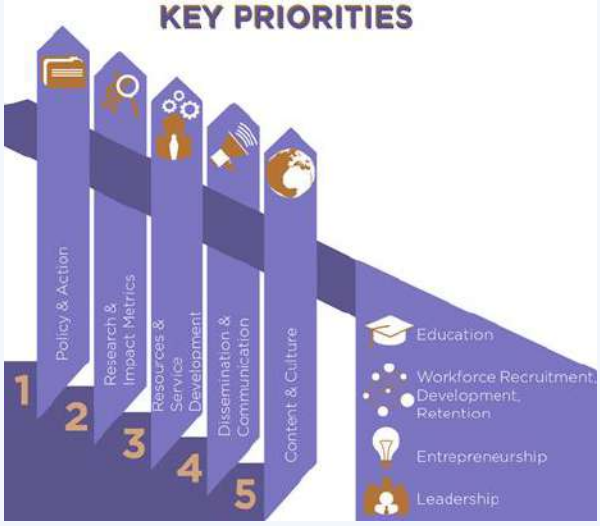
Box 28. European Centre for Women and Technology [52]

The European Centre for Women and Technology (ECWT) is a multiple stakeholder partnership consisting of more than 130 organizations and a significant number of individuals from governments, business, academia, and non-profit sectors with high-level expertise in women in technology development. It aims at increasing the number of girls and women in STEM and integrating a critical mass of women in the design, research, innovation, production, and use of ICT in Europe. Additionally, the European Network for Women in Digital aims at enhancing women's participation in digital studies and occupations across the EU.

ECWT helps organizations to find the best talents and helps girls and women to match their career lifecycles with industries needs through providing a community of excellence, leveraging resources and research, presenting and rolling out best practices, innovative actions and services and benchmarking and measuring impact.

ECWT functions as the European Regional Single Point of Contact, the first of Ten Regional Centers established upon the initiative of the International Taskforce on Women and ICTs (ITF).

The ECWT implements its strategy through the National Point of Contacts (N-PoCs) established in Member States and other European countries functioning as a national platform of multi-stakeholders supporting women's full participation in the knowledge based economy and the implementation of the Commission's Digital Agenda and the Europe 2020 strategy.



Source: Retrieved from http://ecwt.eu/en/key-priorities

3.2.8.4. Introduce the concept of "Lifelong Learning Centres"

A further solution to the continuous encouragement and development of talent might represent the **introduction of "Lifelong Learning Centres"** which would be similarly accredited to Business Schools and would concentrate on the **provision of high-tech t-shaped skills**. Any organisation could apply and seek funding from both private and public actors. Contrary to traditional educational bodies, "Lifelong Learning Centres" would be **flexible in the provision of their courses** and could allow students to go back to school throughout their working life without having to deal with the requirements and eligibility criteria demanded by the traditional academic system. Instead of basing their assessment of possible candidates on their previous degrees or certifications, these schools would be open to everyone sufficiently motivated to gain new skills.

Initially, the introduction of "Lifelong Learning Centres" could be supported by a significant funding effort at EU-level to spread the European spirit and facilitate the exchange of knowledge. At the same time, these funds would directly serve the development of new innovative teaching systems that might ultimately revolutionise the education system. In a second instance, EU funding could progressively be replaced by private and public funding to liberate these EU funds for further upskilling initiatives.

[52] For more information, please refer to: ECWT, 2019, accessed 06 June, <http://www.ecwt.eu/en/home>

SECTION IV – BEST PRACTICES

3.2.9. Module 9 – Communication at all levels

The public still has very limited awareness of the growing skills gap marking the European workforce and labour market, and the ensuing impact on the continued competitiveness of Europe's industry. 43% of Europeans still do not have basic digital skills[53].

While awareness for the need to upskill their workforce is rising among CEOs, many SME owners still offer few training or upskilling opportunities to their employees. Only 21% of businesses training budgets are dedicated to the development of digital skills[54].

A comprehensive communication strategy and campaign will be necessary to ensure the wider uptake of upskilling initiatives and programmes across Europe. The public needs to have a clear understanding of the changes affecting the local labour market and the skills that will be required to ensure their continued employability.

3.2.9.1. Launch of a dedicated promotion campaign to highlight the tools, trainings and jobs available

At EU-level, a **dedicated promotion campaign under a common umbrella and branding** could be envisioned. A high-level awareness raising campaign could be launched, highlighting wider EU trends and underlining the EU funding mechanisms available to support companies and individuals in their upskilling journey. The Erasmus+ branding can serve as inspiration when developing a well-known high-tech skills promotion campaign. Further strong synergies are possible with the European Vocational Skills Weeks, which promote the development of vocational skills across Europe and have been widely introduced.

[53] https://ec.europa.eu/digital-single-market/en/human-capital
[54] https://www.eib.org/attachments/efs/economic_investment_report_2018_key_findings_en.pdf

Box 29. Erasmus+ [55]

Erasmus+ has long been considered a best practice in terms of branding and disseminating an EU programme or initiative. The programme acts as an umbrella brand for all education, training, youth and sport initiatives in the EU.

Even within the website, the distinct visual identity reflects the objectives of the programme. The website also includes multiple explanatory videos, tools and supporting information.

The effective dissemination of the programme's opportunities has resulted in a wide use of student mobility, training, and not only, from which around 2.3 million people benefited by January 2018.

Erasmus+ has been effective not only in realising its objectives, but also to improve European citizens' attitudes towards the EU in general.

Source: Retrieved from https://ec.europa.eu/programmes/erasmus-plus/anniversary/resources

Moreover, an **interactive platform** allowing for the widespread dissemination of tools, trainings and jobs available across Europe could be developed and launched. By collecting all basic information on a common platform, valuable knowledge relating to the growing skills gap marking Europe and potential solutions would be facilitated and easily shared among the public. This platform could also facilitate communication among regional and national leaders to increase the attractiveness of labour mobility schemes and tackle skills shortages/surpluses in particular territories. Best practices could thus be widely shared between Member States and cross-regional collaboration simplified.

[55] For more information, please refer to: Erasmus+, 2019, European Commission, accessed 05 June, < https://ec.europa.eu/programmes/erasmus-plus/node_en>

Box 30. European Vocational Skills Week [56]

European Vocational Skills Week is an initiative that aims to promote vocational education in the EU. The weeklong series of events organised across Europe range from open doors and information campaigns to conferences and exhibitions.

Besides the regional events, high-level discussions take place in a European city, as well as the VET Excellence Award. The contest awards best practices in various categories and thus helps disseminate good practices as well as foster innovation in the VET sector.

Source: Retrieved from https://ec.europa.eu/social/vocational-skills-week/sites/evsw/files/evsw_-_summary_leaflet_2018.pdf

3.2.9.2. Definition of a national communication campaign to release all public and private initiatives

At the **national, regional and local levels, the vision, strategy and tools developed should be widely communicated** among the public and industry leaders to boost digital transformation and industrial modernisation. By raising awareness on existing infrastructures, education and training offerings, as well as benefits to individuals, employers and industry, the operationalisation of the Skills for Industry Strategy 2030 will be simplified and sped-up.

In line with the EU-wide communication campaign addressed above, **the national communication campaign should highlight national particularities and industries**. National and regional skills trends should be underlined and local programmes and funding mechanisms widely disseminated. Furthermore, information on public and privates initiatives should be easily accessible. Simultaneously, the trainings available in the region as well as any open positions could be shared via national communication platforms.

[56] For more information, please refer to: European Vocational Skills Week, 2019, European Commission, accessed 05 June, < https://ec.europa.eu/social/vocational-skills-week/>

3.3. Results of the survey

3.3.1. Aim of the survey

The aim of this survey was to include all stakeholders in the development of the final recommendations and give them opportunity to share their final input following the high-level Conference on Skills for Industry Strategy which took place on June 18-19, 2019.

3.3.2. Structure of the survey

The survey addressed the key recommendations of the 9 modules presented above. It asked all participants to assess the usefulness of the recommendations proposed to the implementation of a common vision for a Skills for Industry Strategy, and to indicate the 3 key recommendations they believe to be of the highest priority to the successful implementation of said strategy.

To facilitate the comparison of the usefulness of the recommendations presented, the average usefulness score of each recommendation was calculated.

Finally, participants were given the opportunity to share their qualitative assessment of the recommendations proposed and to communicate any additional feedback or reflections that should be taken into consideration to ensure the successful implementation of the Skills for Industry Strategy.

3.3.3. Overview

3.3.3.1. Overall assessment

Overall, the feedback collected supports the findings of the previous reports and the qualitative feedback converged from stakeholders throughout the study. **All recommendations** were assessed as **useful** and should influence the development of a common Skills for Industry Strategy.

The **3 most useful recommendations** as identified by the respondents were the following:

- *Develop new partnership models*
- *Definition and implementation of Territorial Skills Strategies*
- *Set-up of a one-stop-shop*

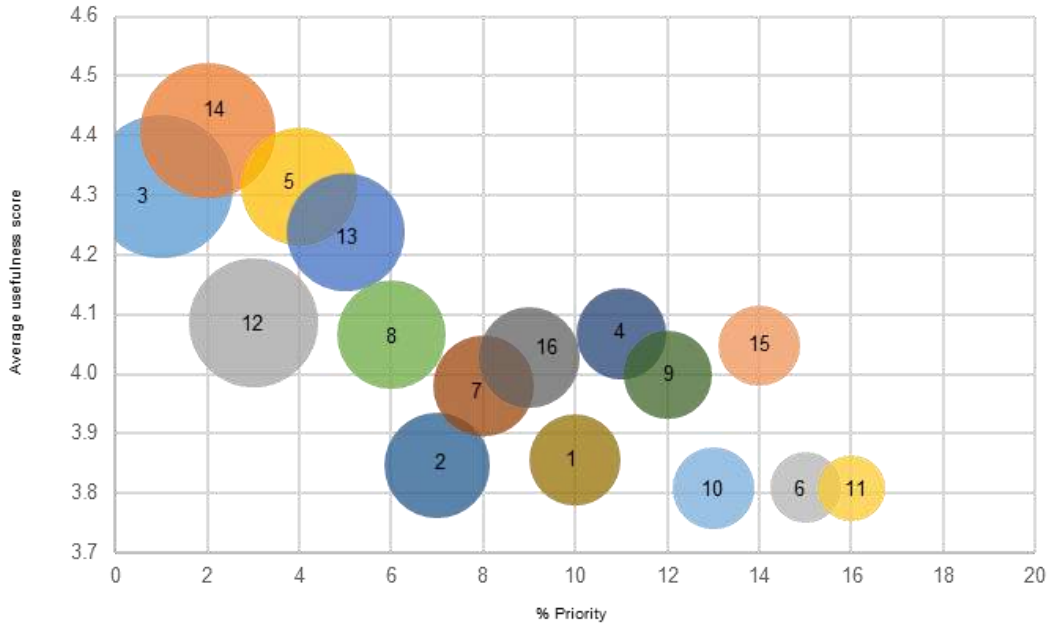
These recommendations gathered the support of most stakeholders and should be further explored during the implementation process of the Skills for Industry Strategy. At the same time, to further assess the key recommendations that have been identified as of particular interest, respondents were asked to select the 3 recommendations that should be given the **highest priority**. These were the top 3 recommendations selected:

- *Definition and implementation of Territorial Skills Strategies*
- *Develop new partnership models*
- *Adapt curricula offered to market needs to ensure employment*

Interestingly, the top 3 most useful recommendations do not entirely align with the 3 recommendations of highest priority. While '*Set-up of a one-stop-shop'* has been identified as highly useful by survey participants, respondents only rated this recommendation as the 7th most urgent among the 14 recommendations presented. Instead, the '*Adapt curricula offered to market needs to ensure employment'* was underlined.

Overall the findings of the survey highlight the need to develop curricula that meet market needs and to encourage new partnership models that facilitate closer collaboration between private and public actors as well as facilitating the development of state-of-the-art trainings/curricula. These efforts should be integrated into Territorial Skills Strategies to ensure the implementation of comprehensive upskilling and reskilling programmes at the city, regional, national and EU-level.

Figure 1: Usefulness score and priority



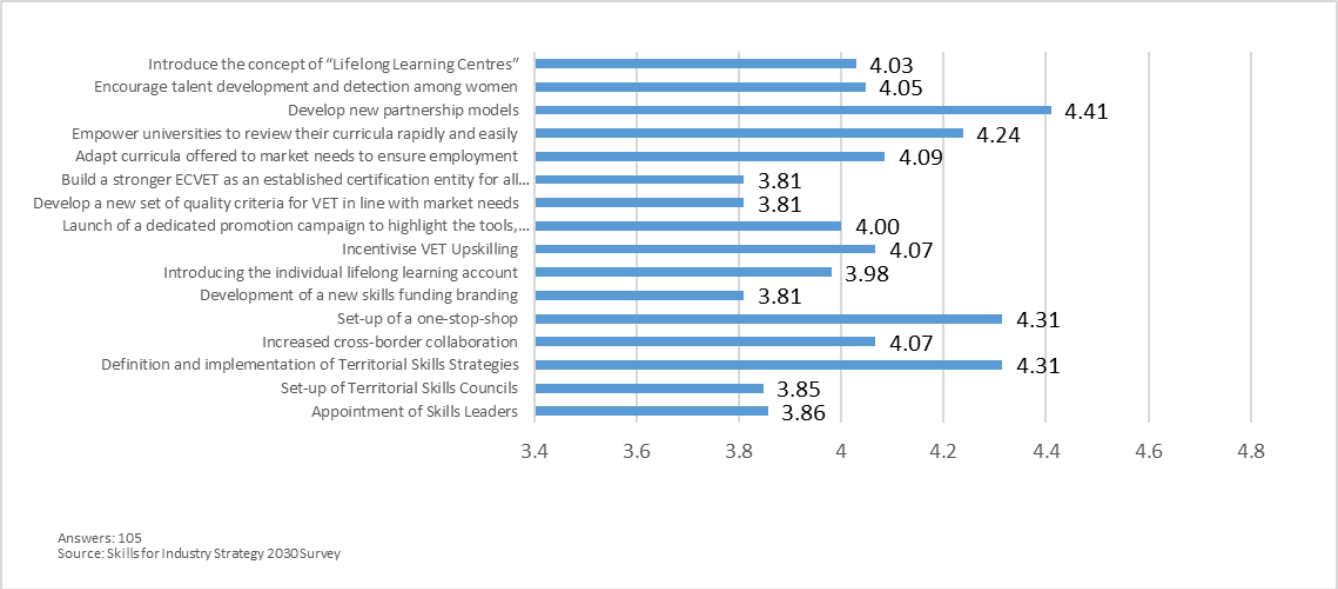
1. Appointment of Skills Leaders
2. Set-up of Territorial Skills Councils
3. Definition and implementation of Territorial Skills Strategies
4. Increased cross-border collaboration
5. Set-up of a one-stop-shop
6. Development of a new skills funding branding
7. Introducing the individual lifelong learning account
8. Incentivise VET Upskilling
9. Launch of a dedicated promotion campaign to highlight the tools, trainings and jobs available
10. Develop a new set of quality criteria for VET in line with market needs
11. Build a stronger ECVET as an established certification entity for all players in the VET system
12. Adapt curricula offered to market needs to ensure employment
13. Empower universities to review their curricula rapidly and easily
14. Develop new partnership models
15. Encourage talent development and detection among women
16. Introduce the concept of "Lifelong Learning Centres"

Answers: 105
Source: Skills for Industry Strategy 2030 Survey

3.3.3.2. Assessment by usefulness

Taking a deeper look at the usefulness of the recommendations developed, the results of the survey confirm that all recommendations suggested will be helpful to the successful implementation of the Skills for Industry Strategy. 10 out of 16 recommendations scored a 'usefulness score average' of above 4, with the overall average of all recommendations being 4.04.

Figure 2: Average usefulness score per recommendation



As mentioned above, the 3 most useful recommendations were the following:

- *Develop new partnership models*
- *Definition and implementation of Territorial Skills Strategies*
- *Set-up of a one-stop-shop*

The review of the current educational and training system thus remains of high interest to the public and has been identified as highly useful to the successful implementation of a common vision for the Skills for Industry Strategy. At the same time, the definition and implementation of Territorial Skills Strategies uniting all upskilling and reskilling efforts under a common vision would facilitate the development of training curricula and partnership models that align with the overall objectives defined. A one-stop-shop providing all available information on funding, skills trends etc. would facilitate interactions between stakeholders and support the development of new partnership models.

3.3.3.3. Assessment by priority

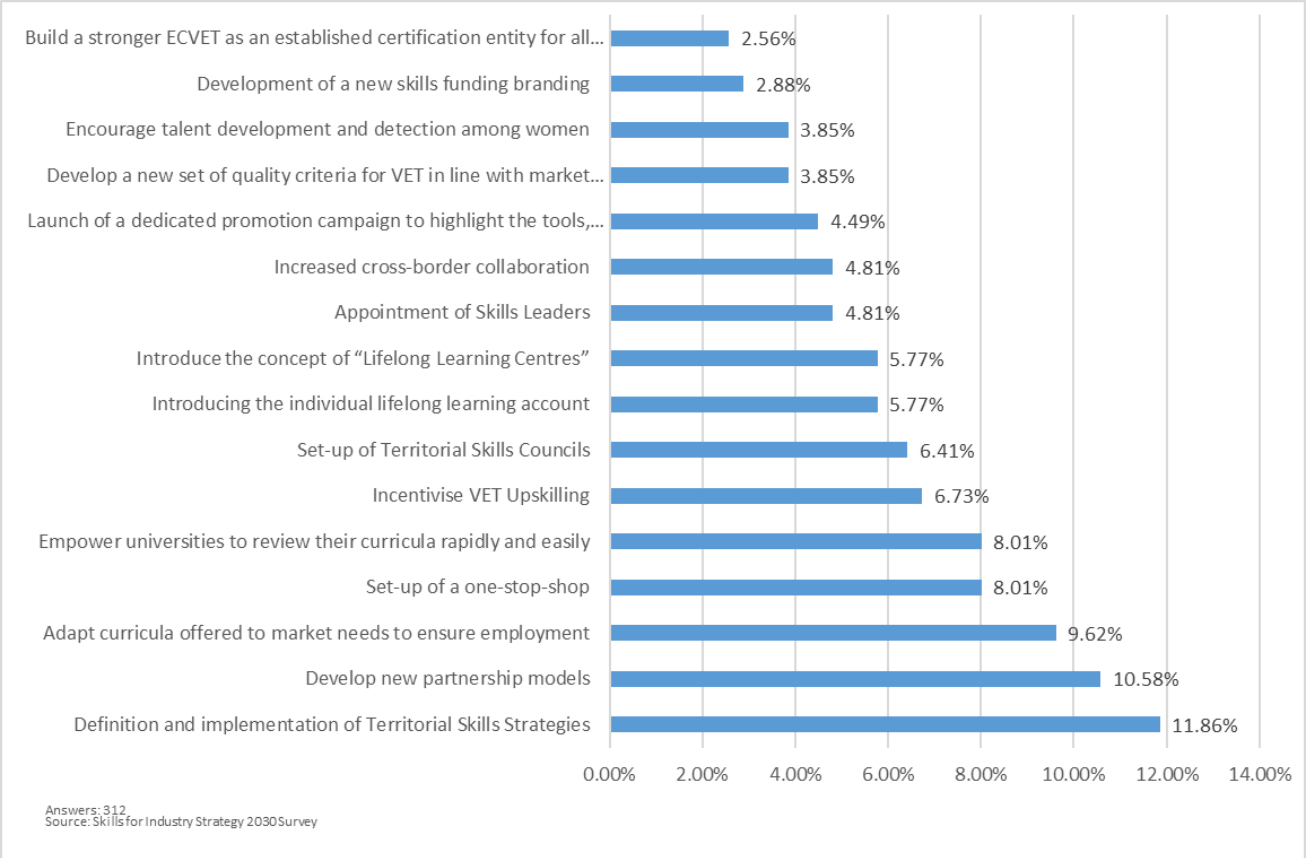
By assessing the urgency of the recommendations suggested, an initial indication of the actions to be prioritised can be given. Respondents thus believe that these recommendations should be implemented in a first instance and should receive particular attention when discussing the wider implementation of the Skills for Industry Strategy. According to the responses received, the following recommendations should be urgently implemented:

- *Definition and implementation of Territorial Skills Strategies*

- *Develop new partnership models*
- *Adapt curricula offered to market needs to ensure employment*

The adaptation of curricula to market needs has been identified as particularly urgent, which aligns with the findings of the previous studies regarding the misalignment of the trainings and education programmes available with market needs. Only by joining forces can new training methodologies be established and the provision of curricula expanded. Industry leaders need to invest in the overall skills development of Europe's workforce to guarantee the sufficient availability of talent necessary to drive in-house innovation.

Figure 3: Prioritization of the key recommendations proposed[57]



[57] Please note that in order to classify the key recommendations between the 14 under scrutiny, the respondents could choose 3 options each. Therefore, in such a case, the total number of answers is the 300% of the respondents.

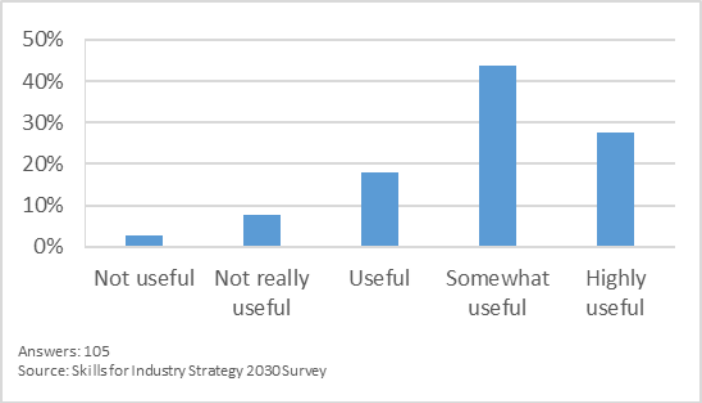
3.3.4. Detailed review of the key recommendations addressed

This section offers a detailed look at the feedback collected for each recommendation and will underline the qualitative results received. First, a short description of the recommendations will be presented, followed by the assessment of the results received.

3.3.4.1. Appointment of Skills Leaders

Throughout the course of the study, the need for 'Skills Champions' and a dedicated leadership was repeatedly underlined. The successful design and implementation of a skills for industry strategy requires the mobilisation of skills leaders/champions to efficiently coordinate activities at city, regional, national and EU-level (connecting academic, business, public and community leaders). This will result in strong partnerships, commitments and a clear governance structure. Yet, our research has shown that few actors feel responsible and/or accountable for providing a territory with the right skills.

Figure 4: Appointment of skills leaders - usefulness rating

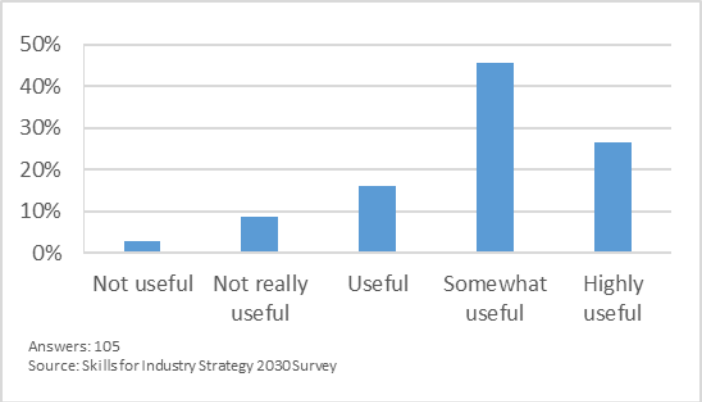


Survey participants confirmed this assessment by rating this recommendation with an **average usefulness score of 3.86.** More than 89% of the respondents consider the appointment of Skills Leaders "Useful" to efficiently coordinate activities. Participants also underlined the need for **concrete action plans** that will facilitate the objective implementation of skills strategies across all territories. Skills Champions need to have clearly defined objectives to meet and need to **offer actionable guidance** on how to implement comprehensive upskilling and reskilling strategies. **Leadership** at the city, regional, national and EU-level need to be **aligned** and supported by a diverse team including representatives from industry, the traditional educational system, trade union spokespersons, as well as local cluster representatives. **Public-private collaboration is seen as crucial** to the successful implementation of territorial skills strategies and should be highlighted. Global as well as market leaders need to join forces and co-create comprehensive skills strategies. At the same time, elected 'Skills Champions' need to actively support the development of a diverse and inclusive workforce.

3.3.4.2. Set-up of Territorial Skills Councils

In line with the identification of 'Skills Champions', Territorial Skills Councils should be introduced to support the leadership in developing and implementing scalable and sustainable up/reskilling actions. In this respect, the main objective of the Territorial Skills Councils would be align the efforts of all leaders involved to ensure the setting-up of relevant partnerships with key stakeholders and the development and implementation of a comprehensive and holistic territorial skills strategy.

Figure 5: Set up of territorial skills councils - usefulness rating

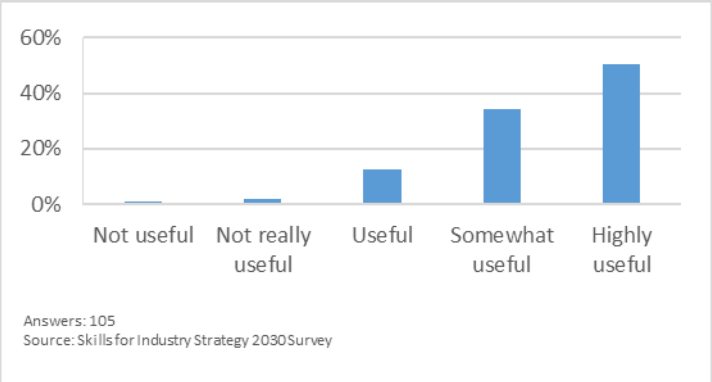


With an **average usefulness score of 3.85**, this recommendation has been assessed as useful to the implementation of a Skills for Industry Strategy. Territorial Skills Councils would facilitate the coordination of all stakeholders involved in the design and implementation of territorial skills strategies. Respondents pointed out the need to ensure the Territorial Skills Councils remain agile in their structure and the administrative burden put on them remains light. At the same time, existing institutions/bodies active in the field should be included and/or restructured to integrate their knowledge/experience into the newly formed Territorial Skills Council.

3.3.4.3. Definition and implementation of Territorial Skills Strategies

To strengthen the competitiveness of Europe's industry and foster the creation of new jobs, efficient territorial re/upskilling strategies need to be developed and implemented consistently at all levels. Member States/regions/cities should be encouraged to develop comprehensive territorial skills strategies including measurable objectives, commensurate resources and clear deadlines. These skills strategies should be developed in line with the territory's economic, industrial, smart specialisation and innovation strategies.

Figure 6: Definition and implementation of territorial skills strategies - usefulness ratings

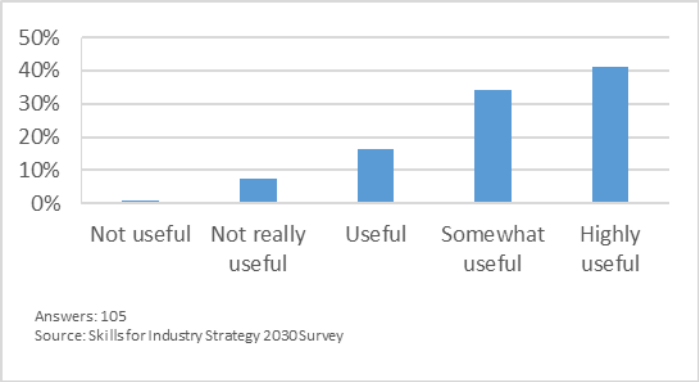


This recommendation was rated the **second most useful and urgent** recommendation by survey participants, thus **confirming the imperative need for territorial skills strategies**. An important point underlined by all respondents is the need to directly include SMEs in this process to ensure their particular needs are included in the respective skills strategies. At the same time, a common framework enabling the assessment of territorial skills strategies across all Member States should be considered. This would facilitate the objective assessment of up/reskilling efforts among Member States and could serve the identification of best practices.

3.3.4.4. Increased cross-border collaboration

The successful development and implementation of territorial skills strategies will rely on increased cross-border collaboration. Considering the rapid transformation of sectors and global value chains as well as demographic changes, increased cross-border collaboration is necessary to expand on existing synergies between regions and facilitate the active implementation of large-scale upskilling and reskilling strategies. Greater collaboration on the provision of training across borders could further reduce costs for regions while underlining a common skills vision in Europe.

Figure 7: Increased cross-border collaboration – usefulness rating

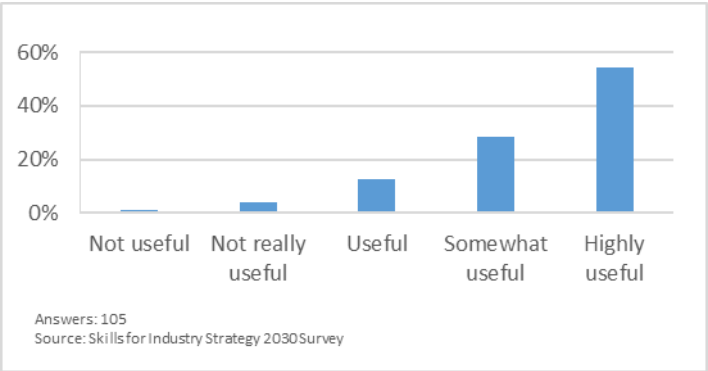


With an **average usefulness score of 4.06**, this recommendation has been assessed as useful to the implementation of a common Skills for Industry Strategy. Yet, its implementation has **not** been identified as very **urgent**. This could suggest that leadership should in a first instance focus on designing comprehensive skills strategies and only in a second instance engage in extended cross-border collaboration. This would ensure national alignment before engaging in skills discussions with bordering neighbour member states.

3.3.4.5. Set-up of a one-stop-shop

The re/upskilling of the workforce will require significant financial support at all levels (city, regional, national and EU) and rely on both public and private sources. Relevant European funding programmes and instruments should be promoted to enable the set-up and implementation of territorial re/upskilling strategies. With the rising diversity of funding schemes available, the introduction of a one-stop-shop, providing stakeholders with a clear view on all the funds available for their skilling needs is recommended.

Figure 8: Set-up of a one-stop-shop - usefulness rating



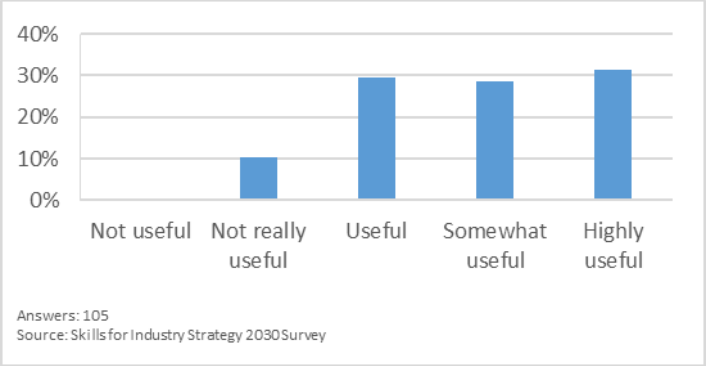
Survey participants rated this recommendation among the **top 3 most useful recommendations** with an **average usefulness score of 4.31**. They also rated it among **the top 5 priorities** of

the Skills for Industry Strategy, thus underlining the importance of the recommendation developed to the future implementation of said strategy. Survey participants further underlined the need for simplified administrative processes to access funding and a common controlling process. Fewer and less complex funding schemes might streamline the administrative process while the one-stop-shop will facilitate access to information and offer businesses additional support on the procedures to respect.

3.3.4.6. Development of a new skills funding branding

A further facilitation of the funding process might represent the introduction of a common branding at the city, regional, national and EU-level. 'Skills funds' should be easily identifiable and promoted under a dedicated umbrella structure.

Figure 9: Development of a new skills funding branding

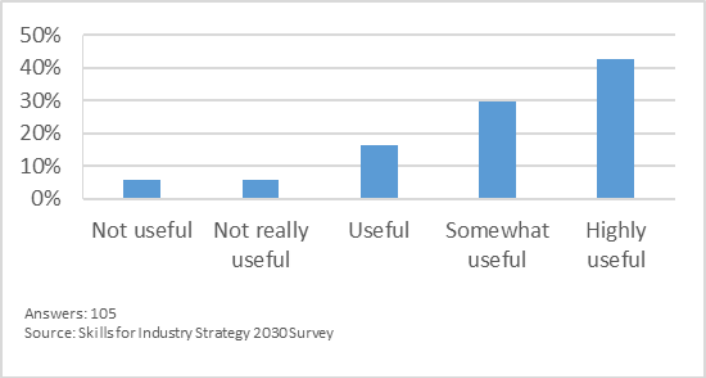


With an **average usefulness score of 3.81**, this recommendation has been identified as **useful** by survey participants yet of **low priority**. In line with a dedicated 'Skills Fund' a common branding might further improve visibility of the funds and support available. However, the development of a well-known brand requires time and should not be the key priority of the Skills for Industry Strategy.

3.3.4.7. Introducing the 'Individual Lifelong Learning Account'

Inspired by existing individual trainings accounts such as the French 'compte personnel de formation', the 'individual lifelong learning account' would be co-financed by contributions from employees, employers and public authorities. It would provide individuals with the opportunity to build up a lump sum of money that they could use to finance their trainings and continued education, in case they lose their job or want to acquire new skills and/or transition to a new position/field.

Figure 10: Introducing the Individual Lifelong Learning Account – usefulness rating

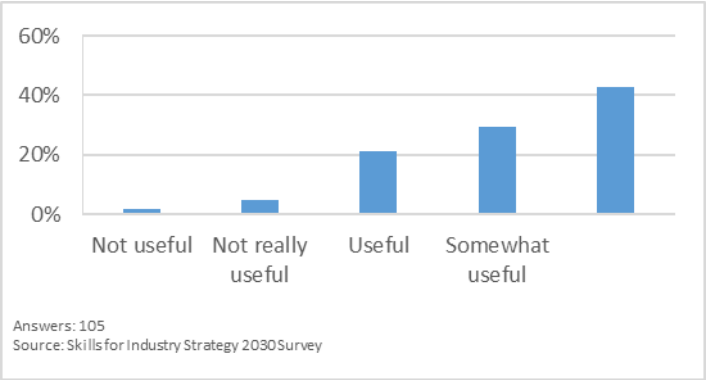


Overall, the introduction of individual lifelong learning accounts was perceived as **useful** by those consulted, with an **average usefulness score of 3.98**. While **not** representing **a priority** of the Skills for Industry Strategy, individual training accounts were seen as especially useful if introduced in coordination with a guidance/support infrastructure that could assist individuals in selecting the right trainings. At the same time, the concept of 'lifelong learning records' was introduced. These records would provide the beneficiary as well as those co-funding the account greater transparency on the individual's talents as well as his/her training record.

3.3.4.8. Incentivise Vocational Education and Training Upskilling

Throughout the course of the study, the importance of ensuring the highest quality standards in education and training has been repeatedly underlined. The creation of new VET programmes and online training opportunities needs to be supported to design trainings that allow participants to acquire new skills. At the same time, incentives should be offered to extend the amount of training available to employees from a couple days a year to, for example, a full-month of intensive training.

Figure 11: Incentivise Vocational Education and Training Upskilling – usefulness rating

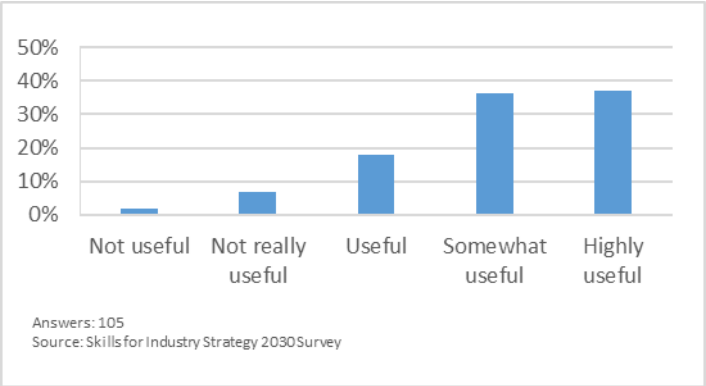


With an **average usefulness score of 4.06**, this recommendation has been identified as useful to the implementation of a common Skills for Industry Strategy. At the same time, this recommendation does **not count among the most urgent ones** and should thus be addressed in a second instance according to the feedback received. An important point underlined by multiple participants concerned the additional support to be offered to SMEs. Small businesses might struggle with covering the associated costs of extended trainings.

3.3.4.9. Launch of a dedicated promotion campaign to highlight the tools, trainings and jobs available

A promotion campaign under a common branding should be launched in close cooperation with Member States, social partners and key stakeholders to increase awareness on upskilling and reskilling solutions as well as funding mechanisms. An interactive platform (linked to the one-stop-shop mentioned above) allowing for the widespread dissemination of tools, trainings and jobs available across Europe could be developed and launched in this context.

Figure 12: Launch of a dedicated promotion campaign - usefulness rating

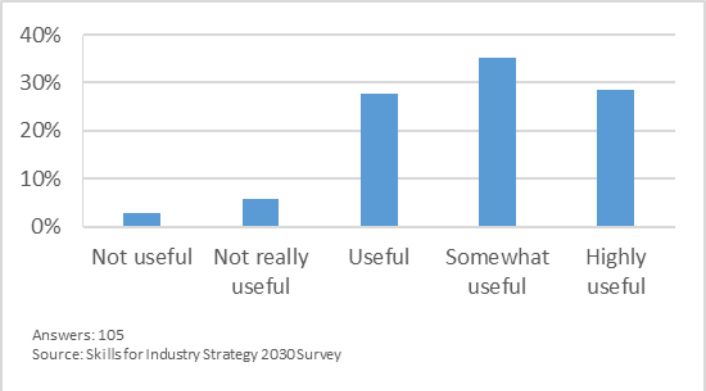


Overall this recommendation was seen as **very useful** to the implementation of a common Skills for Industry Strategy, **scoring a 4 usefulness average**. Survey participants suggested that sectoral communication campaigns at European and regional level addressing employment and training opportunities across Europe could be very useful in sectors with relevant mobility. At the same time, this campaign would raise the public's general awareness on skills development, lifelong learning as well as on interesting training/job opportunities.

3.3.4.10. Develop a new set of quality criteria for VET in line with market needs

In line with developing new curricula and support the review of VET, a new set of quality criteria should be established to allow for the objective assessment of trainings (both on- and offline) offered. Quality criteria to be implemented need to be clearly defined and easily understandable to facilitate their integration into broader skills development plans.

Figure 13: Develop a new set of quality criteria for VET - usefulness rating



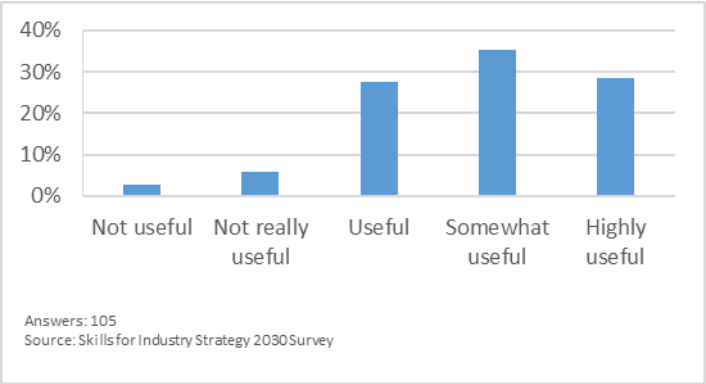
Survey participants agreed with the general usefulness of this recommendation (**average usefulness score of 3.81**) yet found its implementation **not a priority**. One of the main issues

many businesses or teachers seem to face concerns the comparison of VET qualifications, especially with regards to new jobs/technologies. Common quality criteria could be interesting in this case.

3.3.4.11. Build a stronger ECVET as an established certification entity for all players in the VET system

The relevance and quality of VET across the EU would further benefit from the strengthening of the European credit system for vocational education and training (ECVET). It would streamline the certification criteria across all Member States and would facilitate the mobility of skilled workers as well as the exchange of knowledge and trainings across borders.

Figure 14: Build a stronger ECVET - usefulness rating

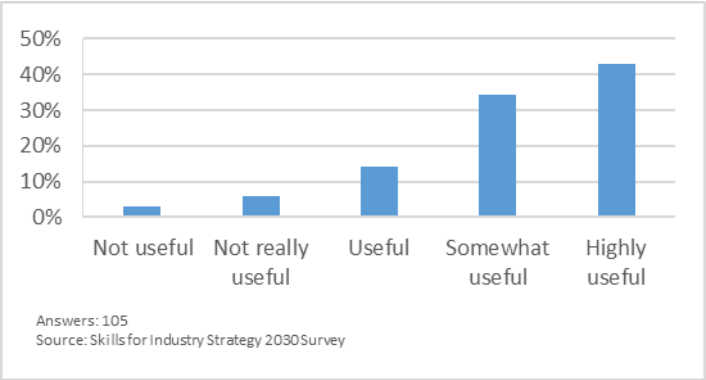


Survey participants agreed with the usefulness of this recommendation (**average usefulness score of 3.81**) yet did not find its implementation urgent. Further reflections hinted at the need to inspire to a credit system that evaluated the added value of the training rather than the time spend. The acquisition of skills should drive the quality of the trainings received.

3.3.4.12. Adapt curricula offered to market needs to ensure employment

A comprehensive review of curricula offered and their alignment to industry/market needs should be envisioned. Each course/degree offered should be set-up to target specific skills needs of industry and the general labour market.

Figure 15: Adapt curricula offered to market needs to ensure employment - usefulness score

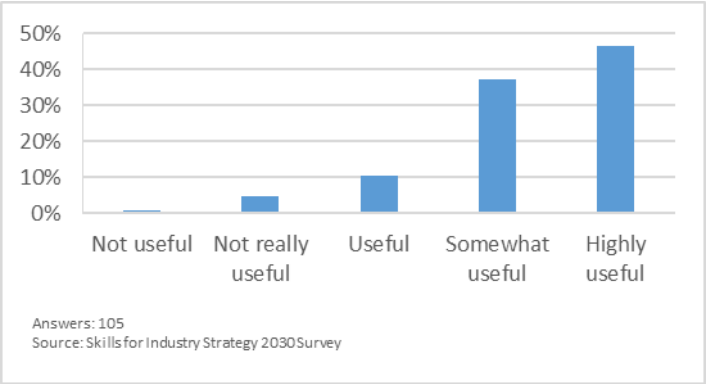


This recommendation received an **average usefulness score of 4.09** and was rated as the **3rd highest priority** of a common Skills for Industry Strategy. Survey participants underlined the need to review the entire educational system and the trainings offered. Some highlighted the present lack of inclusive curricula that exclude some populations from gaining the skills needed by industry. Close collaboration between education and training bodies with employers needs to be strengthened to ensure the trainings offered are relevant to industry needs and provide 'students' with the skills necessary to continue learning new competences in their workplace. Others highlighted that curricula need to be agile and adaptable to the ever-changing skills needs of the market. This, however, does not exclude the need for a baseline of skills that all individuals should acquire no matter the curricula selected or their field of activity.

3.3.4.13. Empower universities to review their curricula rapidly and easily

In line with the continuous adaptation of curricula, universities and training providers need to be given the opportunity to easily and rapidly change the structure and content of the courses offered and receive the necessary accreditation. The application process to ensure the official recognition of degrees/certificates provided needs to be accelerated, streamlined and when appropriate recognised EU-wide. This process should be mindful of the transformation of educational systems and thus need to remain open to innovation.

Figure 16: Empower universities to review their curricula rapidly and easily

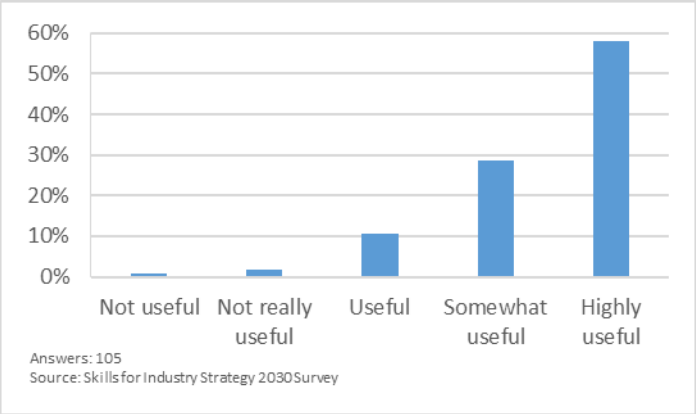


Closely connected to the previous recommendation, survey participants rated the empowerment of academic institutions to review their curricula easily as **very useful** (**average usefulness score of 4.24**) and of relatively **high priority (top 5).** At the same time, respondents were mindful of the complexity and difficulty of changing the accreditation system, suggesting the need for a comprehensive long-term strategy in this regard.

3.3.4.14. Develop new partnership models

New partnership models between industry leaders, SMEs and education and training providers need to be encouraged to build new learning infrastructures. Industry-led training infrastructures would provide learners with the opportunity to gain new skills through practical exercises and the active testing of new technologies /systems.

Figure 17: Develop new partnership models - usefulness rating

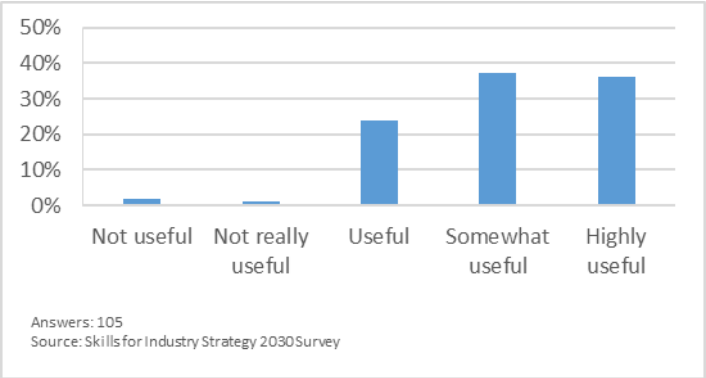


The development of new partnership models has been identified as **highly useful**, with respondents rating this recommendation an **average usefulness score of 4.41**. At the same time, the implementation of such a recommendation was categorized as **high priority**, being selected as **the top 3 most urgent recommendations to implement**. Respondents highlighted the speed with which technology is developing and suggested that industry leaders and academic institutions should consider collaborating in dedicated co-financed labs. At the same time, many mentioned the need for industry leaders to think outside their limited interest (or limited to their products) and to invest in overall skills development.

3.3.4.15. Encourage talent development and detection among women

EU, national and regional efforts should pay special attention to targeting hidden talents and demographics that until today have received less support. Female talent, especially, should be increasingly encouraged and supported in its development of high-tech T-shaped skills (combining both technical and soft skills). Actions dedicated to the detection of female high-tech talent should be introduced at an early stage to tap into this under developed high-tech talent pool.

Figure 18: Encourage talent development and detection among women - usefulness rating

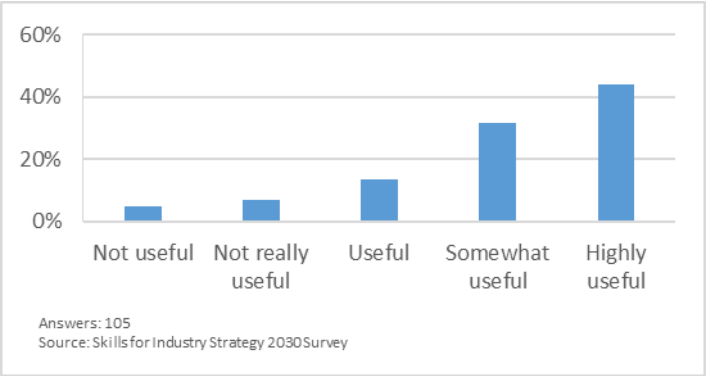


With an **average usefulness score of 4.04**, this recommendation has been assessed as useful by survey respondents, yet of **lower urgency**. Many highlighted the need for inclusive curricula, at an early age. At the same time, these efforts should not be limited to female talent, but should also engage immigrants, refugees, and those with special needs. Everyone should have access to good education and trainings that will provide them with the skills necessary to belong to today's workforce.

3.3.4.16. Introduce the concept of "Lifelong Learning Centres"

The modernisation of education requires the re-invention of the educational system. "Lifelong Learning Centres" could be introduced in this respect. They would concentrate on the provision of high-tech T-shaped skills and be flexible in the provision of their courses. They would allow learners to go back to school throughout their working life without having to deal with the requirements and eligibility criteria demanded by the traditional academic, thus facilitating lifelong learning.

Figure 19: Introduce the concept of 'Lifelong Learning Centres' - usefulness rating



Overall, respondents rated this recommendation as **useful**, giving it an **average usefulness score of 4.203**. Yet, it should **not be seen as a priority** of the Skills for Industry Strategy. One interesting opportunity mentioned by respondents concerned the possible integration of public libraries into the development of Lifelong Learning Centres. This reflection could be further developed during the implementation of the Skills for Industry Strategy.

3.3.4.17. Conclusion

Overall, the findings of the survey support the recommendations developed throughout the course of the study. All recommendations have been identified as useful and should thus be included in future discussions on the implementation of the Skills for Industry Strategy.

Three recommendations in particular should be further developed and implemented, these focus specifically on the adaptation of the education and training realm to actual market needs; closer collaboration between public and private actors to develop new curricula and learning infrastructures; and the definition and implementation of territorial skills strategies to ensure the cohesiveness of the upskilling and reskilling efforts made.

The findings of the survey reiterated the need for a comprehensive Skills for Industry Strategy to strengthen the competitiveness of Europe's industry. They also demonstrated the involvement of all stakeholders consulted in ensuring the development of a successful up/reskilling strategy. This present engagement and motivation should be used at its fullest potential to advance the definition and subsequent implementation of the Skills for Industry Strategy by 2030 and beyond.

SECTION IV – BEST PRACTICES

4. BEST PRACTICES

4.1. Introduction

To support the implementation of the Skills for Industry Strategy, this section of the Final Report aims to analyse the initiatives that can serve as best practices and inspiration for the operationalisation of the EU 2030 High-Tech Skills Vision. Twenty diverse cases, ranging from initiatives at city, regional and national level, having been initiated by private and public actors have been selected. Despite their diverse scopes and targets, all best practices can be considered as having contributed to the development of SSIS&DT.

The exact selection methodology and additional criteria that have been used when shortlisting the cases is described in detail in the following section, Methodology.

The Best Practices section presents the initiatives by following an exact structure of analysis, mostly based on the devised methodology:

1) **Description –** provides a short summary and the context of the initiative, its implementation model, objectives and results.

2) **The EU 2030 High-Tech Skills Vision alignment** – presents the dimensions with which the initiative is aligned with the most and explains how it excels in the particular dimensions.

3) **Key insights for the Skills for Industry Strategy 2030 –** presents a table in which the relevant modules and stakeholder groups are included to generate specific insights for implementation or development of a similar initiative.

4) **Transferability, replicability and scalability –** this section presents the initiative's implementation potential in other contexts or by other stakeholders based on these three dimensions. It also explains why and how it would be possible to implement it from these perspectives.

5) **Potential challenges and success factor for implementation –** Two tables are presented in this section that contain: (1) the potential challenges that would have to be addressed or at least should be considered when introducing a similar initiative; (2) the success factors that facilitated the implementation of the initiative and represent favourable conditions for the successful operationalisation of the initiative. Both challenges and success factors are ordered according to impact potential, namely High, Medium or Low.

6) **Take away messages –** Based on the initiative's context, the alignment with the selection methodology, and the generated insights for a potential implementation, the last section presents some key points to be considered regarding each initiative.

Finally, this section of the Final Report aims to build up on the conducted individual research of the best practices by providing an aggregated analysis of the identified patterns and common aspects between the initiatives. It groups the initiatives by defining categories and summarises the relevant learning points for each groups. This contributes to the to-be-developed guidelines for specific stakeholders and the type of initiatives that can be deployed during the implementation of the Skills for Industry Strategy 2030.

4.2. Methodology

The best practice cases presented in this report have been selected by using a multi-criteria and multi-source methodology. The approach consisted of three components – desk research, expert consultation, and the identification of success signals. The identified cases were then further assessed based on five criteria – replicability, scalability, transferability, Vision alignment and Toolbox alignment. Diversifying the selection process helps mitigate the risks of subjectivity and selecting unsuitable examples in terms of the selected criteria.

4.2.1. Best practices selection methodology

The following methods/steps were conducted to select the best practice case studies:

- Desk research – in depth review of case studies identified in the state-of-play analyses and initial stakeholder consultations;
- Consultation with experts via interviews and workshops – discussing the best practices identified with key experts in order to confirm their leading position in the field;
- Identification of success signals – usually proxied by significant media attention, received awards and frequent.

4.2.2. Best practices selection criteria

Given that all shortlisted case studies serve as good practice examples, the following dimensions have been used to ensure an objective and fair selection of the cases that stand out. In general, the shortlisted best practices have a **higher upscaling potential** and can be used as a **basis for future policy-making**, which will be facilitated by the developed Toolbox. Therefore, the devised criteria are:

- **Replicability** – defined as the ease with which the initiative can be emulated;
- **Scalability** – referring to the potential of upscaling the initiative or implementing it to a higher policy level;
- **Transferability** – the potential of implementing the policy in another context (region/industry);
- **Vision alignment** – the extent to which the case study aligns with the defined dimensions of the EU 2030 High-tech Skills Vision (see Figure 14. The key characteristics of the EU 2030 High-Tech Skills Vision). As a prerequisite, all the selected best practices are aligned with the ethical dimension, either because they are ethically responsible or because they train or encourage ethical skills.

Figure 14. The key characteristics of the EU 2030 High-Tech Skills Vision

- **Strategy alignment** – the extent to which the case study can inform policy-making at different policy-making levels and stakeholder groups.

Figure 15. Skills for Industry Strategy 2030 Policy Recommendation Modules

The Skills for Industry Strategy 2030 comprises **various modules** aiming to address different questions. Currently proposed modules are distributed around the following key questions:

- ***What*** is to be formulated by the policy?
- ***Who*** are the beneficiaries and the stakeholders responsible for the implementation of the policy?
- ***How*** is the policy to be implemented?
- ***When*** is the policy to be delivered?
- What is the ***expected impact*** of the policy?

4.2.3. Overview of best practice cases selected

Following the methodology and selection criteria described below, 20 best practices were identified that will serve as food-for-thought and inspiration for other actors interested in developing dedicated skills strategies. In line with the EU 2030 High-Tech Skills Vision, special attention has been paid to selecting best practices that **break with traditional 'silo' organisational structures** and **encourage transversal activities**. The best practices selected thus all

encourage **active collaboration** between different actors, may they be private, public, clusters, major industry leaders or triple helix. Moreover, as both business initiatives and clusters focus on specific sectoral challenges, they have been regrouped under the 'cluster' category. Finally, to ensure the continued growth and competitiveness of Europe's industry, **new innovative and agile skills initiatives** will need to be launched.

Table 1. Overview of Best Practices Selected

Best Practice	Member State	Region	City	Cluster
Airbus - Engineer of the Future & AGUPP	x			
Allianz Industrie 4.0 and the Lernfabriken 4.0		x		x
Associazione Fabbrica Intelligente Lombardia (AFIL)		x		x
Bosch Centre for Artificial Intelligence	x			
Brainport Development		x		
Bridge - Building the Right Investments for Delivering a Growing Economy'		x	x	
Cisco Networking Academy	x			
IBM Skills Academy	x			
IMEC academy	x			
Luxembourg Digital Skills Bridge	x			
Portugal – Building a National Skills Strategy with the OECD Centre for Skills	x			
Prompt	x			
ReDI School of Digital Integration			x	
SEMI				x
Silicon Europe - The European cluster alliance for innovative electronics & software technologies		x		x
Skillnet Ireland	x			
Skills for Londoners Strategy			x	
Technofutur TIC		x		
The 6 Aike (Cities) Strategy		x	x	
The Business and Shared Services Centre – Centro de Negócios e Serviços Partilhados (CNSP)			x	x

4.3. Best practices

4.3.1. Airbus - Engineer of the Future & AGUPP

Organisation name	Airbus
Type of organisation	Private
Level of implementation	National / Global

4.3.1.1. Description

Airbus' Engineer of the Future is a yearly evolving whitepaper started in 2014 by the Airbus Global University Partner Programme (AGUPP). Its purpose is to **capture key points from the ongoing dialogue among AGUPP stakeholders about the skills and competencies needed by future Airbus engineers**, and how Airbus can work together with universities to develop them. It is developed and shared at first within the AGUPP community to provide insights and inspiration, while Airbus employees participate in the programme development structure of each partner university. It is then published more widely to help other non-partner establishments, students, and candidates to prepare themselves, too.

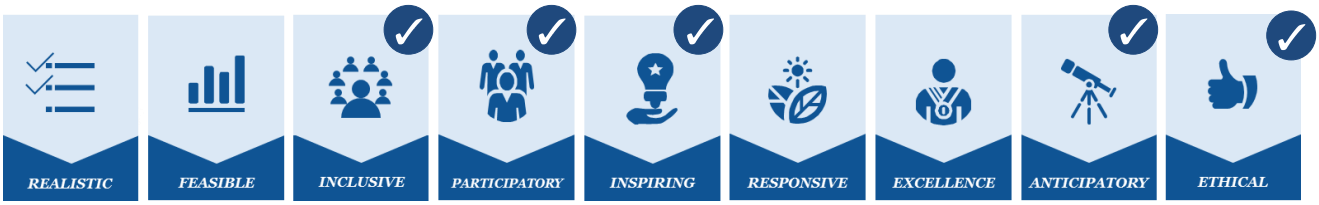
In its essence, **the whitepaper defines the skills needs of the company in the short to medium-term**. It is a mechanism by which Airbus articulates a clear vision of the graduate engineering skills it needs, partner universities remain informed of this vision, and Airbus and partner universities work effectively together to develop and realise this vision on an ongoing basis[58]. It is both a recognition that the skills and competencies required by Airbus are changing faster than the systems in place to provide those skills and competencies, and a platform for facilitating communication and collaboration with universities to mitigate the skills gap and talent shortages.

Airbus' vision of the future engineer is based on four pillars: (1) technical skills; (2) transversal disciplines; (3) generic disciplines; and (4) soft skills. As such, **the traditional 'T-shaped' engineer is becoming a 'Pi-shaped' engineer**, with the extension to the 'π' shape representing an engineer's transferable skills and commercial awareness. In this regard, soft transferrable skills are of great significance, given the need to work together in flatter, more complex environments, with an emphasis on inter-personal, team work, as well as cross-cultural skills. Moreover, in response to the digitalisation of engineering, the vision emphasises the need for digital skills attainment, such as advanced analytics, entrepreneurial thinking, and cybersecurity skills.

On the other hand, **the activities of the AGUPP are also quite extensive**. These include academic cooperation (offering workshops that focus on strategic competencies (technical and soft skills), developing the digital competencies of universities and students, developing online and on-site training courses), innovation (three research centres in the UK and Spain and the Airnovation Summer Academy at TU Delft), network development and engage in campus activity to promote the company in Sweden, Germany, the UK, France, Spain, and Italy[59].

[58] The Engineer of the Future – White paper 2018
[59] https://www.airbus.com/content/dam/corporate-topics/corporate-social-responsibility/Airbus%20Annual%20Report%202016%20Final.pdf

4.3.1.2. The EU 2030 High-Tech Skills Vision alignment



Airbus' skills vision, as well as AGUPP's activities, excel on these particular EU High-Tech Skills Vision dimensions:

Inclusive – Airbus acknowledges the role of diversity, and targets a multi-cultural, gender-equal labour force, which offers the same opportunities for development and employment to all categories of students.

Participatory – The vision and its implementation is based on stakeholder consultations, particularly with academic partners, butalso includes desk research and other expert discussions.

Inspiring – The whitepaper defines the necessary attributes and skills of the future leaders in engineering, which is necessary for a company that takes a forefront role in innovation. This also helps the academic partners in becoming more relevant.

Anticipatory – The vision is forward-looking, setting the agenda for the medium-term, and tries to integrate emerging technologies and the corresponding needed skills in their action plan.

4.3.1.3. Key insights for the Skills for Industry Strategy 2030

This initiative serves as a best practice case for companies aiming to assess their skills needs and for defining the subsequent action plan to tackle the gaps observed. This approach can be applied to various levels of implementation, actors and industries. With regards to the Toolbox, the following points can be highlighted:

Module	**Stakeholders**	
	Companies	*Universities*
Skills Strategy	Consult a wide body of stakeholders and resources to understand the relevant trends Develop a skills vision based on well-defined dimensions and elements	Contribute extensively to the development of the vision Help the corporate partners implement the strategy at academic level
Leadership and Governance	Take a leading role in setting up the vision and the agenda	Be proactive in partnering with corporates and in implementing the agenda
Industry-led training infrastructure	Develop thorough online and offline training resources for students	Offer support in developing the training resources Integrate these trainings in the curricula
Communication	Organise regular communication and meetings with the academic partners	

4.3.1.4. Transferability, replicability and scalability

Given the relatively simple model of cooperation, other companies and universities could partner to set a common vision and subsequently train talent:

Transferability – Companies in industries with emerging skills gaps and talent shortages could easily implement strong collaboration networks with universities to address these problems. The company would need sufficient financial and human resources to develop a value-adding network and to support its continuity. Nevertheless, a one-time skills strategy definition would be highly feasible.

Replicability – Although the initiative may be highly transferable to other contexts, its replicability will depend on the resources available.

Scalability – Given Airbus' Future Engineer and AGUPP global scope, similar initiatives to define company skills strategies and to collaborate with academic institutions to develop the required talent, could be considered at the local, regional, national or EU level.

4.3.1.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by companies willing to create a similar initiative:

Impact Level	Challenges
High	Companies need to receive enough support and insights from academic partners to justify the efforts made. At the same time, companies will need to freely share their knowledge to encourage academic participation.
High	The action plan requires a significant amount of resources which limits the feasibility of similar initiatives.
Medium	The defined skills strategy points may be difficult to operationalise at university level.

Despite these challenges, several **success factors** are likely to increase the success rate of an alliance with similar initiatives:

Impact Level	Success factors
High	This sufficiently large network of partnerships will add value to the activities of all actors involved.
High	The initiative leverages on existing expertise and insights thus strengthening the competitiveness of the sector/industry while identifying existing talent.
Medium	The definition of a clear implementation plan encourages a more active participation from academic institutions.

4.3.1.6. Take away messages

- *Private sector organisations have to regularly consult relevant stakeholders to define a skills strategy for their company.*
- *The elaborated skills strategy can guide all collaboration and promotion activities conducted with academic institutions and students.*
- *A wide array of activities focusing on innovation and research, trainings, consultation events and promotional efforts can contribute to the implementation of the defined strategy.*

4.3.2. Allianz Industrie 4.0 – Learning Factories 4.0

Organisation name	State of Baden-Württemberg
Type of organisation	Public / Cluster
Level of implementation	Regional

4.3.2.1. Description

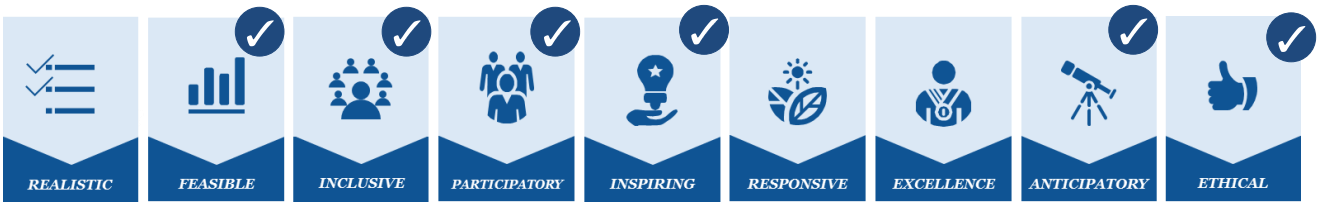
Allianz Industrie 4.0, launched by the State of Baden-Württemberg, is an organisation with **the aim to share resources and know-how of production, information and communication technologies to help businesses in their digital transformation process.** Allianz offers a platform to promote partnerships. The objectives of this platform are to: (1) provide advice and support to SMEs to find their own way into the industrial future, (2) to strengthen innovation processes, as well as (3) to encourage collaboration between industries and technological sectors.

Within the Allianz Industrie 4.0, Learning Factories 4.0 is one of the most prominent and effective initiatives. In the context of digital transformation and the subsequent skills gap, the Learning Factories are government-backed labs implemented in vocational schools. They have two objectives: (1) **to teach students and train employees by providing real-life practice opportunities**; (2) **to act as a research factory for demonstrating and testing new technologies and approaches.** The learning factories have simplified systems, are cost effective and have a smaller footprint. They have been established in 16 training centre projects in vocational schools across Baden-Wurttemberg, involving 30 vocational schools and 250 companies and industrial organisations[60]. The regional government of the land supports the investment costs, the expenses related to teacher trainings, and other associated costs. The estimated budget of the initiative is around EUR 6.8 million[61]. A second call of the development programme was announced in 2018, and as a result a further 21 project have been started in February 2019. By autumn 2021, they will be integrated into the corresponding education and training programmes of the schools. Business enterprises, universities and other institutions as well as business organisations have participated in the individual concepts and supported the learning factories.

For the training part, the learning factories cover three categories of skills: (1) technical skills, such as automation, control and programming; (2) transformation skills; and (3) social skills[62]. Modular, digitally-controlled learning systems are used to provide a simple and safe introduction to components of industrial manufacturing processes. In addition, an interlinked machine system is used to provide training in intelligent production processes on the basis of real industrial standards. The labs further serve the additional purpose of acting as 'showrooms' or research facilities, allowing information and demonstrations about Industrie 4.0 manufacturing technologies for companies, particularly SMEs.

[60] https://www.industrie40.ihk.de/produktmarken/qualifizierung/Die-Lernfabrik-4_0/2736766
[61] http://www.i40-bw.de/de/lernfabriken-4-0/
[62] Burkhard Schallock, Christoffer Rybski, Roland Jochem & Holger Kohl. "Learning Factory for Industry 4.0 to provide future skills beyond technical training". (2018).

4.3.2.2. The EU 2030 High-Tech Skills Vision alignment



The Learning Factories 4.0 is a representative initiative with regards to the devised Vision, particularly on the following dimensions:

Feasible – The initiative has a clear budget, implementation agenda, and addresses specific skills by using a clearly designated training process and procedures.

Inclusive – By implementing the initiative through regional vocational schools, and by allowing SMEs, employees and researchers to make use of the levels of support offered, Learning Factories 4.0 target different audiences with varying levels of skills.

Participatory – The programme was implemented by the regional government with the support of a wide set of stakeholders (e.g.universities and academics, leading companies in the region, other associations).

Inspiring – Implemented at the regional level, Learning Factories 4.0 ensure that the skills needs ot the local economy are met, thus contributing to the further economic development of Baden-Württemberg.

Anticipatory – By focusing on the implementation of emerging technologies and applications, the talent pool developed will ensure the continued competitiveness of industry and facilitate the anticipation of changes in the sector.

4.3.2.3. Key insights for the Skills for Industry Strategy 2030

The target groups of Learning Factories 4.0 are: (1) engineering apprentices in dual training courses, (2) participants in technical training courses, continuing education courses and training courses offered by medium-sized companies. Government, companies and universities thus assume a defined set of responsibilities:

Module	**Stakeholders**		
	Government	*Companies*	*Universities*
Talent detection and nurturing system	Elaborate new training methodologies that correspond to emerging technological needs	Contribute to the trainings by offering real case studies and applications	Integrate the trainings in vocational training curricula
Industry-led training infrastructure	Support the integration of new teaching methods and emerging topics, such as Industry 4.0, in VET	Integrate VET in more forward-looking topics and areas	Offer students in VET enough theoretical support in these emerging technologies
Funding	Support the implementation of such labs with enough funding and consider increasing the budget in case of success		

4.3.2.4. Transferability, replicability and scalability

The following points might be considered to assess the transferability, replicability and scalability of this best practice:

Transferability – Similar initiatives may be implemented in different regions and targeting differing industries.

Replicability – The replicability of the programme heavily depends on the active leadership of the region and the presence of businesses with sufficient expertise to encourage the exchange of knowledge.

Scalability – The initiative could be implemented at national level if a unifying target area has been clearly defined and a strong collaboration between government, academia and industry is possible.

4.3.2.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by public authorities willing to set-up a similar initiative:

Impact Level	Challenges
High	The large variety of skills to be developed through the learning labs can lead to complications at the organisational (teaching) level.
Medium	The offered trainings need to be aligned with the actual future applications of the methods/systems in the final workplace.
Medium	SMEs need to be convinced of the added-value their participation to thee labs will create.

Despite these challenges, several **success factors** are likely to increase the success rate of an alliance with similar initiatives:

Impact Level	Success factors
High	The Learning Factories allow for the combination of theoretical with practical training.
High	The active implication of businesses ensures a sufficient number of real practical cases to be tested by the students.
Medium	The trainings are given by actual users of the methods/systems in question.
Medium	A sufficient number of companies use the labs which generates useful knowledge.

4.3.2.6. Take away messages

- *Regional authorities can establish and finance innovative vocational trainings systems, based on new emerging Industry 4.0 principles.*
- *Strong collaboration with education organisations and private sector ensures the wide implementation and use of the labs.*
- *A simulation of the real working environment helps train not only technical skills, but also social and transformation skills.*

4.3.3. AFIL – Associazione Fabbrica Intelligente Lombardia

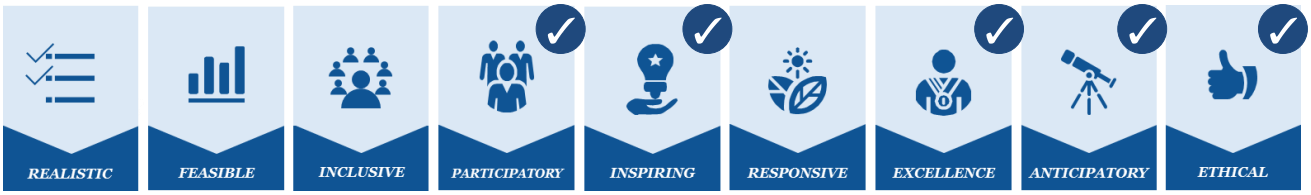
Organisation name	AFIL
Type of organisation	Cluster
Level of implementation	Regional

4.3.3.1. Description

AFIL, or Associazione Fabbrica Intelligente Lombardia, is the cluster for advanced manufacturing in the Lombardy region. It acts as an **intermediary between companies, universities and the regional government of Lombardy.** Set up on the initiative of the Lombardy Regional Authority, the cluster aims to foster research and innovation in the advanced manufacturing sector. It **promotes best practices and enabling technologies** among companies to support and develop **the leadership and competitiveness of the Lombard productive system**. The objective is realised through a collaboration between 145 (122 companies of which around 80 are SMEs, 14 universities and 9 associations) network members who work on priority areas identified by the Regional Smart Specialisation Strategy (S3)[63]. AFIL has set for itself three roles: (1) set up a stable community of stakeholders; (2) be the reference actor in the region for defining the Research & Innovation strategies in manufacturing; (3) develop an interregional network of collaboration through the National Intelligent Factory Cluster and S3.

AFIL stresses the **importance of sharing knowledge between companies** in order to improve their competitiveness. To do this, AFIL has set up the community, has defined a strategic roadmap for manufacturing, creates thematic groups based on this strategy and implements cooperative projects to deploy innovative solutions. Some of the services provided by AFIL include facilitation of collaboration between members, trend scouting (ideas for innovative projects), periodic information dissemination, and support of technology transfer. The partners work on four thematic groups, which are: (1) de- and remanufacturing; (2) digital and intelligent factory; (3) additive manufacturing; and (4) materials and surface treatment. Several projects have since been implemented, most of them with financing support from the EU, such as Digit-T, a project addressing the Industry 4.0 challenges, or Smart Space, which supports digitization and innovation in alpine areas[64].

4.3.3.2. The EU 2030 High-Tech Skills Vision alignment



The AFIL initiative indirectly relates to the Skills Vision, as it does not directly address the skills development or training of either students or employees. Instead, the cluster targets companies as the main beneficiary, which means that the thematic groups and the cooperative projects represent a learning opportunity for companies. In turn, this would positively affect the qualifications of the employees, thus increasing the competitiveness of the region as well.

Participatory – The cluster functions by ensuring the collaboration between industry, universities and research centres, and government. This creates a network in which all relevant stakeholders can provide useful input.

[63] https://www.afil.it/?lang=en
[64] https://www.afil.it/progetti-iniziative/smart-space-eng-qr/?lang=en

Inspiring – The initiative has the aim to increase Lombardy's competitiveness at both national and European level, as well as to support the innovation processes that can lead to sustainable growth for companies.

Excellence – Even though Lombardy is one of the leading Italian regions in economic competitiveness and innovation, AFIL nonetheless helps materialise projects that can boost the region's status at European and global level.

Anticipatory – AFIL focuses on smart manufacturing innovation, which covers elements from the Circular Economy, Industry 4.0 and other emerging themes that are likely to require new skills and new capabilities to be developed by companies.

4.3.3.3. Key insights for the Skills for Industry Strategy 2030

The AFIL initiative can inform policy-making at the following levels and for the respective stakeholders:

Module	**Stakeholders**			
	AFIL	*Companies*	*Universities*	*Government*
Skills Strategy	Define, together with the other stakeholders, a roadmap of priorities	Participate in crafting an agenda for addressing new technologies	Participate in crafting an agenda for addressing new technologies	Participate in crafting an agenda for addressing new technologies
Funding	Access state and EU funds to implement projects	Participate in funding relevant projects		Contribute to the financing of projects
Leadership and governance	Take a coordinating role in managing the network			

4.3.3.4. Transferability, replicability and scalability

Given the collaboration structure, AFIL grants successful applications in other EU regions and industries. This is based on the following assessments:

Transferability – A similar structure and agenda setting can be implemented at the initiative of other regional governments willing to push the competitiveness of a particular sector.

Replicability – Replication of this association and its programme could be possible in a context with enough universities, research centres and companies that contribute to a certain level of innovation in an industry.

Scalability – The initiative may be scaled up to national and European level, as long as regional specificities remain at the heart of the efforts made.

4.3.3.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Companies need to be convinced of the added value their collaboration and exchange of knowledge will bring to their business as well as the regional industry.
High	Industry and regional needs have to be aligned and a common strategy be developed to address the challenges observed.
Medium	Working with SMEs can be difficult given the management's more stability-focused mind-set.

Despite these challenges, several **success factors** are likely to increase the success rate of the initiative:

Impact Level	Success factors
High	By collaborating and joining forces, new innovative projects can be developed and implemented.
High	Increased regional stakeholder involvement facilitates collaboration and ensures the implementation of long-lasting improvements.
Medium	Collaboration with other clusters can enhance the knowledge transfer and added value of the cluster.

4.3.3.6. Take away messages

- *Regional authorities can initiate similar platforms for collaboration and catalysing innovation in line with the regional specialisation strategies, especially for SMEs.*
- *Besides improving local competitiveness, the cluster can take part in cross-national projects to achieve its goals and foster wider collaboration.*
- *More bottom-up initiatives can be combined with top-down strategy creation and innovation to meet the needs of both industry and government.*

4.3.4. Bosch Center for Artificial Intelligence

Organisation name	Bosch Center for Artificial Intelligence
Type of organisation	Private
Level of implementation	National / Global

4.3.4.1. Description

The Bosch Centre for Artificial Intelligence (BCAI) is a multinational programme with locations in Germany, USA, Israel and India to advance the usability of Artificial Intelligence (AI) across multiple products and services. Next to advancing the state-of-the-art of AI research and making AI more robust, secure, safe and explainable, this programme creates a short way from R&D to adoption at Bosch, with its wide range of products from white goods to autonomous driving in its more than 250 production locations. Bosch will invest €300 million in the initiative until 2021[65].

The BCAI, as the Bosch internal competence centre, offers in-house consulting, training and support in applying AI in all Bosch entities. To facilitate world-class research, as one success factor, one key element of the programme represents **collaboration with academic institutions**. Bosch has partnered with Carnegie Mellon University in the US with Technion in Israel, and with the University of Amsterdam and University of Freiburg in Europe. Additionally, Bosch is a founding member and core partner of the Cyber Valley, which includes as academic partners the University of Stuttgart, the University of Tübingen and the Max Planck Institute for Intelligent Systems[66]. Part of the Bosch commitment in the Cyber Valley is the creation of a Bosch-endowed professorship focusing on machine learning at the University of Tübingen, a €5.5 million support over ten years[67]. Furthermore, Bosch will invest €3 million to create the "Delta-Lab" centre in Amsterdam. The overall aim of Bosch AI research is **to promote stronger exchange between fundamental and applied research through knowledge transfer**, thereby generating new knowledge and innovations[68]. The collaboration between researchers delivers findings that are published in leading academic conferences and journals. One focus of this research is on deep learning and its applications in automotive applications and computer vision. A second focus is on reinforcement learning and its applications in manufacturing. Bosch AI Research presents its work at most international leading AI conferences. In fact, some findings have been implemented already in the form of applications and products, such as improved quality monitoring systems and process data analysis.

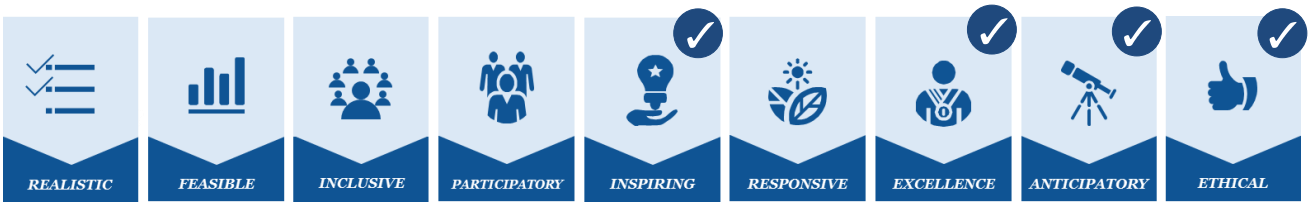
To further promote the collaboration between industry and academic research, Bosch, in cooperation with Cyber Valley, hosted the first AI CON[69] in 2018 – a dedicated AI research conference in Europe that brings together expert researchers from industry and academia. The conference will be held again in 2019. The Bosch AI Young Researcher[70] Award was launched in 2019 – offering €50 thousand in prize money for outstanding achievements in AI research that contributes to making AI safe, robust, and explainable. Researchers who have received their PhD within the last six years and are employed at a European university or another non-profit research organization can apply.

---

[65] https://www.bosch-presse.de/pressportal/de/en/artificial-intelligence-bosch-and-university-of-amsterdam-to-cooperate-closely-98944.html
[66] https://cyber-valley.de/en
[67] https://www.bosch-presse.de/pressportal/de/en/cyber-valley-top-researcher-matthias-hein-appointed-bosch-endowed-chair-160576.html
[68] http://www.uva.nl/en/content/news/press-releases/2017/04/uva-and-bosch-launch-joint-lab-for-research-into-deep-learning.html?1551192858572
[69] https://www.bosch-ai.com/ai-con/
[70] https://www.bosch-ai.com/young-researcher-award/

In terms of skills and talent development, **the programme and these initiatives support the development of experts on AI**, as these PhD students benefit by working with both academia and industry to advance their research. Moreover, from Bosch's side, **the employees also have the opportunity to develop their skills and expertise in AI**, contributing to a lifelong learning aspect. This creates a basis for forming more expert on AI and machine learning on both sides.

4.3.4.2. The EU 2030 High-Tech Skills Vision alignment



BCAI's objective to advance AI research and its implementation scheme through deep collaboration with academic institutions supports some dimensions of the defined Vision:

Inspiring – The various cooperations in Europe (Delta Lab, Freiburg, Cyber Valley) promote the nurturing of AI experts within the EU, thus strengthening Europe's expertise and competitive advantage in the field.

Excellence – The creation of a research lab in Amsterdam as well as the Bosch-endowed chair at the University of Tübingen support the development of relevant expertise in the EU and strengthen its competitiveness with respect to the international competition.

Anticipatory – The programme focuses on advancing state-of-the-art knowledge on AI, which is likely to be one of the key industries to define the future competitive advantage of companies, regions and countries as a whole. Moreover, BCAI tests potential applied solutions, particularly smart mobility and IoT, which again are important emerging industries.

4.3.4.3. Key insights for the Skills for Industry Strategy

The programme, besides helping advance AI research, indirectly represents a nurturing system to develop talent in this field, specifically by supporting both PhD students and Bosch's employees in developing their expertise in AI. The initiative can thus serve as an example for companies and/or academic institutions to develop talent in emerging fields.

Module	**Stakeholders**	
	Companies	*Universities*
Talent detection and nurturing system	Offer employees the opportunity to work and share knowledge with academic institutions Offer students from partner universities the opportunity to work on company-site	Create curricula and opportunities for students to work with industry
Funding	Invest in such programmes, as they both develop the knowledge base of the firm and trains in-house talent	Consider contributing to research labs, possibly by receiving public funding if needed
Industry-led training infrastructure	Offer practical cases for researchers	Be flexible with students working on company applications of findings

Communication	Ensure effective communication is held with the university in setting up the agenda of the common lab/structure

4.3.4.4. Transferability, replicability and scalability

Given the relatively simple model of cooperation, other companies and universities could partner to advance research and train talent. Implementation would be possible assuming:

Transferability – The partnership model underlying BCAI is relatively simple, with the company providing the necessary funding. Therefore, other companies could implement such alliances. However, the common objective should be based on an emerging, complex topic, if the aim of the collaboration is to develop world-class knowledge and talent.

Replicability – Although the initiative may be highly transferable to other contexts, its replicability would be rather difficult, as Bosch and the mentioned academic partners are some of the leading organisations in the field of AI. Therefore, the partnering organisations have to be leading institutions in the respective field in order to create valuable knowledge sharing between experts.

Scalability –Assuming that the initiating company has sufficient resources at its disposal, similar initiatives could be scaled-up to the international level or down-scaled to the regional/city-level.

4.3.4.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by companies willing to create a similar initiative:

Impact Level	Challenges
High	A sufficient number of universities suitable for collaboration needs to be identified.
High	The developed knowledge may not be applicable outside the company's operations.
Medium	Students and employees need to interact sufficiently to facilitate the exchange of knowledge.

Despite these challenges, several **success factors** are likely to increase the success rate of an alliance with similar initiatives:

Impact Level	Success factors
High	The close collaboration between research students and experts active in the field might lead to the identification of complementary findings advancing the overall expertise of all actors an industries targeted.
High	Students that receive sufficient support will inevitably contribute to the production of new knowledge and advance the competitiveness of the industry.
Medium	Motivated employees that are willing to exchange their knowledge with students will benefit from new inspiration and the latest academic findings.

4.3.4.6. Take away messages

- *Companies willing to expand their knowledge base can collaborate with academic institutions to research advanced, emerging systems/technologies.*
- *This collaboration is two-way since it supports the development of future experts in the respective field but also trains current company employees.*
- *The programme has to include both academic and practical components, with the latter being offered by the company.*
- *Such a collaboration between leading companies and universities can generate sufficient world-class knowledge and innovation.*

4.3.5. Brainport Development

Organisation name	Brainport Development
Type of organisation	Triple Helix
Level of implementation	Regional

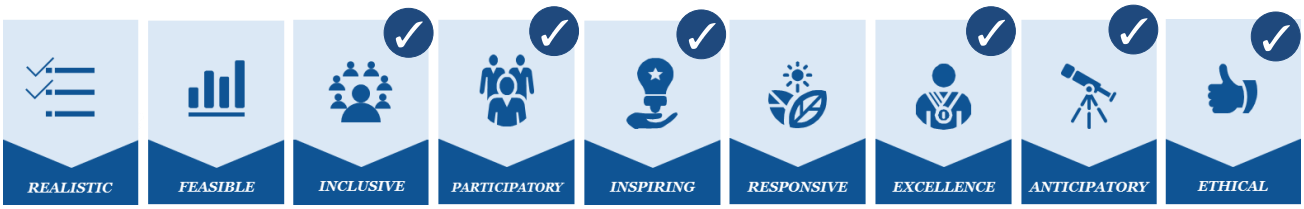
4.3.5.1. Description

Brainport Development is the regional economic development organisation of the Brainport Eindhoven economic region working with industry, research institutions and public authorities in a Triple Helix model. The agency **has the mission to strengthen the region's competitiveness at a global level**, which is a key area for the Dutch and even the European economy, mainly due to its successful concentration of companies in the high-tech systems & materials industry, food, health, mobility and design industries[71].

In its essence, **the organisation creates knowledge sharing networks, offers business advice and support, and implements projects that aim to solve company-wide issues**. The agency thus divides its roles and activities in five sectors: (1) strategy; (2) projects and programmes; (3) communication; (4) business services; and (5) SME services[72]. In terms of developing networks, Brainport Development develops clusters and business incubators for a group of companies in need of a strong collaboration. Brainport Development focuses on the setup and emerging stages of cluster development, with the successful ones spinning off and becoming self-sustainable organisations.

Besides the extensive work done on developing clusters and supporting companies, **Brainport Development has also developed a strategy to address the education and labour market challenges of the region**, which are considered crucial in maintaining the leading position of the region. Therefore, the National Action Agenda formulated by the agency focuses on creating an action plan for the region's stakeholders. The key points are: (1) increase availability of tech and IT (inter) national talent; (2) future skills and education innovation; (3) hybrid learning environments; and (4) lifelong development[73]. This agenda has been supported by joint agreements that ensures the stakeholders' commitment to these points.

4.3.5.2. The EU 2030 High-Tech Skills Vision alignment



Given its mission to support a region to sustain its global champion status, which includes a qualified labour force, Brainport Development is primarily aligned with the following Vision dimensions:

Inclusive – The skills strategy formulated by the agency and its partners refers to all levels and types of education, including vocational trainings, which ensures that everyone has access to IT & tech qualifications. Moreover, the strategy includes both international and local talent, which creates opportunities to attract expats and foreign students.

[71] https://www.clustercollaboration.eu/cluster-networks/brainport-development
[72] https://www.photondelta.eu/partners/brainport-development/
[73] https://www.brainport.nl/uploads/documents/BPE-18014-Akkoord-A4-Engels.pdf

Participatory – Brainport Development is operating based on the Triple Helix model, which engages the private sector, academia and the government. This model fosters cooperation, which enables a more open basis for strategy realisation. Moreover, the new strategy of the agency defines a more flexible and adaptive structure defined as Multi Helix, which will include citizens, customers, investors, artists and others[74].

Inspiring –The agency's objective translates into more effort from industry and academia to innovate and develop new technologies, besides developing the required talent.

Excellence – The agency has the objective to facilitate and conduct all necessary activities that will strengthen Brainport Eindhoven's competetiveness at EU and global level. The development of more tech specialists underlies this ambition to compete at global level.

Anticipatory – By focusing on industries that are likely to significantly grow and evolve in the future, namely high-tech and smart materials, food, health, mobility and design industries, Brainport Development encourages innovation and more talent development in these fields.

4.3.5.3. Key insights for the Skills for Industry Strategy 2030

Although the agency operates at a relatively high level with respect to skills strategy, the existing initiatives can still offer valuable insights for the formulation of a relevant Toolbox, particularly on supporting SMEs and world-class innovation. The following actions can be undertaken by the relevant stakeholders to improve the competitiveness of the labour force:

Module	**Stakeholders**			
	Brainport Development	*Companies*	*Universities*	*Government*
Skills Strategy	Develop a dedicated skills strategy that gathers the support and commitment of all stakeholders concerned	Commit to offering sufficient levels of in-house training to support lifelong learning	Be flexible enough to adapt curricula to emerging trends and industry needs	Offer regulatory support that facilitates the implementation of the regional skills strategy
Industry-led training infrastructure	Encourage companies to offer more in-house training	Offer in-house and hybrid trainings to update employee skills Offer infrastructure and resources that support lifelong learning	Consider including company trainings in university curricula	Support more in-company trainings as part of the traditional education system
Leadership and governance	Assume a coordinating role			

[74] https://brainporteindhoven.com/wp-content/uploads/2018/01/Welcome-to-Brainport-2017.pdf

4.3.5.4. Transferability, replicability and scalability

Given the success of the model and its overarching view on developing a region, Brainport Development grants successful applications in other EU regions. This is based on:

Transferability – The partnership model underlying Brainport Development, namely the Triple Helix, could be successfully applied in other settings. Bringing together the needs of industry and expertise of universities could be beneficial to other European regions. The requirement would be a significant number of corporates and universities that could exchange valuable knowledge and create added value for the region.

Replicability – The initiative is highly replicable in other countries. The enabling conditions would require a strong willingness of companies and education institutions to cooperate and share knowledge, sufficient governmental support, and the identification of areas of potential competitiveness for the region.

Scalability – A similar agency could be organised at national level. Nevertheless, the coordination required would be higher and more complex, with significant resources having to be dedicated to management, communication and expertise development. In terms of defining a skills strategy, a similar initiative could be envisioned at national level.

4.3.5.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Organisations may not clearly understand the value of cluster memberships which would require a significant amount of communication among different stakeholders.
High	Companies often underestimate the importance of trust-building and cooperation which will require a shit in mind-set.
Medium	Significant time may be needed for clear member benefits to develop.

Despite these challenges, several **success factors** are likely to increase the success rate of an agency with similar initiatives:

Impact Level	Success factors
High	The identified action points of strategies, including skills, can be implemented at once.
High	Cluster managers can build a strong community while gaining in-depth knowledge of the industry.
Medium	Proximity enables increased interaction which again favours a regional approach.
Medium	The active contribution of each member to the initiative increases commitment levels and encourages continued support.

4.3.5.6. Take away messages

- *Clusters can support leading regions in specific industries to enhance cooperation and knowledge transfer.*
- *By having a helicopter-view on the entire region's economic activity, development agencies can work with the relevant stakeholders, namely companies, universities and the government, to define a regional skills strategy.*
- *All stakeholders need to commit to the formulated strategy and the subsequent action points in a concerted approach.*

4.3.6. Bridge - Building the Right Investments for Delivering a Growing Economy

Organisation name	City of Rotterdam
Type of organisation	Public
Level of implementation	City/Regional

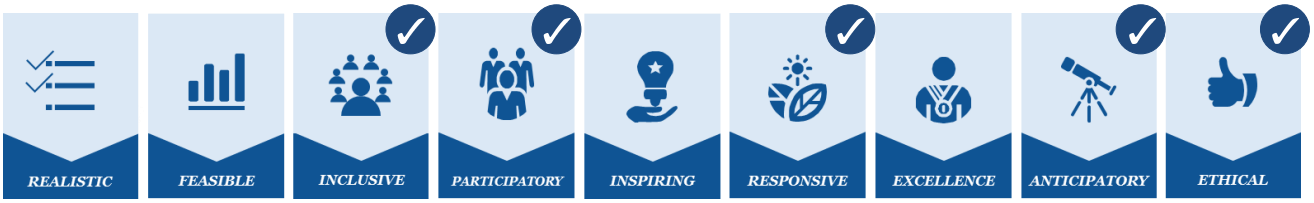
4.3.6.1. Description

The initiative "Building the Right Investments for Delivering a Growing Economy" (BRIDGE) is a project carried out by the city of Rotterdam in close collaboration with industry partners and education institutions. It aims to **prepare students in vocational education** from the South of Rotterdam region **for the future labour market**, with a focus on stimulating the following career paths - engineering, healthcare, maritime, food, construction and logistics.

The programme directly targets the Green Digital Economy and the opportunities created in major growth sectors. It provides a **regional skills agenda,** and serves as a call to action to **reform the vocational education system**. Furthermore, by having a finite timeline (2016-2019), the initiative's main role is to experiment on the most effective ways to **connect with students** and to encourage a **deeper collaboration** between **employers and schools**, especially with regards to the **promotion of available career choices to youth**.

The career and talent orientation programme starts in primary school (age 9) and ends with the students' entry to the labour market. BRIDGE targets that by 2020, 600 pupils per year in Rotterdam Zuid following vocational education choose a specialisation in technology sectors (35%) and health (15%), and that those pupils have a guaranteed job after graduating[75]. In fact, employers will offer 600 pupils per year a Career Start guarantee (420 for technology sectors and 180 for healthcare) the moment they enter secondary vocational education. Provided that the pupil chooses the trainings required to meet labour market needs, an employer will commit in advance to that individual with a guaranteed career start after graduation. Students will thus be encouraged at an early stage to acquire the skills required by industry while employers will be given the opportunity to become actively involved in the continuous skilling of their employees.

4.3.6.2. The EU 2030 High-Tech Skills Vision alignment



The BRIDGE initiative is aligned with the formulated Vision primarily on these dimensions:

Inclusive – By focusing on the most deprived district of Rotterdam, BRIDGE offers disadvantaged youth the opportunity to be better prepared for the future demands of employers and thus improve their social and economic status in the long run.

Participatory – The initiative is led by a steering group, which coordinates the interaction with schools and employers, and is responsible for monitoring and evaluating the interventions as well as the impact of the programme on the region, with the assistance of academics from Erasmus University. The initiative thus involves multiple stakeholders: employers, teachers, parents, authorities and education institutions. This ensures that the interests of each actor are taken into account and that their goals are aligned.

[75] https://www.uia-initiative.eu/en/uia-cities/rotterdam

Responsive – The initiative excels in being socially responsive. By targeting Rotterdam Zuid, BRIDGE focuses its efforts on a disadvantaged region whose students require greater support to acquire the skills required by industry and thus ensure their future employability.

Anticipatory – BRIDGE is forward-looking by encouraging careers in sectors with high-growth potential, such as tech, health and logistics.

4.3.6.3. Key insights for the Skills for Industry Strategy 2030

Based on its alignment with the EU 2030 Skills Vision, this best practice case can inform the relevant stakeholders on particular dimensions of the Toolbox at city and regional level. Given the scope of the programme, the following stakeholders have been identified as key to the programme's implementation: the steering group, employers, city authorities and the schools.

Module	**Stakeholders**		
	Steering group	*Employers*	*Schools*
Talent detection and nurturing system	Define a clear intervention programme for each school Monitor and evaluate the impact of the interventions	Offer career-start guarantees, trainings and company visits Be open to new initiatives	Recognise and increase the importance given to career guidance Support teachers in their efforts
Leadership and Governance	Assume leadership and encourage school-employer interaction	Take an active role in the programme	Be open to implement the interventions
Funding	Explore sustainable financing models beyond EU funds		
Communication	Elaborate a dissemination strategy to help children and inform teachers	Participate in defining the future skills needs	

4.3.6.4. Transferability, replicability and scalability

Given its alignment with the EU 2030 Skills Vision and the Toolbox, this best practice case serves as an example for other cities to facilitate the collaboration between employers and education institutions with the goal to guide and help pupils in choosing their career paths:

Transferability – The model and interventions can be transferred to other contexts and tailored to local stakeholders, socio-economic distributions and leading industries.

Replicability – Other cities and regions might consider introducing similar initiatives given the necessary support and collaboration between government actors, schools and employers.

Scalability – Given the regional embeddedness and resource-intensiveness of the initiative, this best practice can best be implemented at local (city) or regional level.

4.3.6.5. Potential challenges and success factors for implementation

To be able to implement a similar initiative, several success factors and potential challenges have been identified.

Based on the most recent evaluation reports, the following **challenges** have been observed:

Impact Level	Challenges
High	Monitoring and impact evaluation is difficult given the variety of interventions and engagement levels of schools to assess.
High	Difficult to implement without a financially viable model, which may limit long-term implementation.
Medium	Stakeholders, especially schools and employers, may not be willing to fully commit and their active participation might thus be limited at instances.
Medium	Coordination across stakeholders requires significant human resources and efficient communication strategies.

Besides addressing such challenges, some **success factors** have been identified:

Impact Level	Success factors
High	Significant investment in improving relationships between schools and employers which leads to long-term improvements in career guidance.
High	Investments in teachers' qualifications which increases their motivation to guide children and inevitably results in a better support system for students.
Medium	Design of an effective and convincing career guidance model.
Medium	Ensure higher employer buy-in in such programmes which will encourage the further reform of the vocational training system.

4.3.6.6. Take away messages

- *Municipalities should be encouraged to create associations that enhance the collaboration between industry and education institutions.*
- *Career guidance and trainings have to be offered at an early stage and schools supported in implementing new methodologies.*
- *Youth from disadvantaged groups should be increasingly included in the ongoing re/upskilling process.*

4.3.7. Cisco Networking Academy

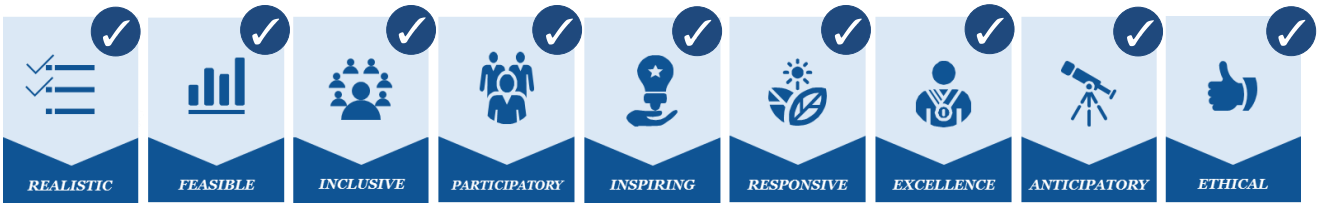
Organisation name	Cisco Networking Academy
Type of organisation	Private
Level of implementation	National / Global

4.3.7.1. Description

The Cisco Networking Academy is an **IT skills and career-building programme for learning institutions and individuals worldwide**, providing education, technical training and career mentorship services. Currently present in all 28 Member States, the programme is a pillar of Cisco's corporate social responsibility policy, and delivers classroom instruction, online teaching materials, interactive tools and hands-on learning to students from all socioeconomic backgrounds. The main themes covered by the courses are: networking, programming, IoT, cybersecurity, operating systems and entrepreneurship.

Since its inception in 1997, over 9 million students in 188 countries have been through the programme, with about 2.2 million in Europe alone[76]. In this way, the program delivered 424.300 Cisco-certified career ready students (IT-Professionals) to the labour market. While online content and courses are also available, the majority of content is delivered in person through affiliated education institutions in local communities, of which there are 4,265 courses and 8,770 educators in Europe. The total in-kind contribution in Europe amounts is more than €800 million. The program is basically offered for free to all students. Despite its small start in 1997, the academy has now developed into an organisation that creates a community of all relevant stakeholders: other companies (e.g. IBM and Verizon), universities, government agencies and educators, and has set ambitious targets: bring the benefits of digitisation to 1 billion people by 2025. In the EU, Cisco has pledged to train 1 million students in the period 2017-2020 (4 years)[77]. For instance, Cisco has joined the European Commission partnership Grand Coalition for Digital Jobs. The programme has also built an extensive network of Academy Support Centres and Instructor Training Centres, training not only students but also teachers.

4.3.7.2. The EU 2030 High-Tech Skills Vision alignment



The initiative is a flagship model of industry-led training of digital skills. Cisco Networking Academy is thus aligned with the Vision primarily on the following dimensions:

Realistic – The programme, through its extensive experience, has developed demonstrably trainings that achieve the desired results.

Feasible – Cisco Networking Academy has set clear targets, budget and timing to continue growing the organisation and its impact.

Inclusive – The wide scope and the impressive results achieved at both global and European level by the programme speak for themselves.

[76] https://www.netacad.com/web/eu/impact-profile/
[77] http://pledgeviewer.eu/pledges/cisco-networking-academy-17.html

Participatory – The programme collaborates with other companies, government agencies and educators around the world, creating a participatory community where stakeholders contribute and benefit.

Inspiring – The programme has a wide impact on encouraging high-potential careers.

Responsive – Being part of Cisco's CSR efforts, the Networking Academy represents an effort of the company to contribute to social development by focusing on skills development and addressing the skills gap in the IT sector.

Excellence – Based on Cisco's expertise and resources, the Academy is able to provide world-class, career-ready knowledge and experience.

Anticipatory – The course catalogue is updated in line with the future needs of industry (but also for non-IT students in health care, infrastructure, legal tech), ensuring the provision of state-of-the-art trainings.

4.3.7.3. Key insights for the Toolbox

The initiative's success can help other programmes by providing insights on the following Toolbox modules:

Module	**Stakeholders**		
	Cisco Networking Academy	*Universities/vocational/ secondary educational institutions*	*Other companies, state authorities*
Talent detection and nurturing system	Liberate the necessary resources to offer relevant courses and encourage lifelong learning	Encourage the participation of students to innovative training concepts/methods	Support the development of new training methods/concepts
Funding	Invest in the development of trainings and the skills of employees/students	Accept collaboration as the programme is offered for free	Support the provision of new training programmes at city, regional, national level
Leadership and governance	Take a leading role in building and managing the community	Partner with companies offering innovative and proven trainings Offer support to the educators' trainings	Support industry-led training initiatives
Industry-led training infrastructure	Leverage on existing expertise and knowledge to develop up-do-date and relevant trainings	Encourage the participation of students to industry-led training initiatives (e.g. certification system)	Support the participation of students to industry-led training initiatives

4.3.7.4. Transferability, replicability and scalability

The initiative has had notable success globally, as well as in the EU. For companies or authorities willing to build a similar community, one must take in consideration that this worldwide ecosystem has 20+ years of knowledge and experience. Copying is therefore complex. However, partnering with Networking Academy is a promising possibility. This would depend on:

Transferability – Similar initiatives may be implemented at city, regional, national level, and for various industries depending on the resources available.

Replicability – The programme could be replicated by others assuming a high level of expertise in the field and the availability of sufficient funds to invest in the development of trainings.

Scalability – Similar initiatives, where stakeholders work together under private investment and leadership, could be implemented at smaller scales to have a local impact on the IT labour market.

4.3.7.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Need to build a sufficient network of industry partners to secure the investments required.
High	To have a wider impact, the company has to develop partnerships not only with academia and training centres, but also public authorities, other businesses and associations, which require even more coordination and investments.
Medium	The wide network of partners needs to be sustained by a similarly extensive network of training centres for educators.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar initiative:

Impact Level	Success factors
High	Large, regular investments made by the company to scale up the programme allow for the wider dispersion of benefits and network effects.
High	The offered trainings are constantly updated by the company and thus remain relevant for the labour market.
Medium	The company collaborates with all relevant stakeholders and participates in the broad conversation on skills gaps and education.

4.3.7.6. Take away messages

- *Company training initiatives can be adapted to local needs and offer a good opportunity to introduce new training methods/concepts to the existing education system.*
- *Industry-led initiatives can encourage a wider reform of the education system and facilitate collaboration between businesses willing to invest in the development of new talent as well as the upskilling of their employees.*
- *Governments and universities should consider increasing their support and cooperation with companies willing to invest in new innovative training initiatives. IT education without the contribution of companies, is nowadays hard to implement.*

4.3.8. IBM Skills Academy Poland

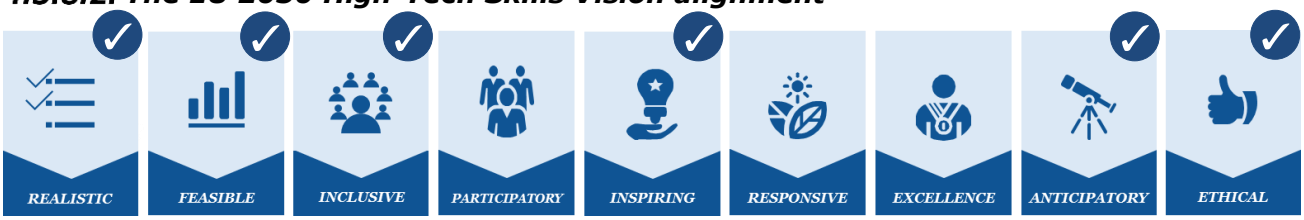
Organisation name	IBM
Type of organisation	Private
Level of implementation	National / Global

4.3.8.1. Description

IBM Skills Academy is a private initiative launched by IBM that offers trainings to students enrolled in universities. The programme assists universities in filling the gap between academia and business, improves student learning through hands-on experiences with the latest technologies, and helps connect students to the job market. Through **partnerships with universities, students and educators in IT and non-IT-related fields** can participate in **multiple tracks** that range from AI to Quantum. Each track has a number of distinct **skill-focused learning objectives that are based on market research and in line with high-demand jobs** in the market. The teaching is done through a **blended learning** module that is partly web-based (roughly 80%) and partly classroom based (roughly 20%). Upon successful completion of a track, a student receives an IBM badge.

The Skills Academy started as a pilot in a number of African countries, but has now expanded to different regions, including Asia, the Pacific, and the United States. **Last year, the first Skills Academy launched in Poland, similar to the already existing partnerships in other countries.** The partner organisations are currently EITT, a company offering trainings and coaching, and the Wroclaw University of Science and Technology, while other universities have already presented the programme to their students. The aim of the initiative is to have partnerships with hundreds of universities across Europe. By making use of its wide network of university partnerships, since 2014, the year of the launch, 35,000 university students participated in the IBM Skills Academy programme, and 9000 students received Open Badges. These students came from 10 different countries and studied at 150 different universities. Of the students that attended a course, 60% now have a job.

4.3.8.2. The EU 2030 High-Tech Skills Vision alignment



The IBM Skills Academy serves as an example of the following dimensions of the formulated Vision:

Realistic – The programme leverages IBM's extensive knowledge base to provide trainings on well-defined skills and tools. The trainings are elaborated according to market needs, which well-prepares students for their future careers.

Feasible – The initiative has clear training schedules that are completed with an examination. The obtained certificate serves as an incentive tool and is used to prove the acquired skills.

Inclusive – The Skills Academy has targeted students from multiple continents in both developed and developing countries. In this way, the programme excels in offering these trainings to students coming from all kinds of backgrounds. In Poland, the courses are offered to STEM students, but also business and even navy students.

Inspiring – Based on IBM's extensive expertise in IT, the offered training programmes prepare students to the relevant careers and serve as a basis for more expertise to be developed.

Anticipatory – By collaborating with employers, IBM defines the most promising career specialisations within IT. In this way, the training catalogue is aligned with the emerging needs of the employers, such as cybersecurity and AI analysts.

4.3.8.3. Key insights for the Skills for Industry Strategy 2030

This private initiative corresponds with the formulated Vision, and therefore can also serve as a guideline for the Toolbox, specifically on the future training system to be designed in the EU. The programme is relevant for two stakeholders, who make the IBM Skills Academy possible, namely the company (IBM) and its partner universities. In its essence, the IBM Skills Academy builds the case for a deep collaboration between private and public organisations, especially from the education system, for adequately preparing the future workforce. In fact, this private initiative illustrates that companies can take a more active role and be directly involved in developing IT and digital skills of students. This can grant a more accurate training system, based on direct input from employers on what skills are and will be needed. With students being the direct beneficiaries of the programme, the following recommendations can be offered to the private and education organisations:

Module	**Stakeholders**	
	IBM Skills Academy	*Universities*
World-class curriculum	Create state-of-the-art innovative trainings that meet the needs of industry leaders	Promote company-led initiatives to students and integrate possible solutions into the existing curriculum
Talent detection and nurturing system	Consider well-performing students for jobs in the company thus facilitating talent detection	
Industry-led training infrastructure	Identify the in-demand skills and design the appropriate trainings	Collaborate with industry-led training infrastructures to share knowledge and facilitate exchange
Leadership and governance	Take a leading role in developing skills strategies, training students and managing the programme	Support industry-led initiatives that could be integrated into traditional academic institutions
Funding	Invest in high-impact and relevant partnerships and locations	Invest in high-impact and relevant partnerships ad locations

4.3.8.4. Transferability, replicability and scalability

The scope of the initiative and its alignment with the Vision should interest other companies in the EU to create a similar partnership model with education institutions. With respect to the potential of implementation:

Transferability – Similar collaborations and training modules could be implemented in other Member states, focusing on a variety of sectors and industries.

Replicability – Other businesses might be interested in collaborating with existing education systems. The scope of activities would be influenced by the financial means available and the willingness of academic institutions to agree to private-public collaborations.

Scalability – Depending on the size of the companies participating, collaboration programmes might be limited to the national level at first. Global industry leaders could, of course, build on their global networks, which significantly facilitates the scalability of activities.

4.3.8.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Set-up and continued scaling up of the programme will require significant resources.
Medium	Educators will need to be trained in the methodologies and trainings developed as well as encouraged to adopt a collaborative mind-set with regards to industry-led initiatives that work with traditional academic institutions.
Low	Students may not sign up as expected, because university curriculum confines their availability.

On the other hand, several **success factors** are likely to increase the success rate of the initiative:

Impact Level	Success factors
High	Diversification of the network of universities offered at national level by introducing innovative trainings/courses to the existing curriculum.
High	Content and us cases reviewed on a six-month basis to ensure market relevance
High	University buy-in to industry-led training initiatives stimulates knowledge sharing and innovation.
Medium	Increasing investments in e-learning and cloud-based trainings facilitate access to education and spread knowledge.

4.3.8.6. Take away messages

- *Company-led initiatives can have a great scope of impact, mainly due to large committed investments.*
- *Company-led trainings can introduce innovative methods to the education community and ensure that the relevance of the trainings offered remains high and aligned with industry needs.*
- *Universities have to be open to cooperate with industry to better prepare students to the demands of the labour market and ensure they are given the opportunity to develop the right skills.*
- *Dual partnerships (industry – university) can facilitate the implementation of trainings that meet the needs of industry.*

4.3.9. imec.academy

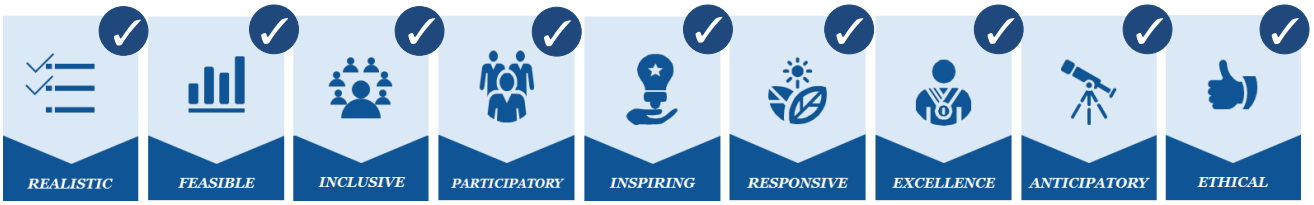
Organisation name	imec.academy
Type of organisation	Non-profit
Level of implementation	National /Global

4.3.9.1. Description

Imec.academy is the learning institute of IMEC, an innovation hub in nanoelectronics and digital technology located in Leuven, Belgium, which employs over 4,000 researchers. The Academy offers specialised online and on-site courses on nanotechnology and promotes research in education technology, **aiming to increase learning effectiveness by using smart technologies**[78]. Imec uses both technical and non-technical courses to engage with partners from industry and academia in their respective areas of expertise. The aim is to educate, develop, inspire and empower individuals and groups to stay successful in their research and development. imec's unique high-tech environment and international top talent enables the academy to combine advanced world-class expertise with hands-on applications in a state-of-the-art training offering.

Imec.academy offers courses to both its own employees, as well as to local and international industry and academia. The training offer is divided into three main categories: (1) semiconductor technology; (2) Integrated Circuit, System on Chip and Printed Circuit Board design; and (3) applications, health & energy. The programme charges for most of the courses, however significant discounts are applied for local industry and academia. Certain training programs are also part of a larger (bi-lateral) partnership which means the training services are provided in kind. In total, over 750 training events are organized each year, over 20k hours of online courses and seminars are available and about 10k of external users can benefit from imec.academy's training activities.

4.3.9.2. The EU 2030 High-Tech Skills Vision alignment



The initiative is aligned with the defined Vision on the following dimensions:

Realistic – The academy offers courses based on its own and its partners extensive experience and knowledge, which provides a basis for high-quality trainings.

Feasible – All types of courses have a clear curriculum, set timing and level of difficulty. This helps potential students understand the requirements and the course details beforehand.

Inclusive – IMEC Academy offers trainings to three different groups of participants: employees from top Flemish and international companies, students from universities, and IMEC's employees, who are encouraged to continue learning and growing. This ensures an inclusive approach to attracting talent from all possible sources.

[78] https://imec.csod.com/catalog/CustomPage.aspx?id=20000167&tab_page_id=20000167

Participatory – All the topics related to the trainings and curricula are carefully selected by all the involved stakeholders in order to ensure a high standard of quality trainings in imec's high-tech environment.

Inspiring – IMEC's global leadership in nanoelectronics research means that its courses are built on getting-edge knowledge and the latest findings. By working closely with leading experts in the field the academy wants to inspire its students to become leading experts in the field themselves.

Responsive – Together with other business units, imec.academy recently started the imec.school program. This is a program which gives the opportunity the people without any technical experience or background a chance to work in our state-of-the-art cleanroom facilities. This program also aims to support people who cannot easily find a job in the current economic landscape by designing the imec.school program according to the 'dual learning' principles.

Excellence – By contributing to the development of the nanoelectronics specialisation of the Flemish region, IMEC Academy strengthens the excellence of the region in the field.

Anticipatory – IMEC Academy offers courses on emerging aspects in semiconductor technology thus anticipating changes in industrial needs and developments.

4.3.9.3. Key insights for the Skills for Industry Strategy 2030

The initiative's success can help other programmes by providing the following insights:

Module	**Stakeholders**		
	IMEC Academy	*Companies*	*Universities*
World-class curriculum	Engage leading experts to develop cutting-edge training programmes	Support academies in offer relevant training materials that will ensure industry needs are met	Collaborate and share knowledge on emerging trends in the field
Funding	Efficiently price the courses to reflect the added-value and ensure a sustainable business model		
Industry-led training infrastructure	Although IMEC is an R&D organisation, the close collaboration with industry makes the trainings highly practical and adapted to the actual needs of businesses	Support trainings with relevant learning materials/resources	

4.3.9.4. Transferability, replicability and scalability

For companies or authorities willing to build a similar community and training centre, a similar implementation depends on:

Transferability – A similar academy may be set up in other industries, granted that there is a strong collaboration between academia and industry to ensure the high quality of trainings offered.

Replicability – The programme could be implemented in other regions given a sufficient level of expertise in the domain targeted.

Scalability – Similar collaborative initiatives could be implemented at national level to target strategic industries, sufficient expertise and funding being a pre-requisite.

4.3.9.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Need to create sufficient student participation to ensure the financial stability of the programme and create better learning environment for participants.
High	Need to develop a sustainable and scalable business model to ensure the availability of high-quality and experienced trainers
Medium	Need to efficiently price the courses to ensure the financial feasibility of the programme.
Medium	The required investments in education technology may not result in sufficient returns or significant learning improvements.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar initiative:

Impact Level	Success factors
High	Implement smart learning methodologies to test their applicability and effectiveness.
High	Offer greater flexibility in the teaching methodologies adopted to attract more students.
Medium	The trainings offered focus on the practical application of skills.

4.3.9.6. Take away messages

- *Leading industry research centres can build training and learning facilities that leverage their expertise in the field and strengthen the attractiveness of regions.*
- *Industry-led research centres play a crucial role in the development and growth of local talent.*
- *Private-public collaborations should be expanded to target the development of niche and highly specialised skills.*

4.3.10. Luxembourg Digital Skills Bridge

Organisation name	Luxembourg Digital Skills Bridge
Type of organisation	Public
Level of implementation	National

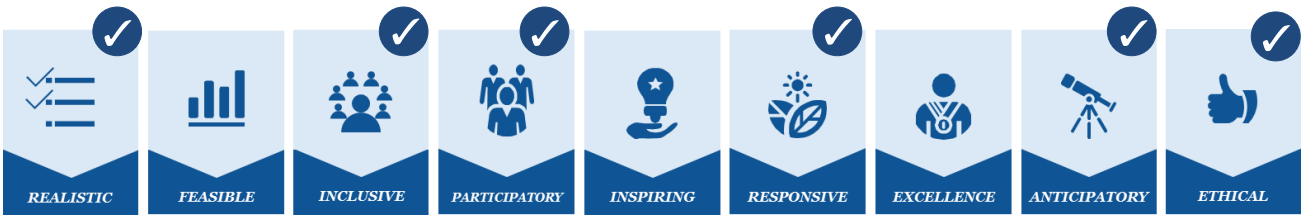
4.3.10.1. Description

The Ministry of Labour, Employment and the Social and Solidarity Economy launched the Luxembourg Digital Skills Bridge programme in 2018, a pilot project aimed at employees whose positions are changing or at risk due to digital transformation. The programme strives to anticipate the impact technological developments will have on the skills of employees and employment in general. Following an in depth strategic workforce planning exercise, companies and their employees are accompanied through the required upskilling efforts. The current skills of employees are assessed and the existing skills gap evaluated. Then the newest state-of-the-art trainings are selected to help the employee bridge the skills gap between their current and future position. All employees are thus given the opportunity to invest in new business, digital and cross-functional skills. To further ensure the successful completion of the upskilling journey, specialised advisors accompany the employees throughout the process to ensure they fully understand the philosophy of the programme and to encourage a shift in mind-set in line with the upskilling process.

This preventive and pro-active approach anticipates the changes introduced by the digital transformation and allows both companies and employees to adapt to this new environment. Employees gain new skills, which improves their future employability, while participating companies ensure that the experience and knowledge their employees have gained, remain within the business. The aim of the programme is to upskill the workforce while on the job and to encourage the internal mobility of employees.

In 2018, 20 companies applied to the programme, with 11 being selected to participate to the pilot. Businesses of all sizes and from various sectors were accepted and are currently undergoing the upskilling process. Of these participating companies, 9 businesses will upskill their employees for internal mobility exclusively, demonstrating their need for skilled talent as well as the value of retaining the knowledge these employees already have of the business within the company. At the end of the pilot over 300 employees will have been upskilled.

4.3.10.2. The EU 2030 High-Tech Skills Vision alignment



This project serves as an example of the defined Vision, mainly because it is aligned with the following dimensions:

Realistic – The scope and vision of the programme were designed following various stakeholder consultations and feasibility studies. The efforts identified are thus aligned with national capabilities and respond to the needs of the participating companies, the national workforce.

Inclusive – The programme attracts companies of all sizes and from different sectors, demonstrating an inclusive national upskilling approach. The processes and tools designed within the Skills Bridge programme were developed with the intention to ensure their wider applicability

to Luxembourg's workforce. The unemployed as well as NEEDs might thus benefit from the programme at a later stage.

Participatory – The programme was developed in close collaboration with the Ministry of Labor, the Luxembourg Employment Agency (ADEM) and the Ministry of Economy. Social partners and trade organisations were closely consulted throughout the set-up of the programme and continue to play an important role through the execution phase via the direct participation of the staff delegations to the Skills Bridge process.

Responsive – The initiative was launched as a solution to the increasing risk of unemployment in Europe due to a mismatch of the skills required by industry and the skills currently maintained by the workforce. At present, especially SMEs are struggling to find the right talent and to upskill their existing employees. Moreover, the financial sector is being heavily impacted by digital transformation, constituting a significant risk to the national labour market.

Anticipatory – By focusing on preventing unemployment and strengthening the continued employability of Luxembourg's workforce, the programme aims to strengthen competitiveness of industry while preventing large-scale unemployment in the future.

4.3.10.3. Key insights for the Skills for Industry Strategy 2030

Encouraging multi-stakeholder collaboration and cross-industry cooperation, the Luxembourg Digital Skills Bridge programme can serve as inspiration to the following modules in particular:

Module	**Stakeholders**		
	Government	*Companies*	*Employees*
Leadership and governance	Assume the set-up and governance of the programme while ensuring close collaboration with participating businesses and social partners	Ensure internal leadership and governance to encourage the uptake of the Skills Bridge solution	
Funding	Liberation of significant amounts of funding to encourage the participation of companies	Liberate the required internal resources to accompany the programme	
Incentives	The financial and technical support offered facilitate the upskilling process	Incentivise employees to participate by offering them the necessary HR support and onboarding them in the process at an early stage	Active participation encouraged by the personal advisor accompanying the employee The employee receives his/her full salary while completing the trainings.

4.3.10.4. Transferability, replicability and scalability

Other Member States, regions or associations willing to invest in a comprehensive upskilling programme, could be inspired by the present best practice:

Transferability – The scope of the programme can be easily adapted to local/regional needs or to a specific industry.

Replicability – Similar programmes could be imagined at a city, regional and national level, given the existing close collaboration between industry, government bodies, and training providers. The funds and incentives given might be more difficult to replicate due to local factors (e.g. different funding structures, limited funds available, different legislations).

Scalability – Depending on the financial and technical support available, this programme could be up-scaled to the regional or national level. A strong and clear leadership would be a necessary pre-requisite to respect.

4.3.10.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by bodies willing to create a similar agency:

Impact Level	Challenges
High	Significant levels of funding and support are required to facilitate the upskilling process and offer targeted trainings.
High	Participating companies need to be willing to invest in the skills of their employees and to adopt the 'lifelong learning' mentality.
Medium	Training providers need to adapt their services to industry/business demands.
Medium	The buy-in of trade unions is important to ensure the willingness of employees to participate to the programme.

Despite these challenges, several **success factors** are expected to increase the success rate of a similar programme:

Impact Level	Success factors
High	The wide communication of support and funding available encourages businesses and employees to participate to the programme.
High	Close collaboration with business leaders, trade unions and employer organisations ensure wider acceptance of the programme.
High	Active and motivated leadership ensure the successful implementation of the programme.
Medium	The personal support offered to employees (i.e. personal advisors) ensures high participation rates and successful job transitions.

4.3.10.6. Take away messages

- *Governments should assume a leading role in encouraging companies to invest in the skills of their employees and to adopt a pro-active upskilling approach. Corresponding incentives should be developed and implemented.*
- *Smaller businesses and SMEs require governmental support to upskill their employees and strengthen the competitiveness of their companies. Governmental efforts should therefore target SMEs in particular when introducing new re/upskilling programmes.*
- *Employees should be actively included in the upskilling process and encouraged to strengthen their continued employability through lifelong learning.*

4.3.11. Portugal – Building a National Skills Strategy

Organisation name	The Government of Portugal and the OECD
Type of organisation	Public
Level of implementation	National

REPÚBLICA PORTUGUESA
EDUCAÇÃO

4.3.11.1. Description

The Portuguese National Skills Strategy, developed by the cross-ministerial Portuguese National Project Team with the support of the OECD, is built on the in-depth analysis of the **existing education system and the skills gaps noted**[79]. The OECD Skills Strategy initiative provides a strategic approach to skills policies to strengthen countries' skills strategies through the coherent development, activation and effective use of skills.

The skills strategy's main objective is to promote economic prosperity and social cohesion, reflecting a strong focus on 'lifetime employability'. Another key aspect is to foster, across the whole society and its different sectors, the central role of skills for individual and social development. This enables a progressive adjustment of the education and training systems, but also of the public institutions' and companies' strategies, articulating them over a common endeavour and language, and therefore enabling their cooperation in common programmes and projects. Moreover, the strategy has a multi-level character. This means promoting and articulating local, regional and national strategies by taking into account the needs, strengths and dynamics of different areas. This is particularly important in historically centralised countries as Portugal, thus empowering and committing public and private actors at different levels.

The Portuguese project started in 2014 with a diagnostic phase that included numerous workshops and stakeholder consultations, and resulted in the 2015 Diagnostic Report that identified 12 key challenges to be addressed by Portuguese policy-makers. The **key challenges identified for Portugal** and which are **critical to an effective skills system** were the following:

- **Develop relevant skills**: improve quality and equity in education, strengthen the responsiveness of VET to labour market demands, target lifelong learning for low skilled adults;
- **Activate the supply of skills** – reduce youth unemployment, increase labour market re-entry for the long-term unemployed, and reduce barriers to employment;
- **Use skills effectively** – promote entrepreneurship, stimulate innovation and high-skilled jobs, and incentivise employers to engage in skills development;
- **Enabling conditions** – finance a more equitable and efficient skills system, adjust decision-making power to meet local needs, build capacity and partnerships to enable evidence-based policy.

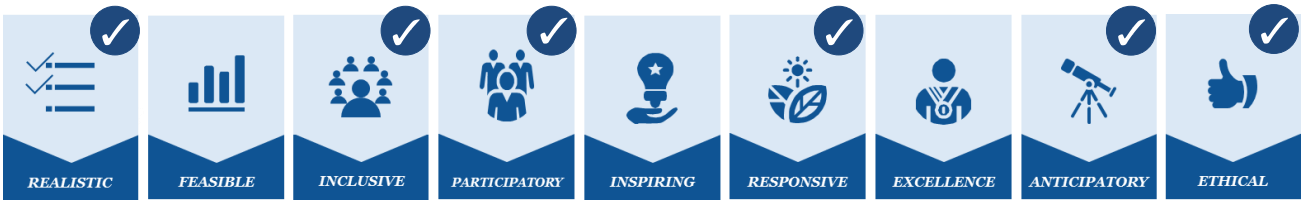
In line with this initiative, the Portuguese government **launched a number of concrete actionable programmes between 2014 and 2018**, which resulted in the reduction of school dropouts in basic and early education and decreased the number of students leaving education early. Furthermore, a significant decrease of youth unemployment, an increasing number of adults in qualification programmes (20,000 to 110,000), and an increase in students entering higher

[79] http://www.oecd.org/skills/nationalskillsstrategies/Diagnostic-report-Portugal.pdf

education could be noted. An example of an initiative in this area is the strategy to identify and support NEETs[80].

The positive results observed thus far, have led the Portuguese authorities to focus more extensively on lifelong learning and adult training through the *Strengthening the Adult-learning system* action report developed with the OECD[81]. Furthermore, additional programmes such as InCoDe 2030 and Portugal Industria 4.0 have been launched to facilitate the digitisation process of the private sector and encourage the development of digital skills among the population[82].

4.3.11.2. The EU 2030 High-Tech Skills Vision alignment



By serving as a best practice example for defining national skills strategies, the Portuguese case is significantly aligned with the defined Vision, particularly on these dimensions:

Realistic – The strategy definition process was based on the guidelines of the OECD, which has proven successful in other countries (Slovenia, Italy, and The Netherlands) and regions (Flanders). This allowed Portugal to build on previous experiences and lessons learnt.

Inclusive – The new National Skills Strategy targets all population segments, including children, youth and adults. Specific initiatives targeting NEETS and adults have been implemented and are ongoing.

Participatory – The development of the national skills strategy required the active participation of all stakeholders and a clear leadership by the government to identify the challenges faced by the workforce, and to build on them through dialogue and cooperation.

Responsive – Portugal has been facing serious issues regarding the education and skills of its population, which created high unemployment and an uncompetitive economy, and the new strategy enables an overarching response to these societal problems.

Anticipatory – Besides attempting to bridge the existing skills gap noted in Portugal, the new strategy is also forward-looking by introducing new policies in the area of digitisation (i.e. InCoDe 2030 and Industria 4.0).

4.3.11.3. Key insights for the Skills for Industry Strategy 2030

This initiative should be used as a best practice case for countries that are willing to reform their skills systems and increase the qualification level of its population. The initial diagnosis, which required the implication of the wider government and integrated the feedback from multiple stakeholders, can serve as good inspiration regarding the design of a national skills strategy. By involving multiple government institutions, the private sector and universities, each party was given a specific role in building a shared purpose and developing a fair skills system for Portugal. This initiative can thus inform authorities and relevant stakeholders from other Member States on the following dimensions of the Toolbox primarily:

[80] https://skillspanorama.cedefop.europa.eu/en/news/refernet-portugal-national-strategy-identifying-and-supporting-neets
[81] https://www.oecd.org/skills/nationalskillsstrategies/Action-Report-Portugal.pdf
[82] https://ec.europa.eu/futurium/en/system/files/ged/pt_country_analysis.pdf

Module	Stakeholders			
	State authorities	*International organisation (e.g. the OECD)*	*Private sector*	*Universities*
Skills strategy	Develop a comprehensive strategy based on: stakeholder consultations, country best practices, local specificities	Offer expertise and other support to authorities while defining their strategy	Proactively contribute to the strategy definition process by offering extensive evidence and feedback	Proactively contribute to the strategy definition process by offering extensive evidence and feedback
Leadership and governance	Take a leading role in the process The implementation team must be cross-ministerial Include a project champion at senior level to ensure broad political support and consensus Include members outside government Make the process as transparent and open as possible	Offer support in governance issues and stakeholder consultations Consider proposing members in the implementation team	SMEs need to be included in the process	
Communication	Ensure cross-sectoral dialogue	Communicate with other countries to gain insights and facilitate exchange	Actively participate in discussions	Actively participate in discussions

4.3.11.4. Transferability, replicability and scalability

The Portuguese skills strategy serves as a best practice case for other Member States willing to initiate such a process.

Transferability – The model that Portugal used was largely based on the OECD Skills Strategy guidelines, which offers a straightforward framework for defining national skills strategies and can be easily transferred.

Replicability – The implementation of a similar staged approach to defining the national skills strategy would require an adaptation of the OECD guidelines to the existing national and regional skills system, as well as the general economic and social context. The implementation to this date by several countries and regions proves the case for a high replicability of the used methodology, but authorities have to extensively consult stakeholders to take into account all the relevant aspects.

Scalability – The framework used by the Portuguese authorities has been used at regional level (e.g. Flanders), which suggests that its implementation at different policy levels should be possible,

granted that the enabling conditions are met: whole-of-government approach, stakeholder consultations, etc.

4.3.11.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by authorities willing to define a skills strategy based on a similar approach:

Impact Level	Challenges
High	Important to ensure the longevity of the process, as it requires extensive coordination and political will.
Medium	Important to involve the stakeholders concerned, with a particular focus on universities who have been more passive.
Medium	Cross-ministerial collaboration might be difficult and requires strong leadership.

Despite these challenges, several **success factors** have been identified as critical to the initiative:

Impact Level	Success factors
High	Leadership is critical – the implementation team has to take a leading role in the process.
High	Whole of government approach – minimum of three different ministries have to be involved.
High	Ensure cross-sectoral dialogue, which is critical for building understanding and commitment.
Medium	Encourage development of regional skills strategies tailored to their specific contexts.

4.3.11.6. Take away messages

- *National skills agendas are crucial to tackling societal challenges such as unemployment and slow economic performance, and facilitate the review of the existing education system.*
- *The success of the initiative relies on the set-up of a cross-ministerial team which distributes ownership of the success of the programme to the wider government.*
- *The skills strategy has to be based on extensive stakeholder consultations and should address the key challenges identified in the system.*
- *The definition of the skills strategy needs to be followed-up by a concrete implementation plan and a set of reforms that will be widely communicated and whose successful implementation will be performed by multiple ministries.*

4.3.12. PROMPT – Professional Master in Software Engineering

Organisation name	PROMPT (Mälardalen University)
Type of organisation	Triple helix
Level of implementation	National

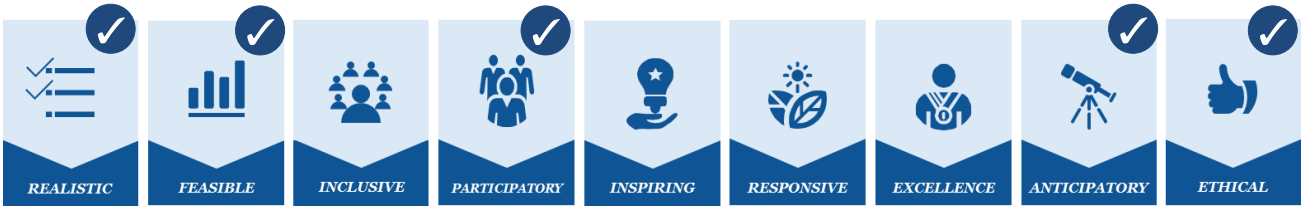
4.3.12.1. Description

The PROMPT (Professional Master in Software Engineering) initiative aims to **ensure a steady and high-quality supply of advanced software competencies** and innovativeness that benefits both Swedish industry and higher education. It is an education initiative created by academic parties and leading industrial companies that **promotes lifelong learning.**

PROMPT develops advanced, master-level courses in web-based format tailored to the skill development needs of current professional engineers and software developers. The courses are **designed for participants with a professional and/or academic background** in software development and who need to combine work and studies. Currently, PROMPT offers 21 courses that fit within five subject-related areas. The courses are based on existing courses taught at different universities, and adapted with industry input[83]. Most of the courses within these areas are worth 7.5 credits, which is the equivalent to 200 hours of study. Since Master's education is free in Sweden for EU-nationals, there are no fees for participating in PROMPT. The PROMPT initiative has also resulted in similar activities, where more topics and courses are added within the same pedagogical framework.

The programme is managed using the Triple Helix model. As such, Mälardalen University leads the PROMPT initiative in cooperation with education institutions (Blekinge Institute of Technology, Chalmers, the University of Gothenburg and RISE SICS) and dozens of industry partners. Industry partners include but are not limited to Ericsson, Fujitsu, Schneider Electric, Bombardier, Scania, and Volvo. The contents of the courses are then designed by the two parties to make the contents highly relevant and focused on emerging topics. The third stakeholder in the initiative is the government. PROMPT is fully financed by the Swedish Knowledge Foundation's (KKS) Expertise for Innovation programme, which supports mid-sized universities, and which aims to promote cooperation between academia and industry. Funding runs from 2011 until 2020, with talks about the extension of the programme ongoing. The ultimate goal is to include the courses in the ordinary university curricula. **Thousands of professionals from 300+ different companies** and organisations have participated in PROMPT courses since 2015. On December 1, 2016, the PROMPT Initiative was further awarded the European Digital Skills Award in the category More and better trained ICT professionals in Europe[84].

4.3.12.2. The EU 2030 High-Tech Skills Vision alignment



PROMPT is aligned with the formulated Vision primarily on these dimensions:

[83] http://www.promptedu.se/category/courses/
[84] http://www.promptedu.se/awards/

Realistic – PROMPT courses are based on existing knowledge and methodologies, which makes their implementation realistic. Moreover, input from both universities and companies is used in designing the courses, which makes the trainings highly relevant to current industry needs.

Feasible – By focusing on a specific field of specialisation and by introducing courses with a clear timeline while simultaneously promoting higher career prospects PROMPT represents a straightforward operation model.

Participatory – PROMPT's courses are based on feedback from both education institutions as well as employers, creating a common basis for more relevant training systems.

Anticipatory – By taking into account and partnering with corporates, the initiative is forward-looking in terms of the skills and expertise required in the future workplace.

4.3.12.3. Key insights for the Skills for Industry Strategy 2030

PROMPT directly focuses on reskilling and upskilling of the labour force to meet the needs of the digital economy. The courses it offers attempt to boost lifelong learning and encourage the collaboration between industry and universities. By targeting employed professionals, who are the beneficiaries of the initiative, PROMPT bridges the private sector with academia.

As such, three types of stakeholders are identified: companies, universities and the steering group of PROMPT. The government side could be also included, but is mostly limited to the funding aspect. The initiative's experience and recognised success suggest the following actions with regards to the Toolbox modules:

Module	**Stakeholders**		
	PROMPT	*Companies*	*Universities*
World-class curriculum	Ensure company participation and contributions to the curriculum	Define current and future skills needs and communicate them to universities	Contribute with recent, emerging insights in the academic community
Industry-led training infrastructure	Ensure that the courses offered meet industry needs	Contribute to the trainings with the necessary resources (e.g. funding, tools)	Integrate the courses offered into the academic offering Develop more innovative, online-based courses
Leadership and governance	Effectively manage the relationship and collaboration between all actors involved	Communicate the importance of the skills strategy to their employees	
Funding	Ensure the necessary funding is available		

4.3.12.4. Transferability, replicability and scalability

Given the success of the model, PROMPT may serve as a source of inspiration to other Member States:

Transferability – The partnership model underlying PROMPT could be successfully applied to other settings. The web-based format of the trainings and the flexible learning experiences this allows for could be adapted to the respective needs of the city/region/country.

Replicability – The model can be replicated if the necessary collaboration between industry and education can be encouraged. The number of participants might however be lower as higher education is not for free on most EU countries. Alternative incentives might thus be required.

Scalability – While the courses offered are web-based, the online interaction between the instructor and the course participants limits the number of students per class. Moreover, the high level of expertise required from teachers limits the scalability of the programme.

4.3.12.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Universities and companies might struggle building a sustainable collaboration model.
High	Universities are seen as slower to adapt to the lifelong learning requirements that need more flexible and agile learning environments.
Medium	Dropout rates might be higher due to the struggle of participants to combining studies with a full-time job.
Medium	Lengthy admission processes of universities may be discouraging for professionals.

Despite these challenges, several **success factors** are likely to increase the success rate of the initiative:

Impact Level	Success factors
High	Effective, institutionalised and trust-based knowledge transfer between industry and academia.
High	The courses are free of charge and are officially certified.
High	The courses are possible to combine with a full-time employment.
Medium	Companies increasingly encourage their employees to follow the trainings they have helped develop.

4.3.12.6. Take away messages

- *Universities should partner with companies to offer innovative upskilling courses and thus support lifelong learning.*
- *Universities and companies should work together to design relevant courses, resulting in the development of innovative teaching methods and facilitated knowledge transfer.*
- *Universities need to be encouraged and supported through this transformation to realise organisational change and become more agile in their procedures/processes.*

4.3.13. ReDI School of Digital Integration

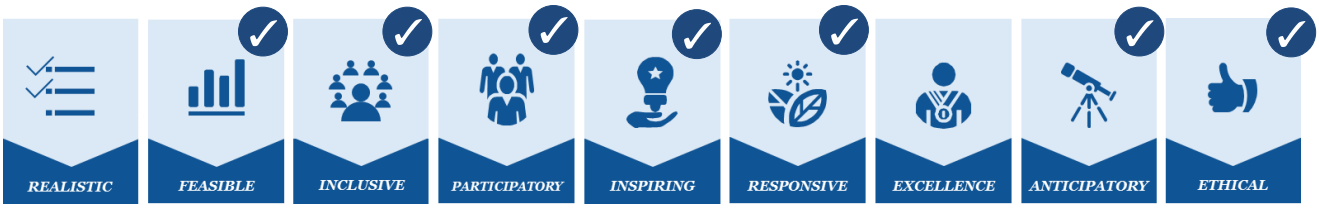
Organisation name	ReDI School of Digital Integration
Type of organisation	NGO
Level of implementation	City – Berlin and Munich

4.3.13.1. Description

ReDI School of Digital Integration is a **non-profit digital school for tech-interested locals and newcomers in Germany**, offering trainings in English and German. The school has the aim to offer students valuable digital skills and a strong network of tech leaders, students and alumni to help create new opportunities for all. The organisation offers IT and programming courses, workshops, company visits as well as hackathons to primarily migrants, refugees and asylum seekers[85]. Special courses are dedicated to women that have little background in IT. Moreover, the NGO provides career counselling as well as employment matchmaking, thus not only training students, but actively helping them enter the workforce. **This ensures the successful integration of migrants, refugees and asylum seekers into the German labour market and society.**

The programme offers three levels of training: beginner, intermediate and advanced. In addition, trainees develop their IT core competencies (presentation skills, agile project management, and development), soft skills and professional network by participating in conferences and company visits. The offered courses touch upon networking, Java, IoT and blockchain, mobile development, data science, and web development. The selection process has three stages: (1) information session; (2) online form; and (3) interview stage, where the applicant's knowledge, experience and motivation are tested. In general, classes have around 10-15 participants. Teachers are usually volunteers from the tech industry that while teaching technical skills also share important insights on the industry and the practical applications of theory. With around 500 students, the school can take a personal approach and help each individual find a job according to his/her skills and interests.

4.3.13.2. The EU 2030 High-Tech Skills Vision alignment



ReDI is aligned with the defined EU vision of high-tech t-shaped skills with respect to the following dimensions:

Feasible – The initiative has a clear budget structure, schedule for implementation, effective management and project application procedures.

Inclusive –By offering relevant trainings and helping refugees and migrants find jobs, the organisation ensures that those disadvantaged are prepared for the ongoing digitalisation and can integrate into society. The school offers dedicated courses to women with less skills, ensuring that their inclusion and integration into the workforce is significantly strengthened. This translated into a 56% share of students being female.

[85] https://www.redi-school.org/mission

Participatory – The organisation strongly collaborates with industry to match students to specific jobs, mainly through organising networking opportunities and practitioners volunteering to teach at the school. Moreover, ReDI is supported by municipalities as it contributes to the well-being of the city population.

Inspiring – The school and its trainings, by helping those most in need, inspires them to develop digital skills and focus on careers in IT. This is particularly true for the female students, which are rather underepresented in the IT sector.

Responsive – The initiative started in 2016, in the advent of the migrant crisis, and originated from the idea to help refugees integrate in the Germany labour market and society. It thus targets a clear societal challenge that remains ongoing worldwide.

Anticipatory – The courses are set-up to meet the meet the new skills needs developing in line with the latest IT trends.

4.3.13.3. Key insights for the Skills for Industry Strategy 2030

ReDI represents a best practice to other organisations wanting to focus on the provision of digital skills trainings, with a specific focus on those disadvantaged. The following Toolbox modules are thus relevant:

Module	**Stakeholder**		
	ReDI	*Companies*	*Municipalities*
Talent detection and nurturing system	Develop quality courses Identify talent and support its entry into the workforce	Collaborate with NGOs and alternative training providers Be open to offering opportunities to refugees, immigrants, asylum seekers	Offer sufficient (monetary) support and facilitate collaboration between the NGO and industry
Funding	Develop a sustainable financing model	Support alternative training programmes	Offer sufficient (monetary) support to these
Communication	Develop a personal approach to working with the trainees Extend the network of corporate partners	Have clear employment requirements	
Industry-led training infrastructure		Support employees that would like to volunteer and teach	

4.3.13.4. Transferability, replicability and scalability

The initiative has a relatively simple model of cooperation, with a similar implementation process depending on the following aspects:

Transferability – A similar initiative may be implemented by individuals or authorities to offer trainings to migrants or other social segments. The scope and target audience can be easily adapted to local, regional, national needs.

Replicability – The programme could be replicated to other cities, given the presence of a capable, dedicated management team and the continued support of local authorities.

Scalability – Similar initiatives may be scaled up to the regional or national level, but significant human resources have to be allocated to operate at local level.

4.3.13.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	A strong network of industry partners is required to ensure the students' successful entry into the local workforce.
High	Students have to be matched to jobs available, which can be time intensive and requires the willingness of companies to employ refugees, migrants and/or asylum seekers.
Medium	Refugees have to be identified, informed and encouraged to participate.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar initiative:

Impact Level	Success factors
High	Active industry participation facilitates the provision of targeted trainings that meet concrete industry needs while simultaneously simplifying the recruitment process.
High	Students receive the soft and professional skills required by the labour market.
Medium	Multiple stakeholder implication ensures the provision of necessary funds to facilitate the provision of trainings to the disadvantaged.

4.3.13.6. Take away messages

- *NGOs can play an important role in the integration process of disadvantaged groups by giving them access to qualifying trainings and offering career support.*
- *Strong collaboration with industry is critical for the success of non-profit training activities.*
- *Volunteer-based teaching in small classes allowing for a close relationship between students and teachers is crucial to the integration of students from disadvantaged backgrounds.*

4.3.14. SEMI Workforce Development

Organisation name	SEMI
Type of organisation	Private
Level of implementation	Global / National

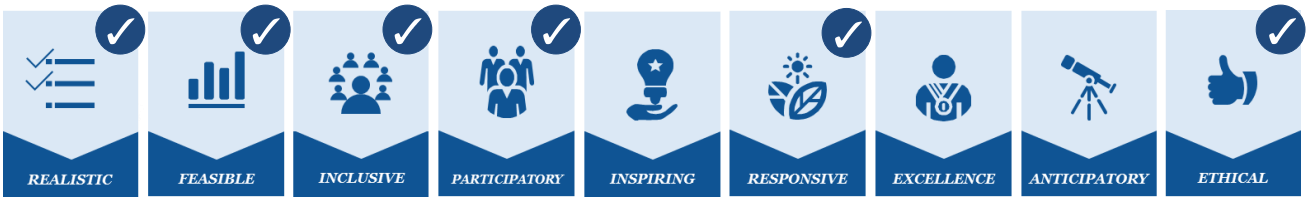
4.3.14.1. Description

SEMI is a global industry association of companies in the electronics manufacturing value chain. **The association has the mission to advance the interests of this industry, mainly though promotion of these interests and advancing the growth of its members**[86]. Therefore, it acts as a pre-competitive platform for communication and collaboration between companies at the different stages of the value chain, from materials until the electronic systems industry. The main activities of SEMI include: organising conferences, developing industry standards, conducting market research and advocating for industry interests.

One focus area of the association is workforce development, in which SEMI is influent by having an overarching view on the industry and its challenges. The association has conducted the **Global Workforce Study** to identify the features of this challenge, and identified that **companies face a shortage of talent and specific skills, with most of the shortages in electrical engineering**. To address them, SEMI Foundation has established Workforce Development Councils, including one in Europe, which aim to tackle issues at a regional level. It has partnered with several research centres and companies, such as IMEC, FAB, and Fujifilm. The council aims to: connect relevant businesses; identify the common skills gaps; highlight best practices and action plans for the industry; disseminate industry positions and recommendations; expand workforce development programmes with members; and promote EU initiatives toward association members. Some initiatives implemented by SEMI include: Workforce Advocacy, SEMI High Tech U, Industry Image Campaign, Workforce pavilions at various events, Industry Training Courses, Diversity & Mentoring programmes and established high school and university connections[87].

For instance, **the High Tech U** delivered **233 events** at global level to date, including in Europe, with its scale expected to grow**.** This is a 3-day programme consisting of hands-on workshops aimed at connecting high school students to career opportunities in the industry. SEMI works together with teachers, volunteers and parents to make sure that students are informed and convinced of following a career in semiconductor manufacturing. Events are organised at schools or can include company visits, and students can also apply individually to attend the events. The programme is free of charge, as it is funded by SEMI. Since 2001, the programme has worked with more than 6,000 students in eleven US states and nine countries.

4.3.14.2. The EU 2030 High-Tech Skills Vision alignment



The initiatives, with a focus on the High Tech U programme, are aligned with the formulated Vision on the following dimensions:

[86] https://www.semi.org/en/mission
[87] https://www.semi.org/en/connect/workforce-development

Realistic – SEMI's Workforce Development Program is already tested, and commercially applied by 250+ companies. It is also growing and touching upon on new areas, such as image building, mentoring, and diversity & inclusion.

Feasible – The High Tech U initiative has a clear timeline, objectives, and model that allows it to be easily organised at schools in various countries. Moreover, its other activities are clearly defined.

Inclusive – The programme is open to all students interested in a career in tech. It tries to reach out to as many youth as possible and can be considered inclusive in scope due to its integration of students, parents and teachers in the training process. Moreover, the initiative promotes gender balance in its programs, as well as promoting diversity.

Participatory – SEMI High Tech U and SEMI Talent Forum are consensus driven, approved by the SEMI Workforce Development Council, and collective and open to everyone.

Inspiring – The High Tech U programme aims to inspire students to follow higher education in STEM subjects and subsequently choose to work in semiconductor manufacturing. This increases the number of potential experts in the field, who will ensure that the industry continues growing and innovating.

Anticipatory – All initiatives launched under the workforce development objective of SEMI are based on existing and future projections that the labour force gap will widen and thus aim to anticipate resulting challenges.

4.3.14.3. Key insights for the Skills for Industry Strategy 2030

The SEMI workforce development initiatives represent a best practice case for ensuring the sufficient supply of talent to meet industry needs. The following analysis will be based on the High Tech U programme as it represents the flagship initiative of SEMI. With companies and possibly students being the main beneficiaries of the initiative, this case can inform similar policy-making within the following dimensions of an implementation Toolbox:

Module	**Stakeholder**		
	SEMI	*Companies*	*Schools*
Talent detection and nurturing system	Invest in early-stage career guidance programmes to encourage the uptake of relevant careers Offer practical examples to showcase the careers Match specialists from the industry with students to offer career guidance and mentoring Include teachers and parents in the process	Participate in the programmes by encouraging employee volunteering and necessary case studies Offer company visits to showcase the working environment	Be open to hosting networking events Offer teachers the flexibility to participate in relevant trainings and be more involved in career guidance
Leadership and governance	Coordinate the collaboration with schools and encourage SEMI members to be involved	Support the development of effective trainings and lead workshops	

Funding	Use own funds to finance a free programme	Contribute to funding the workshops	
Communication	Focus on effective communication of the benefits of such a career Clearly communicate these benefits to the parents and teachers	Use attractive communication with the students during the workshops	Highlight the participation benefits to the students

4.3.14.4. Transferability, replicability and scalability

For organisations willing to build such a programme, a similar implementation depends on:

Transferability – Similar programmes can be implemented by representatives from other industries, assuming that it would be possible to have effective interactions with students.

Replicability – The same programme could be established in other contexts, with an association needed to overlook and manage it, and the support of industry members and education institutions.

Scalability – Similar initiatives, could be scaled up at European level and implemented across industries to offer more career guidance to youth.

4.3.14.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
Medium	Industry members may not be willing to contribute because of added-value doubts related to working with pupils.
Medium	Organising the workshops depends on the availability of relevant volunteers, who work for SEMI member companies.
Medium	Scaling up the program would require more resources and coordination with members.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar programme:

Impact Level	Success factors
High	Offer practical, straightforward modules in workshops and events to showcase the appeal of the industry.
High	Develop a sufficient network of partner schools to target different regions and countries.
Medium	Get financial and organisational support from the cluster's members.
Medium	Devise a clear communication strategy when discussing career opportunities with pupils.

4.3.14.6. Take away messages

- *Associations and companies can develop programmes that target early talent detection and career guidance.*
- *Workshops, company visits and mentoring are effective ways to encourage students to follow relevant career paths.*
- *Parents and education stakeholders should be implicated in the career guidance process of their children.*

4.3.15. Silicon Europe - The European cluster alliance for innovative electronics & software technologies

Organisation name	Silicon Europe Alliance
Type of organisation	Meta-cluster
Level of implementation	Regional

4.3.15.1. Description

Silicon Europe is an alliance of twelve European clusters that unites the most advanced technologies and expertise in all fields of the electronics and software value chain. The established meta-cluster has the goal to **support Europe's objective to become the world's leading centre for innovative electronics and software technologies.** It is the platform and brand under which the leading European electronics and digitisation clusters in different EU countries collaborate to represent, support and promote primarily SMEs and the organisations of their regional business networks at European and global levels. Silicon Europe acts as an intermediary between all the relevant partners from research and academia, public authorities and industry, particularly SMEs, counting around 2,500 members. The initiative started in 2012, being financed by the EU, but its success has convinced the members to continue the alliance.

The alliance operates along five main themes, formulated in the Joint Action Plan (2016-2018)[88]:

(1) Knowledge and technology transfer – organise fairs, map knowledge sources, support human capital development, and encourage SMEs to use existing and new platforms/labs;

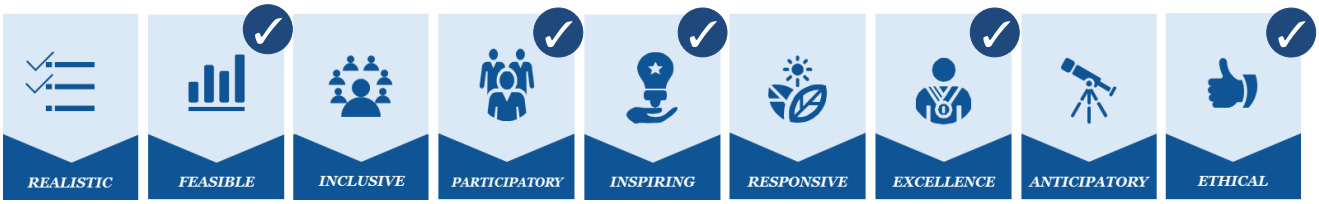
(2) Smart specialisation – support the creation of regional field labs, develop new approaches to build interregional value chains, establish a platform for best practice exchange, and support cross-regional cooperation;

(3) SME funding – act as an intermediary between SMEs and financing opportunities, organise events to attract investors, support SMEs and investors in assessing risks and needs, identify accelerator, and contribute to designing SME financing schemes;

(4) International business development – support primarily SMEs in foreign market entries (e.g. the US and Taiwan), and attract foreign capital not present in Europe.

(5) Promotion of micro- and nanoelectronics – create case studies promoting the role and the entire value chain, encourage companies to explain their role to a broader audience, and communicate the strengths of the European semiconductor industry.

4.3.15.2. The EU 2030 High-Tech Skills Vision alignment



Silicon Europe is aligned with the formulated Vision primarily on these dimensions:

[88] https://www.silicon-europe.eu/fileadmin/user_upload/silicon-europe/Dokumente/Silicon_Europe_Joint_Action_Plan.pdf

Feasible – Given that the initiative was financed by the EU and has a clear action plan, the project is feasible in terms of funding and timing, while its goals have been straightforward.

Participatory – By providing a platform for major European clusters, Silicon Europe brings together all the relevant stakeholders for developing new technologies and their business potential, such as corporates, SMEs, research organisations, and policy-makers.

Inspiring – The alliance facilitates stakeholder interaction to develop cutting-edge technologies across the involved clusters through knowledge transfers. This collaboration directly impacts the level of shared knowledge that can enable further advanced technologies.

Excellence – Silicon Europe's objectives and action plan impact both regions, through increased regional collaboration, and regional businesses, who are the ultimate beneficiaries of a region's increasing expertise in electronics and software.

4.3.15.3. Key insights for the Skills for Industry Strategy

Although Silicon Europe does not specifically address upskilling, its members, for instance Silicon Saxony, implemented a VET programme and training programmes. Moreover, there is an indirect effect for education, as research organisations, as well as companies can learn about new technologies to then disseminate this knowledge within their organisations.

The implementation guidelines are done based on the identification of three main stakeholders, considering the high level of implementation of the initiative: the alliance (Silicon Europe), the member clusters, and the members of these clusters (companies, research organisations, etc.). Silicon Europe thus offers the following insights for the toolbox:

Module	**Stakeholders**		
	Silicon Europe Alliance	*Clusters*	*Cluster members*
Leadership and Governance	Take a leading role in defining a regional skills strategy		Be proactive in collaborating with members outside the regional cluster
Communication	Communicate to foreign actors the existing advantages Ensure strong communication occurs at member level as well	Efficiently intermediate the discussions between partners and the alliance	
Funding	EU-funding can serve as a starting point for a long-term initiative	Contribute financially to sustain the alliance	

4.3.15.4. Transferability, replicability and scalability

The success of the initiative and its alignment with the Vision should interest other stakeholders in the EU to create a similar model. With respect to the potential of implementation:

Transferability – Despite its focus on electronics, Silicon Europe's model could be applied to other relevant sectors in order to enhance Europe's competitiveness in the respective field. A condition

would be to have a sufficient number of existing clusters across Europe who would be able to cooperate.

Replicability – Regrouping clusters from nine countries, similar initiatives could be envisioned on different topics or industries.

Scalability – Given that Silicon Europe acts as a meta-cluster at the European level, a similar initiative may be scaled back to the national level, where the alliance will gather regional clusters to develop national competitiveness.

4.3.15.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar initiative:

Impact Level	Challenges
High	Bringing together multiple clusters, some of which are not publicly financed, requires a certain level of networking and communication.
High	SMEs might be hesitant to join a cluster/ an alliance of clusters as they might have limited funds and availability.
Medium	Without EU funding, the impact will be slightly reduced, since the initiative's activities have to be financed by own means.

On the other hand, several **success factors** are likely to increase the success rate of the initiative:

Impact Level	Success factors
High	Ensure sufficient member participation and interaction, especially of SMEs.
High	Deliver solutions that clearly target the problems/concerns of SMEs.
Medium	Work with education institutions to foster knowledge creation and upskilling.

4.3.15.6. Take away messages

- *Meta-clusters can facilitate the collaboration between regional clusters and enhance the competitiveness of the EU as whole.*
- *Meta-clusters need to balance SMEs problems and priorities with the existing priorities of the EU or its Member States.*
- *Stakeholder consultation is essential in defining the priorities of any initiative and the corresponding action plan.*

4.3.16. Skillnet Ireland

Organisation name	Skillnet Ireland
Type of organisation	Public
Level of implementation	National

4.3.16.1. Description

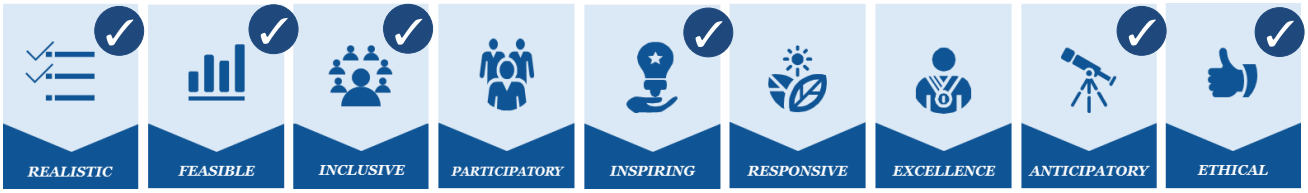
Skillnet Ireland is a flagship national agency **responsible for the promotion and facilitation of enterprise-led workforce training**. The aim of the organisation is to sustain Ireland's national competitiveness by contributing to the learning and upskilling of the working population.

The agency supports and funds the creation of sector-specific learning networks of firms, which eventually become self-sustaining through the active participation of the members and the founding industry association or steering group. This approach ensures that the programmes delivered by Skillnet are relevant for industry, while providing a flexible and informative model for member firms. To this day, 65 learning networks operate across sectors such as ICT, pharma, financial services, agriculture, retail and transport[89].

In 2017**, 94% of the network members were SMEs**. Skillnet Ireland therefore also supports activities related to enhancing SME productivity, through driven programmes spanning multiple industry sectors, and both accredited and non-accredited learning. Skillnet Ireland further manages the Future Skills Programme, which promotes collaborations between enterprise, academic institutions and industry training providers to develop innovative new programmes that speak directly to the future skills needs of businesses and that address gaps in existing provision. Lastly, the agency operates the Employment Activation Programme, which provides upskilling opportunities for jobseekers, mainly by participating in training programmes along with employees from the member companies and by providing job placements in areas of high employment potential. Skillnet Ireland is partly state-funded and partly derives its financing from network members' contributions[90]. It finances the steering organisation that lead the learning networks thus decreasing the costs of trainings.

Since 1999, Skillnet Ireland has facilitated over 70,000 Irish enterprises, in over 400 networks to improve the range, scope and quality of training and allowed over 300,000 employees to upskill and meet their work related training needs. Moreover, the participating companies all report high satisfaction levels for addressing their skills gaps[91]. As such, OECD has highlighted the initiative as a best practice case for government sponsored, enterprise-led workforce development.

4.3.16.2. The EU 2030 High-Tech Skills Vision alignment



The initiative is aligned with the defined Vision on the following dimensions:

Realistic – The agency has extensive experience in facilitating learning networks and working with SMEs, which allowed it to fine-tune its methodologies and operations.

[89] https://www.skillnetireland.ie/our-networks/
[90] https://www.skillnetireland.ie/about/about-skillnet/
[91] https://www.skillnetireland.ie/publication/annual-report-2017/

Feasible – The agency has a clear financing model, as well as procedures for setting up new networks. It acts as an intermediary between government policy and private needs, which gives it a clear set of objectives and tools.

Inclusive –Skillnet targets all businesses irrespective of their size and centre of activities. Both employed and unemployed can benefit from their activities and trainings.

Inspiring – The agency encourages particularly SMEs to develop the necessary talent that will ensure Ireland's international competitiveness.

Anticipatory – The agency encourages lifelong learning and skills development in key, high-growth sectors, ensuring that the labour market is prepared for future changes in the economy.

4.3.16.3. Key insights for the Skills for Industry Strategy

The initiative's success can help other programmes by providing the following insights:

Module	**Stakeholders**		
	Skillnet Ireland	*Companies*	*Government*
Talent detection and nurturing system	Encourage and support enterprise-led training systems Offer sufficient support to the unemployed	Be engaged and collaborate with other companies in identifying the challenges and designing solutions	Offer guidance by creating a skills strategy
Leadership and governance	Take a coordinating role between the different companies and government authorities	Take a leading role in designing and conducting the trainings	
Funding	Create a sustainable financing model with both public and private money Leverage public money with private contributions	Be open to invest in the training solutions	Invest accordingly in these schemes
Industry-led training infrastructure	Offer necessary support	Collaborate with others in order to improve the trainings	

4.3.16.4. Transferability, replicability and scalability

For companies or authorities willing to build a similar community and training centre, a similar implementation depends on:

Transferability – A similar academy may be set up in other countries, granted there exists sufficient political and private support as well as a clear national skills strategy.

Replicability – The same programme could be established in other countries. However, Member States have to be aware that the development and growth of strong networks requires some time and sufficient resources will have to be liberated to facilitate the set-up of necessary infrastructures and processes. The Skillnet model enjoys optimum replicability where there is maturity in the extent to which industry sectors or clusters are organised.

Scalability – Similar initiatives could be scaled down to the city or regional level, given sufficient public and private support.

4.3.16.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar agency:

Impact Level	Challenges
High	It may be difficult for the member companies to encourage their employees to participate in trainings.
High	Align the goals of the individual networks with the existing problems in the national labour market or national skills strategy.
Medium	Engage as much as possible with SMEs, since they are more prone to not have a growth mind-set.
Medium	Enhance collaboration between networks, which can lead to more creative solutions as well as standardised trainings across sectors.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar organisation:

Impact Level	Success factors
High	Achieve a decent leverage factor on public funding, as it will allow the agency to invest in more networks or more issues solved within existing ones.
High	Work with authorities to include SMEs needs in national policy-making, as the SMEs may be focused on issues not currently addressed by national policy.
High	Ensure networks remain value-adding, mainly for SMEs, which may have a low motivation to pay a contribution fee.
Medium	Be forward-looking in setting up the agenda/priorities of the agency, as new trends may shift the current topics discussed in the clusters.

4.3.16.6. Take away messages

- *Semi-public agencies can be established to facilitate collaboration within the private sector and solve skills and talent challenges.*
- *This bottom-up approach to solving skills development can be more effective and satisfying for enterprises.*
- *Networks can operate at both sectoral and regional level, with SMEs remaining a priority in both instances.*

4.3.17. Skills for Londoners Strategy

Organisation name	*Mayor of London*
Type of organisation	Public
Level of implementation	City

MAYOR OF LONDON

4.3.17.1. Description

Skills for Londoners aims to create a single, integrated skills and adult education offer for London that delivers a comprehensive and strategic post-16 education training strategy. Three key priorities stand at the heart of this effort – the need: (1) to **empower all Londoners** to access the education and skills to **participate in society and progress in education and work**; (2) to **meet the needs of London's economy and employers now and in the future**; and (3) to **deliver a strategic city-wide technical skills and adult education offer**.

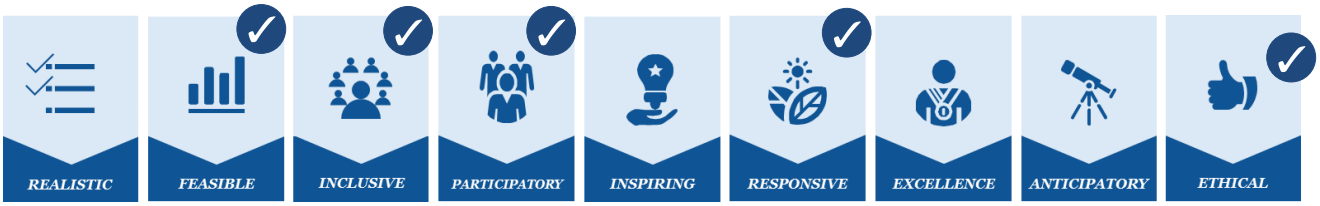
To support the active implementation of the strategy, a Skills for Londoners Framework was published in 2018. It outlines how the objectives of the strategy will be delivered through the devolution of the Adult Education Budget (AEB) in London to the Mayor from the academic year 2019-20, transferring responsibility from the Department for Education for the delivery of adult education provision to London's residents[92].

The strategy's three objectives will be materialised by focusing on the completion of specific action points: To achieve this, the paper articulates:

- **11 points for the first objective** – with a focus on reducing barriers to participation in lifelong learning and progression in work, increasing targeted support to the most disadvantaged groups, and increasing the number and diversity of adult learners in London gaining the skills they need to participate in the labour market.
- **12 points for targeting the employer side** – with a focus on promoting increased productivity by supporting employers to develop and make the best use of the skills of their current and future workforce, working with employers to ensure the vocational education system delivers for the London economy, and increasing employer engagement to improve the relevance and quality of training.
- **10 action points for addressing the third goal** – with a focus on helping improve access to information to support learners and employers to make informed decisions, improving progression pathways into intermediate and higher-level skills, and raising the quality of facilities, teaching and leadership in London's further and adult education sector.

Generally, **the strategy emphasises the need for more investments in apprenticeships and lifelong learning, and for offering enough opportunities to disadvantaged groups.**

4.3.17.2. The EU 2030 High-Tech Skills Vision alignment



[92] https://www.london.gov.uk/sites/default/files/md2389_appendix_a_-_framework.pdf

The Skills for Londoners Strategy represents a model for other cities to acknowledge existing skills challenges and to address them accordingly. The contents of the strategy, as well as the underlying process of elaborating it, are aligned with the Vision on these particular dimensions:

Feasible – The strategy elaborates specific actions to be taken in the future and offers practical guidance on how to do so. The defined points should guide the implementation of the strategy.

Inclusive – The strategy accounts for the local specificities and extensively focuses on addressing the skills gaps of the more disadvantaged groups, including those that, for instance, do not yet have a sufficient level of English proficiency. The devised action plan specifies the needed actions to support these groups.

Participatory – City Hall consulted a wide range of stakeholders (around 61 organisations) and collected direct citizen input through questionnaires and focus groups. As a consequence, the strategy accounted for the majority of opinions and suggestions about the future skills system.

Responsive - The Skills for Londoners Strategy excels in addressing existing and emerging social issues by targeting gender, race and regional differences.

4.3.17.3. Key insights for the Skills for Industry Strategy

The Skills for Londoners Strategy elaborated can serve as a guideline for other cities or regions willing to adopt a more proactive role in addressing the local skills challenges. As such, this best practice case can inform other authorities on the following Toolbox modules:

Module	**Stakeholders**	
	Government	*Companies, universities, associations*
Skills Strategy	Consult large number of stakeholders to gain strong insights Adopt an evidence-based approach to identifying the challenges (cross-sectoral) and pay particular attention so sub-regional and local issues Develop a subsequent action plan based on impact evaluation that outlines the implementation phase	Actively participate in the discussions Provide necessary evidence and insights Offer regular feedback on current skills needs
Leadership and Governance	Take a leading role in designing and conducting the analysis Actively negotiate with the national government in case regulatory changes are needed, such as the devolved Adult Education Budget to the City Hall	
Funding	Define sources of financing before devising the implementation plan Fund training schemes for disadvantaged people	Businesses should contribute to offering VET
Incentives	Offer sufficient career support to beneficiaries	Offer enough human resources that will offer guidance to beneficiaries

4.3.17.4. Transferability, replicability and scalability

A similar initiative may be implemented by other city or regional authorities, depending on:

Transferability – A similar initiative could be easily transferred to other contexts as long as sufficient resources are available to conduct an in-depth needs assessment.

Replicability – While the processes adopted can be replicated, the recommendations given strongly depend on local realities and can thus not as easily be applied to other regions/cities.

Scalability – Strategy development procedures can be scaled to the national level. However, the success of the effort relies heavily on the in-depth understanding of the local issues faced. This might be difficult to implement at national level.

4.3.17.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by public authorities willing to craft a similar skills strategy:

Impact Level	Challenges
High	Sufficient stakeholder input and support necessary to define and operationalise the strategy
High	A high commitment and coordination of the involved parties is needed.
Medium	Collection of sufficient insights and evidence necessary to identify key challenges.
Medium	Sufficient resources need to be allocated to collect evidence and analyse it.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar strategy:

Impact Level	Success factors
High	The creation of a clear, actionable plan facilitates the operationalisation of the strategy.
High	Wide stakeholder engagement required to ensure ownership of the strategy and thus ensure its successful implementation.
High	Define KPIs to allow for the evaluation of the implementation process.
Medium	Draft a comprehensive strategy, addressing both social, economic and technological issues to ensure the set-up of a well-performing and all-encompassing skills strategy.

4.3.17.6. Take away messages

- *Regional and city-level authorities have to launch a wide effort of evaluating the current skills system and identify solutions to the existing challenges.*
- *An evidence-based approach and stakeholder consultations are essential for defining an accurate and realistic strategy.*
- *The implementation plan needs to be consulted and communicated with relevant parties as well to build trust and gain support.*
- *Negotiations and changes in legislation should occur to facilitate the implementation.*

4.3.18. Technofutur TIC

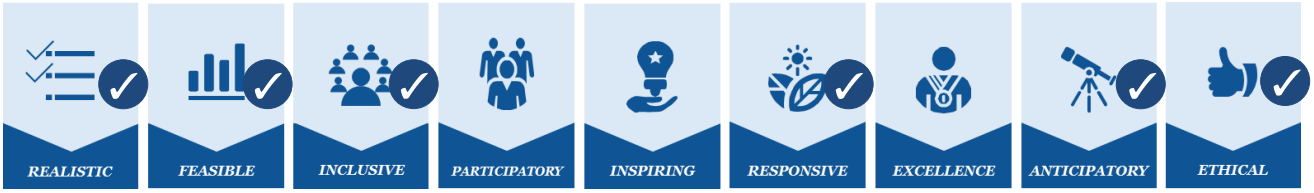
Organisation name	Technofutur TIC
Type of organisation	Non-profit organisation
Level of implementation	Regional

4.3.18.1. Description

Technofutur TIC is a non-profit organisation which offers trainings on **IT skills** for four target groups (i.e. employed trainees, educators, students and jobseekers). The organisation currently offers on-site and online trainings in Software Development, IT management, Business IT and digital marketing. All trainings are offered either by training companies and experts from partner universities or companies, which are invited by Technofutur TIC. The courses are offered at three levels of IT readiness: basic, advanced and expert[93]. The latter specifically focuses on cross-functional skills acquirement in order to enable jobseekers to enter the labour market for the medium and long term. Moreover, new courses are developed in collaboration with employers to reflect emerging trends in industry. In this context, Technofutur TIC also provides trainings in resume writing and digital identity, as well as offering job interview simulations. The programmes usually last from six to eight months and might end with an internship of four to six weeks as well as a recommendation to obtain formal education[94].

Technofutur TIC provides training to around 350 jobseekers per year and in **2018 74% of the jobseekers have reintegrated into the workforce.** The success of the initiative is based on a partnership model between – (1) **the local employment agency**, FOREM, which mainly funds the action and offers additional support to the unemployed, (2) sector federation Agoria, which relays the needs of employers, (3) two Universities (UC Louvain, ULB), which guarantee the scientific content of the training programs and (4) the Unions (Setca, CNE), which support the overall initiative from a worker perspective. These significant successes provided further incentives for the non-profit to create new initiatives such as the launch of the Data Academy in 2017 and the Agile Academy. Furthermore, they were planning to start an Open Learning Lab, an Edulab and a Netlab in 2018. These lab will function as areas where a variety of people are welcomed to work and train on specific skill sets either as in completion of an existing training either totally apart.

4.3.18.2. The EU 2030 High-Tech Skills Vision alignment



Technofutur TIC is aligned with the formulated Vision primarily on these dimensions:

Realistic – The organisation uses existing training methodologies, which have been time-tested and are offered by expert trainers. Simultaneously, the content of the programmes focuses on skills and knowledge that is highly applicable in the work environment and targets the needs of industry.

Feasible – The project is feasible, as it offers short-term trainings, with the ones targeted at employees and educators being offered for a fee. This helps in investing in the development of new training product and innovation services. The unemployed group is also clearly incentivised,

93 http://www.technofuturtic.be/Nosservices/Formationsqualifiantes/Nosformations.aspx
94 http://www.technofuturtic.be/Nosservices/Formationsqualifiantes/Notreobjectiflemploi.aspx

starting with the free trainings until the support offered to find a job or internship, in addition to the actions taken by the public employment agency.

Inclusive – Technofutur TIC ensures that it helps different target groups, especially the unemployed. By developing digital skills for different types of customers, it creates an inclusive community that has an impact on multiple levels.

Responsive – By teaching digital skills, the non-profit increases the chances of upskilling and employment, helping tackle societal problems, such as talent shortages and unemployment in general.

Anticipatory – By focusing on IT and digital skills, Technofutur TIC constantly offers new trainings that become increasingly relevant in the sector, such as big data analytics. It also offers courses on less-common or emerging topics, such as robotics and machine learning.

Ethical – The unemployment programme, offering not only technical trainings, but assistance in finding a job is ethically and socially responsible, primarily by offering these services for free.

4.3.18.3. Key insights for the Skills for Industry Strategy 2030

The initiative's good practice in terms of trainings offering grants a more detailed investigation of its potential guidelines for the Toolbox. This is done based on the identification of three main stakeholders: Technofutur TIC, employers and the state authority. The beneficiaries of the policy are trainees, with a special focus on unemployed people.

Module	**Stakeholders**		
	Technofutur TIC	*Employers*	*State authority (via Forem, employment agency)*
Talent detection and nurturing system	Offer an up-to-date, high-quality catalogue of courses Offer additional support to the unemployed	Be open to offering internships or traineeships and job opportunities	Offer support to the unemployed through the responsible agencies Detect unemployed potential candidates and inform about training offer
Leadership and Governance	Actively coordinate and develop the network of partner employers and trainers	Contribute by updating the needed skills and giving the respective trainings	Contribute to governance by being members of board of directors Coordinate a network of 25 competence centre like Technofutur TIC
Funding	Combine free and paid trainings to achieve financial stability	Be proactive in funding the employees' digital skills	Fund major part of the unemployed trainings
Industry-led training infrastructure	Develop trainings in partnership with employers	Contribute to the trainings' content and structure by defining the emerging needs	Through the EU ERDF programme, fund investments in equipment

4.3.18.4. Transferability, replicability and scalability

The success of the organisation and its alignment with the Vision should interest other parties from the EU to create a similar model. With respect to the potential of implementation:

Transferability – Given its close cooperation with employers and employment agencies, the model could be applied to other regions, granted that enough support is offered by the authorities in assisting the unemployed.

Replicability – Due to its relatively simple model, the organisation could essentially be transferred to other cities or regions, assuming a similar ability to be connected with all the relevant stakeholders in the region.

Scalability – The non-profit focuses on a specific region in Belgium, Wallonia. A major factor for the success of this initiative is that those involved are knowledgeable about the region and therefore provide a programme and support that are attuned to the characteristics and human capital demands of the region. In order to achieve similar results on a larger scale, cooperation with entities that have comparable knowledge in their respective regions is needed.

4.3.18.5. Potential challenges and success factors for implementation

To be able to implement a similar initiative in a different context, several success factors and potential barriers have been identified. Based on the most recent evaluation reports, the following potential **challenges** have been noted:

Impact Level	Challenges
High	Assist jobseekers in completing the right trainings that will enable them to find a job. The skills gaps to be addressed might be significant and will require a significant level of support and guidance.
High	Resource-intensive to develop the network and support the unemployed. Sufficient funds are thus required.
Low	The financial stability of the company relies on the balancing of free with paid courses and requires regular supervision.

Besides addressing these challenges, some **factors** will enable a successful implementation:

Impact Level	Success factors
High	Develop an extensive network of contacts with employers, agencies and trainers.
High	Work with trainers that have extensive experience.
Medium	Adapt the programme to the backgrounds and skill levels of the trainees.
Medium	Develop personal relationships, especially with job seekers, to facilitate the reintegration process.

4.3.18.6. Take away messages

- *Non-profits can be established to train both the unemployed and the employed thus helping both segments achieve financial stability by improving their employability.*
- *Career guidance and the provision of targeted trainings is important to facilitate the reintegration of the unemployed.*
- *Strong collaboration with all stakeholders in the region facilitates labour market reintegration and enhances the scope and quality of trainings offered.*

4.3.19. 6Aika – The six city strategy

Organisation name	6Aika
Type of organisation	Alliance/ Quadruple Helix
Level of implementation	Regional

4.3.19.1. Description

6Aika - open and intelligent services - is a flagship joint development strategy focused on the sustainable urban development of the six largest cities of Finland which are home to almost 30% of Finland's overall population (Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu). The strategy covers the period 2014-2020 and aims to create new competences, businesses and jobs in Finland. **The strategy is built on three main focus areas: (1) open innovation platforms; (2) open data and interfaces (unlocking and utilising data); as well as (3) open participation and customership (customer-centred co-creation)**[95].

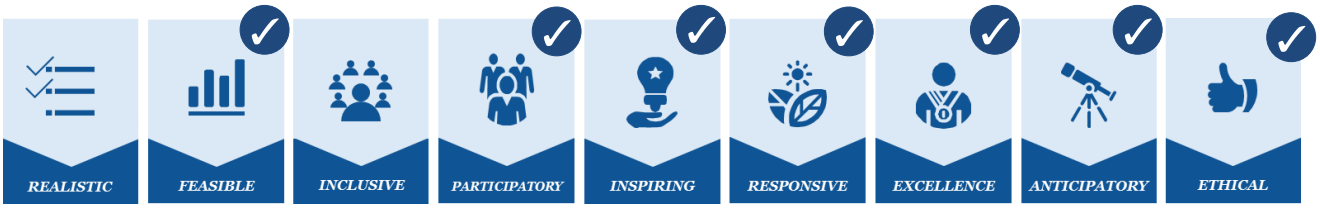
The strategy is based on co-operation between municipalities, companies, citizens, and universities in a quadruple helix model. The realisation of the strategy is project-based, with funding for joint projects being provided through open calls that are organised twice a year. In addition to city organisations, project partners can be other public and third party operators. Funding of nearly €80m is derived from several sources: the European Regional Development Fund (5% allocation of the national funds), the European Social Fund (decided at local level), the six cities' budgets as well as the Finnish central government, which makes up 33% of the total funding[96]. A joint management team and steering group have been set up, consisting of directors from the six cities, to coordinate and monitor the strategy, while the implementation is conducted by the Six Cities Strategy Office which includes city-specific coordinators.

Given the broad scope of developed projects in urban development, the initiatives that are the most relevant to this report refer to training and education. In this context, **four projects have been approved, with a specific focus on smart learning solutions and training citizens in innovative sectors**. In line with the open innovation platform focus, the first project called 'Smart learning environments of the future' focuses on the supply-side and supports companies in developing smart learning solutions by providing co-creation opportunities in primarily education institutions[97]. With schools acting as platforms for innovation and experimentation, a strong collaboration can lead to better products and, in turn, better learning outcomes. Moreover, teachers actively participate in the pilot projects, and can offer valuable input, while pupils can familiarise themselves with the new technologies. The other three projects, called Digipore, Game Time and PoraKONE, are pilot initiatives trying to increase employment and improve the skills in the technology, gaming industry and engineering industries, respectively. All three projects offer trainings and career advice based on company needs, as well as acting as platforms for more ongoing discussion[98].

All in all, The Six City Strategy is seen as a successful initiative. It was chosen to represent Finland at the EU Cohesion Policy's 30th anniversary year and received an award from the International Board of Entrepreneurs & Business People.

95 https://6aika.fi/in-english/
96 https://6aika.fi/wp-content/uploads/2015/11/6Aika-strategia_pa%CC%88ivitys_2015_EN.pdf
97 https://6aika.fi/smart-learning-environments-of-the-future/
98 https://6aika.fi/porakone-project/; https://6aika.fi/digipore-project/; https://6aika.fi/game-time-project/

4.3.19.2. The EU 2030 High-Tech Skills Vision alignment



Given its innovative model of implementation, as well as the contents of the defined strategy for the six cities, 6Aika serves as a model for a defined EU-level Skills Vision:

Feasible – The initiative has a clear budget structure, schedule for implementation, effective management and project application procedures.

Participatory – The strategy's projects emphasise collaboration between different stakeholders, offering a prime example for a participatory approach to implementing a skills strategy.

Inspiring – Through its approach on open innovation, 6Aika targets not only sustainable urban development for the participating cities, but the potential to come up with innovations that will be applicable at global level.

Responsive – The strategy, by employing a collaborative and open innovation model, targets all sectors and aspects of urban life, which is likely to include all social segments and address their problems.

Excellence – By supporting innovation, 6Aika supports the six cities to become European and even global models of developing technologies in a collaborative urban environment.

Anticipatory – The strategy specifically focuses on emerging technologies and models of operation such as using big data to improve urban life or developing online learning solutions to address existing skills challenges.

4.3.19.3. Key insights for the Skills for Industry Strategy 2030

The 6Aika strategy can inform other authorities willing to implement a similar initiative within their cities or at regional level. The programme excels in targeting not only citizens, or employees, but attempts to also improve the status of businesses and universities. With this wide array of beneficiaries and innovative operation models, 6Aika can inform a skills initiative on the following aspects:

Module	**Stakeholders**		
	Programme management	*Municipalities*	*Companies, universities*
Skills strategy	Indirectly support a skills strategy by supporting projects that train skills in innovative sectors or address skills gaps		Contribute by devising projects that address existing skills gaps
Leadership and governance	Lead discussions on defining the strategy and priorities Create a transparent mechanism for selecting projects	Offer necessary support to management	Proactively engage in discussions Be open and offer support for the projects

Talent detection and nurturing system	Support projects focusing on skills development		Strongly collaborate with other stakeholders in creating effective training models
Funding	Use EU funds if available Create a multi-source, flexible funding structure	Contribute sufficiently to cover remaining financing needs	

4.3.19.4. Transferability, replicability and scalability

The initiative has a relatively simple model of cooperation, with similar implementation attempts depending on the following aspects:

Transferability – A similar initiative may be implemented by governments in other cities and regions to support emerging projects for skills development and innovative training models.

Replicability – The programme may have limited replicability due to the strong innovation capabilities of the Finnish society, but a model that increases the project pipeline could help overcome this aspect in less-innovative regions.

Scalability – The initiative could be implemented at national level, assuming that the state authorities collaborate strongly with municipalities to encourage them to support sustainable urban development, including skills development.

4.3.19.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by public authorities willing to create a similar initiative:

Impact Level	Challenges
High	A sufficient project pipeline needs to be ensured to justify the efforts made.
High	Sufficient funding needs to be accessible to allow for the successful implementation of the strategy.
Medium	The wide scope of the strategy may result in less impactful solutions when trying to address very specific issues.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar strategy:

Impact Level	Success factors
High	The active participation of business in the development and implementation of selected projects ensures their feasibility and applicability to the needs on the ground.
High	Good communication and change management efforts will improve the impact of the projects and facilitate their successful implementation.
Medium	The definition of a specific set of priorities helps screen projects and select those that are aligned with the aims of the strategy.

Medium	By encouraging collaboration between relevant stakeholders in an open environment, innovation and the development of new technologies is being supported.

4.3.19.6. Take away messages

- *Cities can become testing and development labs that support the development of innovative solutions to societal problems, including skills development.*
- *Cities should collaborate between them to exchange expertise and technologies.*
- *Companies, universities, citizens and customers can be stimulated to collaborate and co-create innovative solutions.*
- *The project-based and open innovation approach allows authorities to give the 'market' the responsibility to solve relevant issues.*

4.3.20. The Business and Shared Services Centre (CNSP)

Organisation name	The Business and Shared Services Centre
Type of organisation	Public
Level of implementation	City

4.3.20.1. Description

The Business and Shared Services Centre is a business centre project in Fundão, in the central rural region of Portugal. Initiated by the city municipality in collaboration with all relevant stakeholders, **the centre provides technical infrastructure and skills for smart, sustainable businesses, with a focus on information and communication technologies for education** (TICE)[99]. The centre acts as an innovation incubator by providing office space to companies and freelancers. It further offers support to entrepreneurs and organises trainings in digital skills to contribute to the upskilling of the workforce in the region. The sectors under focus are related to the emerging digital age, such as software development, robotics and business services, and aim to modernise the regional business environment. The technical infrastructure and facilities include a training centre, a digital fabrication lab, an open-source IoT centre, a plant biotechnology facility and a software validation and certification. By sharing these facilities, companies, especially SMEs, can cut costs and become more financially sustainable. The centre has been established by accessing ERDF funds in excess of €2 million. **The training centre focuses on digital skills and trains also unemployed people.** Around 240 unemployed persons, out of which 50% without higher education have participated in the trainings, and 97% found a job afterwards. The courses in turn are funded by the participants or the companies.

The centre has attracted 14 specialist companies and created 500 jobs in a relatively small city. The created ecosystem has facilitated the start-up of 68 companies and offered support to over 200 private funding projects, with a special focus on R&D and skills development**. The initiative has initiated strong network effects, which led to a rehabilitation of the region, materialised through a decrease in unemployment, increased demand for real estate and the launch of other innovation projects**. The project has received several accolades, such as the European Enterprise Promotion Awards in 2015, the Municipality of the Year award in 2016 and the RegioStars award of the European Commission in 2018.

4.3.20.2. The EU 2030 High-Tech Skills Vision alignment

This project serves as a best practice, mainly because it is aligned with the following dimensions:

Realistic – The project has combined existing practices in business incubators, training centres and innovation facilities to contribute to the development of Fundão.

Inclusive – The centre has attracted multiple companies and its trainings are open to those unemployed, creating an open innovative and inclusive environment.

[99] https://ec.europa.eu/regional_policy/en/projects/portugal/business-and-shared-services-centre-supports-smart-growth-in-portugals-centro-region

Participatory – The Fundão municipality has collaborated with multiple stakeholders, such as companies, universities and associations, to setup the centre and define its objectives.

Responsive – The initiative was launched as a solution to the declining economic status of the region, and serves as an attempt to revitalise economic activity, innovation and upskilling.

Excellence – Serving as a best practice case for regional development, Fundão's recent growth is attributed in part to the centre's activities and network effects it has created.

Anticipatory – The project focuses on emerging technologies and fields, such as IoT and robotics, to help improve the economic and social outlook of the region. Respectively, the skills development that takes place complements this change in the economic strategy of the city.

4.3.20.3. Key insights for the Skills for Industry Strategy 2030

The Business and Shared Service Centre in Fundão can serve as an example for municipalities and regions willing to shift their economic strategies and specialisations in light of the emerging trends and innovations to help address existing challenges. This broad initiative also touches upon skills development and upskilling, which remains an integral part of successful economic initiatives. The project can thus inform similar initiatives with regards to the following Toolbox modules:

Module	**Stakeholders**		
	CNSP	*Government*	*Companies*
Talent detection and nurturing system	Offer targeted trainings open to everyone (incl. unemployed) thus encouraging lifelong learning and talent detection	Support the centre in tackling unemployment and encouraging the growth of talent	Support the development and presentation of trainings Offer employment/traineeship opportunities
Leadership and governance	Manage the development and execution of trainings, including the necessary facilities	Support the centre by defining a skills and economic development strategy	
Funding	Build a sustainable financing model based on offering value-adding services	Access EU funding to initiate similar projects	Contribute with funding and human resources to trainings
Incentives		Incentivise the unemployed to complete trainings and develop the required skills Encourage local businesses to support the centre's activities	Encourage employees to give trainings and adopt a lifelong learning approach themselves

4.3.20.4. Transferability, replicability and scalability

For municipalities or associations willing to build a similar programme, implementation depends on:

Transferability – Similar projects can be implemented in other cities and regions, given the flexibility of the model and its easy adaption to local specificities and priorities.

Replicability – Business and shared services centres can be replicated in other regions, provided that there is enough potential to build a value-adding network.

Scalability – Additional centres could be established in different cities/regions, adopting a bottom-up approach to reskilling and redefining the economic priorities of the nation.

4.3.20.5. Potential challenges and success factors for implementation

The following **challenges** may be encountered and have to be addressed by organisations willing to create a similar agency:

Impact Level	Challenges
High	A high demand for the services offered needs to exist to justify the efforts required for the set-up and running of the centre.
High	In certain instances the existing skills gap may be too wide to be easily bridged and provide sufficient local talent to member companies.
Medium	The centre's objectives and activities need to be aligned with the government's local/regional/national skills strategy and respond to local challenges.

Despite these challenges, several **success factors** are likely to increase the success rate of a similar programme:

Impact Level	Success factors
High	Ensure a sufficient number of companies and start-ups operate in the centre.
High	The municipal authorities are willing to commit and access enough funding.
High	Prove the value-added of being part of the centre.

4.3.20.6. Take away messages

- *Municipalities and regions lagging behind in economic development can refocus on innovative sectors by unlocking EU funding and developing an innovation ecosystem.*
- *Business and training centres can spur further investments and initiate the transition to a more innovative economy.*
- *Business and shared services centres can address a variety of societal challenges such as unemployment, skills development, and R&D, in a collaborative, open-innovation environment.*

4.4. Key observations

This section of the Final Report has presented twenty best practice cases and analysed the subsequent potential of implementation of similar initiatives in other contexts or by other stakeholders. The analysis of the initiatives has generated diverse, but complementary insights, which are discussed below.

To summarise, the selected examples have been initiated by different stakeholders: **national authorities** (e.g. Portugal Skills Strategy, Luxembourg Digital Skills Bridge, and Skillnet), **regional and city authorities** (e.g. Skills for Londoners Strategy, 6Aika, CNSP, BRIDGE, AFIL and Allianz Industrie 4.0), **corporates** (e.g. IBM Skills Academy, Cisco Networking Academy, Airbus Engineer of the future and Bosch Centre of Artificial Intelligence), **clusters** (e.g. Silicon Europe, Brainport Development, and SEMI), **non-profit organisations** (e.g. Technofutur TIC and ReDI School) as well as **academic institutions** (e.g. PROMPT and IMEC Academy). The initiatives have also been implemented at different levels, ranging from **cluster** (AFIL), **city** (BRIDGE), **regional** (6Aika) level to **national** (Portugal Skills Strategy) and **supranational** level (Cisco Networking Academy). All the best practices analysed have proven the importance of cross-sectorial and cross-regional collaboration. They have also highlighted the need for transversal cooperation among public and private bodies as well as between different sectors and industries.

Overall, two main types of initiatives can be distinguished: (1) best practices that address the supply of skills, which refer to trainings and upskilling of the labour force (e.g. Technofutur, IMEC Academy, PROMPT), and (2) initiatives that target skills needs to further innovation and enhance the competitiveness of key sectors, with particular focus on SMEs (e.g. Silicon Europe, Brainport Development, CNSP). Given the overall objectives of this project, both types of policies help address the labour market challenges, by training and upskilling people, and thus ensuring the competitiveness of Europe's industry.

In this light, some interesting patterns emerge, which provide food for thought and will inform the further development of the EU 2030 High-Tech T-Shaped Skills Vision and the accompanying Toolbox.

- **Skills strategy definition** (e.g. Portugal Skills Strategy, Skills for Londoners Strategy, Luxembourg Digital Skills Bridge, Brainport Development, Airbus Engineer of the Future) – These initiatives serve as a starting point in a new effort of state authorities to define a new skills system at either national, regional, or cluster level. These types of initiatives all have an extensive evaluation element, based on stakeholder consultations and evidence-based sector analysis, which defines the key challenges of the current system. Based on their findings, cross-sectoral and governmental teams work on developing an implementation framework to address the existing challenges. The Portuguese case shows that national authorities with serious challenges can also collaborate with international organisations (such as the OECD) to access support and expertise in better designing the new skills agenda. On the other hand, the Luxembourg Digital Skills Bridge initiative shows that a bottom-up approach, where companies define the needs to be addressed, may work in countries with less structural problems but with existing skills gaps.

- **Private sector (industry-led) - educational system collaboration** (e.g. Cisco Networking Academy, IBM Skills Academy, Airbus Engineer of the Future, SEMI High Tech U) – All the listed initiatives have been launched by private companies and large multinationals in collaboration with academic institutions. They represent private investments in education and upskilling, in part because their respective sectors face widening skills gaps or increasing labour demand. Trainings and research done within

academic institutions enhance the employability of students and prepare them for the future needs of the labour market and industry. The scope and impact of the programmes assessed make the case for private initiatives that ask for the active collaboration of universities, schools and public authorities. By encouraging greater collaboration between academia and industry, students will increasingly gain the skills required by industry, while the overall expertise of European regions and cities will be strengthened.

- **Training and research centres** (e.g. Technofutur TIC, PROMPT, Allianz Industrie 4.0, 6Aika) – Some best practices illustrate the potential role and impact of dedicated training and research centres on skills development in Europe. These public-private facilities are often managed together by industry, academia and even regional governments, making the case for using the more collaborative Triple Helix model to offer more relevant trainings to different target groups: students, professionals, and the unemployed. By targeting a wide variety of people, such centres actively contribute to the lifelong learning of professionals and strengthen the overall competitiveness of Europe's workforce.

- **Socially-responsible initiatives** (e.g. BRIDGE, ReDI School, Technofutur TIC, Cisco Networking Academy) – With respect to the unemployed or disadvantaged groups, further efforts can be made. Initiatives that specifically target youth from poor regions and/or refugees, ensure the inclusiveness of the upskilling efforts and the comprehensiveness of the skills strategies developed. The diverse implementation models and types of initiatives illustrated demonstrate the positive impact these programmes can have on the wider economic development of a city, region or even Member State.

- **Early-stage training** (e.g. BRIDGE, SEMI High Tech U) – Two selected initiatives highlighted the need for increased career guidance for students. To decrease the risk of a continuous expanding skills gap, future policies and initiatives will need to increasingly focus on the detection of talent at an early stage. Students need to be made aware of industrial needs and the opportunities each career path offers. Teachers and parents will have to be deeply implicated in to this process to ensure an adapted and personalised career guidance support.

- **World-class research and trainings** (e.g. IMEC Academy, Bosch Centre for Artificial Intelligence, Silicon Europe, Brainport Development) **-** Leading research centres, such as IMEC and BCAI, can establish trainings and research programmes to grow talent that could advance world-class knowledge in key sectors for the EU. This can be done in collaboration with leading European universities or by leveraging on the existing internal business expertise. On the other hand, clusters can contribute to knowledge transfers between companies in order to generate more innovative solutions. This demonstrates that creating global champions would require both more academic and company-led initiatives.

- **Industry-focused clusters and SME development** (e.g. Silicon Europe, AFIL, SEMI, Brainport Development, Skillnet Ireland) **–** As previously mentioned, some cases address SSIS&DT in an indirect way by first facilitating knowledge creation and the development of key sectors. As prioritised by the EU, clusters are integral to this process. They support the collaboration between industry members and help prioritise key challenges, such as skills gaps and necessary trainings. Be it at regional, national, European or global level, clusters help raise awareness about the key challenges their members face and offer a platform for solution development. Skillnet and Brainport Development, for example, support the creation of networks on various issues and help their members develop concrete solutions. Moreover, clusters offer significant support to SMEs, which are likely to have less resources

to initiate private training programmes. Lastly, meta-clusters, such as Silicon Europe, can provide a platform for greater regional collaboration among clusters, thus further strengthening the competitiveness of Europe's industry.

- **Regional Development** (e.g. 6Aika, CNSP, AFIL, Brainport Development, Allianz Industrie 4.0) **–** Initiatives focusing on regional development need to pay specific attention to the local context while often targeting a broader scope of activities. An interesting observation to be made is that in developed regions businesses often request initiatives that encourage new innovation and collaboration models, while in developing regions (such as CNSP in Fundão) public authorities often lead the transformation and upskilling efforts.

These categories of initiatives demonstrate that all stakeholders - public, private, academia, clusters and international organisations, need to be aware of the expanding skills challenges. All parties need to undertake a concerted approach to addressing the problems at local, regional, national and EU-level. Stakeholders need to increasingly work together to define problems and develop common solutions, mostly in the form of public-private partnerships. The coordination is necessary to make sure that all initiatives and policies are effective, complement each other and are not duplicates. On the other hand, comprehensive policies need to be implemented to support SME development. Traditional training and education systems need to be reviewed and more transversal flexible education systems developed.

SECTION V – US-EU COMPARISON

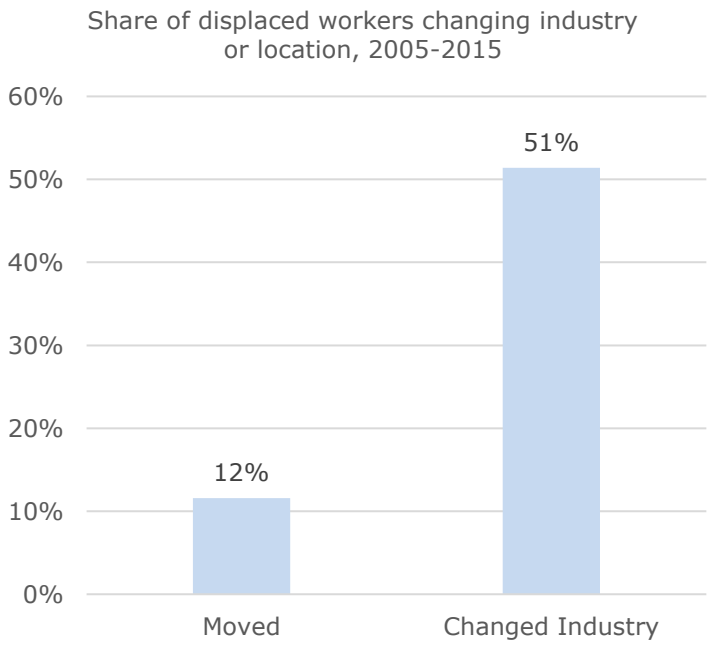
5. Comparison of the high-tech skills situation between USA and EU

5.1. Introduction

In this section, we compare labour-market issues for high-tech T-shaped skills between the European Union and the United States. We discuss general trends in high-tech T-shaped skills challenges and responses that stakeholders from the public sector and the private sector have developed. We then describe and analyse the American policy discourse on skills shortages, and draw parallels in high-tech T-shaped skills issues in the United States and the EU. Subsequently, we describe notable differences in high-tech T-shaped skills issues in the United States and the EU. Finally, we describe what can be learned from this analysis.

As in the EU, the labour market in the United States is transforming in response to high-tech developments. Between 2005 and 2015, about 12% of American workers have migrated domestically in search of work. More than 50% have switched industries to stay employed. Still, in 2018, 6.8 million Americans are unemployed, and another 6.7 million are underemployed and in search of full-time jobs.[100]

Figure 16. Worker displacement in the USA[101]



American policy makers currently are concerned that the United States does not lead in all areas of science and technology, and that it may be impossible for the US to regain the leadership they had. They point to being placed lower in international rankings of research publication impact,[102] and innovation economic competitiveness, as worrying signs.[103]

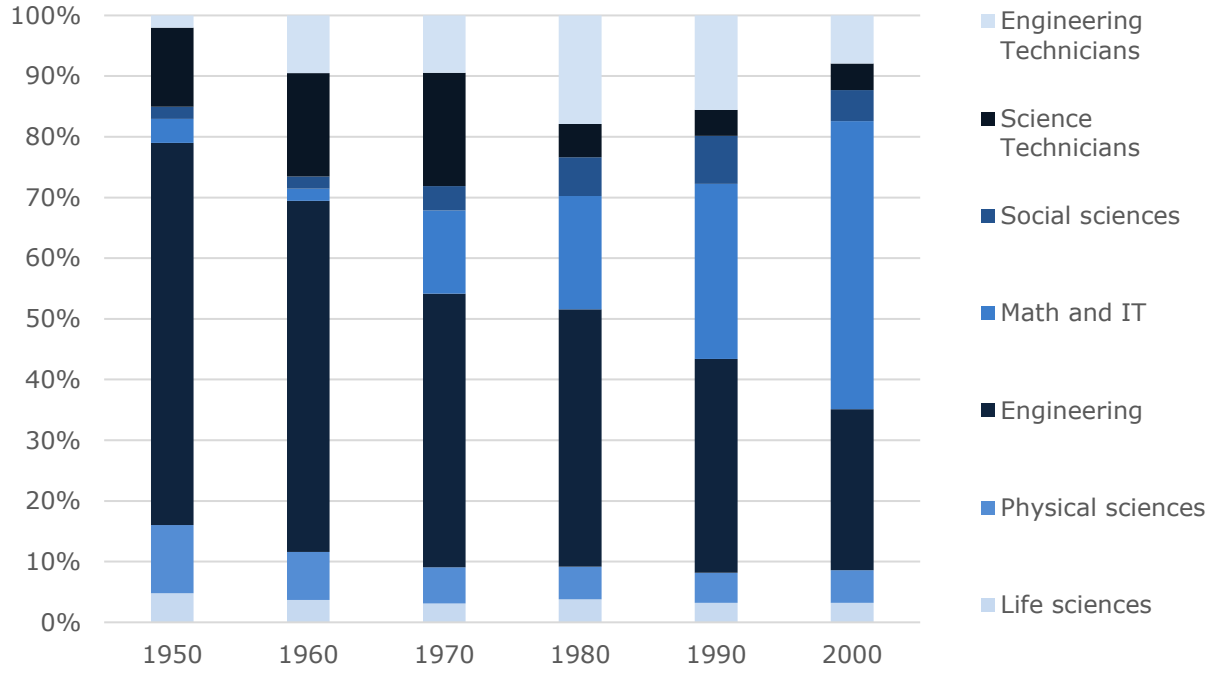
For decades, an important part of the American high-tech talent pool consisted of international top-tier talent that migrated to the United States to study at American universities and start off

[100] Bureau of Labour Statistics, 2018, current population survey (Analysis by MIT future of work)
[101] Bureau of Labour Statistics, 2018, current population survey (Analysis by MIT future of work)
[102] Marshall, Eliot & Travis, John. (2011). UK Scientific Papers Rank First in Citations. Science. 334. 443-443. Counts are national averages and are normalized to the average number of citations in the respective research discipline in 2011
[103] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, chapter 1

their careers. Major pull factors included the US's high level of technological advancement, growing economy, world-renowned universities, and a strong research and innovation culture with ample government support through research assistantships, funding for basic research, and support for research equipment.[104]

In the second half of the 20st century in the United States, the high-tech workforce has grown significantly. This growth was initially driven by a strong growth of employment in science and engineering technologies. The advent of IT took care of the rest, and employment in that segment dominated work in STEM at the turn of the millennium.[105] Also currently, work in IT makes up the bulk of STEM employment in the United States, with engineering work and employment as STEM technician as distant second and third.[106] This is illustrated by the figures below.

Figure 17. USA STEM workforce by occupational group in percentages[107]



[104] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, chapter 1
[105] National Research Council, 2006, CPST analysis 2006a
[106] National Research Council, 2006, CPST analysis 2006a
[107] National Research Council, 2006, CPST analysis 2006a

Figure 18. USA STEM workforce by occupational group in absolute numbers[108]

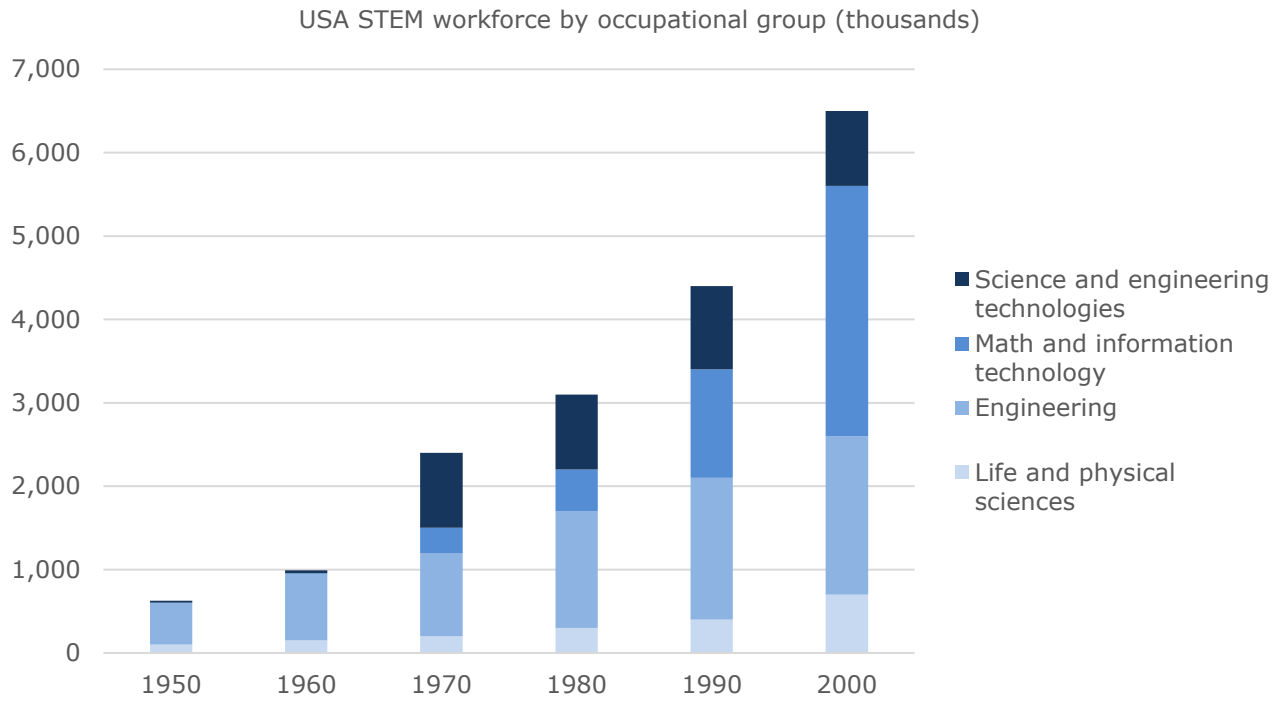
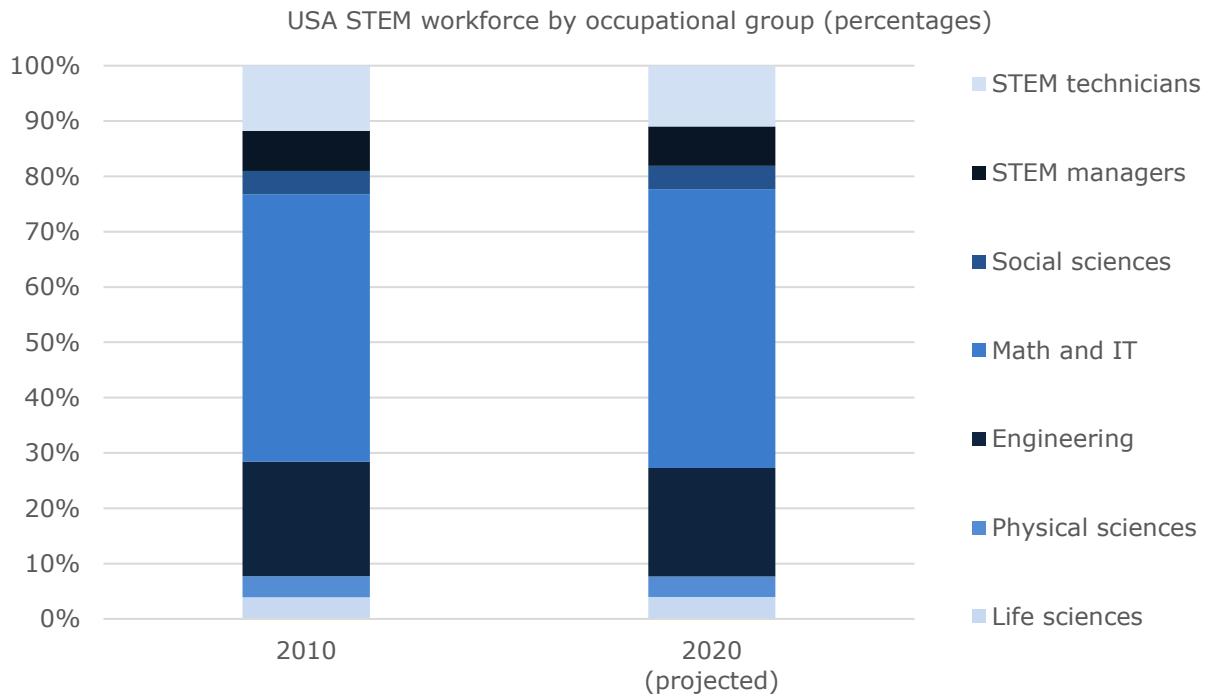


Figure 19. USA STEM workforce by occupational group in percentages[109]



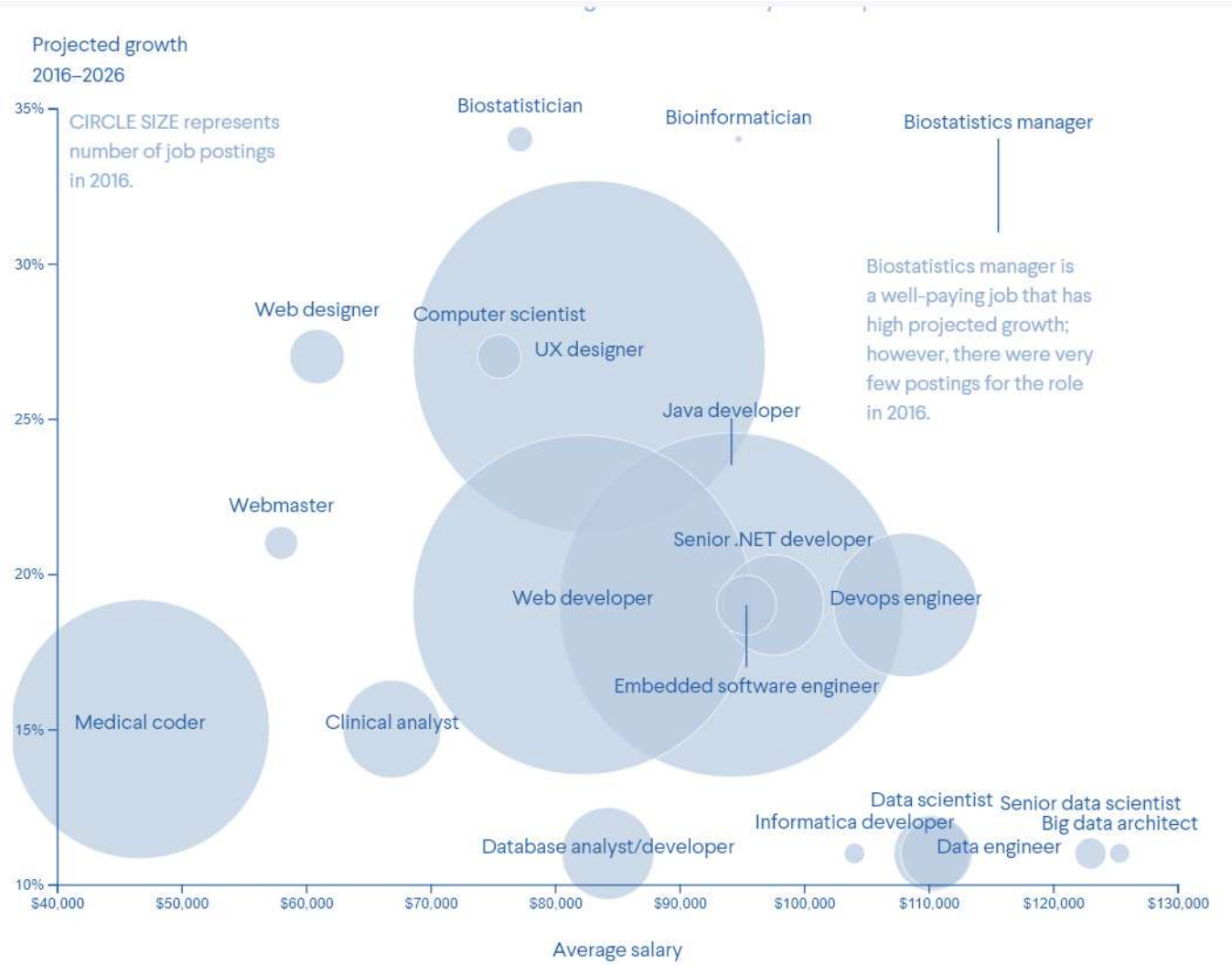
Analysis by Burning Glass technologies, based on job postings, zooms in on high-tech workers that are currently in high demand in the United States, and projects the growth of this demand towards

[108] National Research Council, 2006, CPST analysis 2006
[109] National Research Council, 2006, CPST analysis 2006a

2026. It shows that currently, the highest demand is for UX designers, web developers, java developers and medical coders. Of these occupations, highest growth is forecasted for UX designers.[110]

Other high-tech occupations currently feature less high demand, yet are forecasted to grow rapidly in the coming years. These include biostatisticians, bioinformaticians, web designers and computer scientists. Other occupations also feature less high demand, and demand for such workers is not expected to grow much, yet workers with these skills commandeer higher salaries than most. These occupations include big data architects, data scientists and data engineers.[111]

Figure 20. Volume of high-tech job postings, their associated average salaries and forecasted growth rate in the United States



In response to the increasing demand for workers with high-tech T-shaped skills, employers engage in a myriad of activities that include significant retraining of their employees to generate the right skillsets, hiring people from outside of their industry to bring in new talent, coordinating with educators to establish talent pipelines directly from educational institutions to their

[110] Burning Glass Technologies, 2016
[111] Burning Glass Technologies, 2016

companies, hiring well-performing workers from competitors, and changing the composition of their workforce between permanent and contingent to gain the flexibility and agility needed to keep up with rapid transformation of the digital economy.[112]

CEOs world-wide report to favour retraining of their workers most, and to think altering contractual conditions for their people is less important. When comparing CEO responses from North America to those from Western Europe, it shows that European CEOs favour significant retraining and upskilling more than their North American colleagues. Conversely, North American CEOs report to rely on establishing a direct pipeline from educators in greater numbers compared to West European CEOs.[113] This may be associated with strong alumni ties between employers and educational institutions, although little research appears to have been done on the topic.

Figure 21. Priority of employer activities to address a potential skills gap in their organisation[114]

[112] PwC, 22nd annual CEO survey
[113] PwC, 22nd annual CEO survey
[114] PwC, 22nd annual CEO survey

5.2. Overview of American policy discourse on skills shortages

In this section, we provide an overview of policy discourse in the United States on skills shortages. We describe the issue as to whether a skills gap exists, what it looks like for computer science and IT jobs, how it presents itself at the federal level, and how it relates to the concept of T-shaped skills.

It is a given that new technologies and new ways of working demand state-of-the art skills from employees. There is no doubt that keeping (future) workers up with the demands of a changing economy through education and reskilling is important and necessary. However, attributing the current unemployment rates in the US of the last couple of years to the fact that workers are not educated enough and do not have the right skills, as current and past administrations did, is called into question.[115]

5.2.1. Existence of a skills gap

In public debate, there is a strong narrative that high unemployment rates exist due to a skills mismatch, and workers do not have the right skills for the available jobs. This is in contradiction with research that reveals that a weakness in aggregate demand is the most important driver of high unemployment rates, in combination with other mechanisms.

Researchers from the Economic Policy Institute found patterns in the American labour economy that are consistent with unemployment being caused by cyclic phenomena, namely a weakness in aggregate demand. No other structural patterns that indicate unemployment due to skills mismatches or shortages were found. Their starting point was that if today's high unemployment were a problem of mismatches or a skills shortage, they would expect to find some types of workers or sectors or occupations facing tight labour markets relative to before the recession started.[116]

Analysis showed no evidence for workers at any level facing tighter labour markets in 2013 than before the recession. Even workers with high levels of education have seen a large increase in unemployment rates between 2007 and 2013. Further, they did not find the 'signature of a skills mismatch': workers in some occupations experiencing tighter labour markets relative to 2007. On the contrary, they found that in every occupational category demand for workers was lower in 2013 than before the recession started. Another angle they chose was the number of job openings in a selection of sectors. If high unemployment were due to skills shortages or mismatches, they would expect to find some sectors where there are more unemployed workers than job openings and some sectors with more job openings than unemployed workers. Their finding was that unemployed workers outnumber job openings in all examined sectors. The researchers also analysed wage trends. If there would be a skills shortage, the expectation would be that wages should be increasing in occupations where there is a shortage of skilled labour. However, they found in no occupation major wage increases. They conclude that the reason of a lack of job growth is a declining demand for goods and services.[117]

Another explanation for a perceived skills mismatch or skills shortage is offered in a paper by researchers from Harvard University, Northeastern University and the Federal Reserve Bank of Boston. They found evidence that in the skill requirements employers use to screen candidates opportunistic upskilling takes place[118]. Using data on millions of online job vacancy postings, they

[115] The skills gap is fixed, because there was no skills gap, 2019, Washington Post: https://www.washingtonpost.com/business/2019/01/14/skills-gap-is-fixed-because-there-was-no-skills-gap/?noredirect=on&utm_term=.e1a88c0a649d
[116] Is There Really a Shortage of Skilled Workers?, EPI, 2014: https://www.epi.org/publication/shortage-skilled-workers/
[117] Is There Really a Shortage of Skilled Workers?, EPI, 2014: https://www.epi.org/publication/shortage-skilled-workers/
[118] Sasser Modesto, A, Shoag D., Balance, J, *Upskilling: do employers demand greater skill when workers are plentiful,* Norteastern University, Harvard University, Federal Reserve Bank of Boston

found that employer requirements rise for both education and experience when job seekers are more plentiful. They conclude that their 'findings provide some of the first empirical evidence of a shift in recruitment intensity whereby employer skill requirements are driven—in part—by the available supply of labour'.[119]

Some fields in science and engineering are truly short in supply, at least in specific periods and at certain locations. In some expanding areas of information technology (such as social media), employers are in high demand. The markets differ also geographically. Employer demand is far higher in a few metropolitan areas than in the rest of the country. Recruitment of professionals to these regions may be more difficult as these areas know far higher housing and other costs.[120]

Research from the School of Labor and Employment Relations at the University of Illinois targeted in a survey managers of businesses with knowledge of both hiring and operations. Their focus was: what skills do employers demand, and do the employers that demand high skill levels have trouble hiring workers? Their data showed that hiring problems are less widespread than is widely claimed. The researchers found however that there is a lot of variation in skill levels demanded within each occupation. They emphasize that it is essential not only to focus on adjusting worker skill levels, but also on employer behaviour and on labour market intermediaries such as employment agencies or trade associations, employer relationships with technical colleges or other institutions, and employer-provided training. The main challenge according to the researchers is to improve the 'knitting together' of the supply and demand sides of the labour market.[121]

5.2.2. Computer science and software skills gap

US tech companies face troubles finding qualified employees with relevant computer science and software skills. This is one of the key findings in the Global Knowledge's 2018 IT Skills and Salary Report, which interviewed more than 16,200 tech professionals from around the world about jobs in the IT industry.[122] The US Bureau of Labor Statistics predicts there will be 1.4 million technology-related job openings in 2020, but not enough graduates with the skills required to fill them.[123] [124] At the same time, only forty percent of elementary schools, middle schools and high schools in the U.S. provide computer science classes in which students can learn computer programming or coding, according to a Google and Gallup's study on computer science education.[125] Although interesting, no figures are available on differences on this indicator between elementary schools, middle schools and high schools.

In 2016, the Obama administration spent $4 billion to states and $100 million directly to districts to increase access to K-12 computer science by training teachers, expanding access to high-quality instructional materials, and building regional partnerships. An illustrative example of initiatives under this spending programme can be found at the private companies Florida Power & Light and Pratt & Whitney implemented a promising initiative. These companies partnered with schools in offering paid internship programs where STEM instructors teach IT classes during summer.[126]

---

[119] Ibid.
[120] The Myth of the Science and Engineering Shortage, 2014, The Atlantic:https://www.theatlantic.com/education/archive/2014/03/the-myth-of-the-science-and-engineering-shortage/284359/
[121] The Myth of the Skills Gap, 2017, MIT Technology Review: https://www.technologyreview.com/s/608707/the-myth-of-the-skills-gap/
[122] Most jobs in the IT industry pay well, but skills matter, 2018, TechTarget: https://searchitoperations.techtarget.com/feature/Most-jobs-in-the-IT-industry-pay-well-but-skills-matter
[123] Tech: Where the jobs -- and demand -- are, 2017, USA Today: https://eu.usatoday.com/story/tech/talkingtech/2017/03/22/tech-where-jobs/99496462/;
[124] The high-tech skills gap and education, 2017, TechTarget: https://internetofthingsagenda.techtarget.com/blog/IoT-Agenda/The-high-tech-skills-gap-and-education
[125] More K-12 Computer Science Classes Teach Programming/Coding, 2016, GALLUP: https://news.gallup.com/poll/196511/computer-science-classes-teach-programming-coding.aspx
[126] The Real Reasons Behind the Tech Skills Gap, 2016, Fortune: http://fortune.com/2016/04/27/tech-skills-gap-stem/

Although no data is yet available on their impact or achievements, fact sheets show that interns are expected to work 20-29 hours per week at these companies, and can expect paid training at USD 12 per hour.[127]

5.2.3. Federal workers skill gaps

Government agencies in the US also have difficulties recruiting and retaining employees with information technology skills. In 2016 the White House claimed the federal government needed an additional 10,000 IT and cybersecurity professionals.[128] It is questionable if a skills gap in the US workforce is the only explanation for this gap. Another explanation could be the fact that government often cannot afford to pay as much as the private sector in terms of salary and recruitment incentives and tech people start a career in Silicon Valley for example, instead of Washington. Alternatively, the fact that private companies have more flexibility to offer positions to qualified applicants on short notice can be a reason for job seekers to choose for the private sector, while the federal hiring process often leaves applicants waiting for months to hear if they get the job.

However, in order to close critical skills gaps within government agencies, the Office of Personnel Management has directed chief human capital officers to figure out how to eliminate skills gaps in six mission-critical jobs across government.[129] It concerns jobs in cybersecurity, the job of auditor, human resources specialist, contract specialist or economist, and STEM (science, technology, engineering and mathematics) occupations. The Committee on STEM of the National Academy of Engineering and the National Research Council focuses specifically on the Department of Defence and stresses that 'a workforce with robust science, technology, engineering and mathematics (STEM) capabilities is critical to sustaining U.S. pre-eminence' and 'DOD should focus its limited resources on fulfilling its own special requirements for STEM talent'. [130]

One solution to close the skills gap is to reskill the existing federal workforce. Therefore, the Trump administration announced in 2018 to launch a program to retrain federal employees for careers in government cybersecurity. The Federal Cybersecurity Reskilling Academy aims to address the shortage of trained cyber employees in the federal government. Currently in the pilot phase, this academy will train roughly twenty-five federal employees in a first curriculum of classes that have started March 11th, 2019, and will wrap up shortly before the summer. Participants have been recruited among current non-IT Federal workers through an application process that includes an online assessment of critical-thinking and problem-solving skills. After the programme, they are expected to work in IT jobs within the American federal government.[131]

5.2.4. The T-shaped model was introduced decades ago

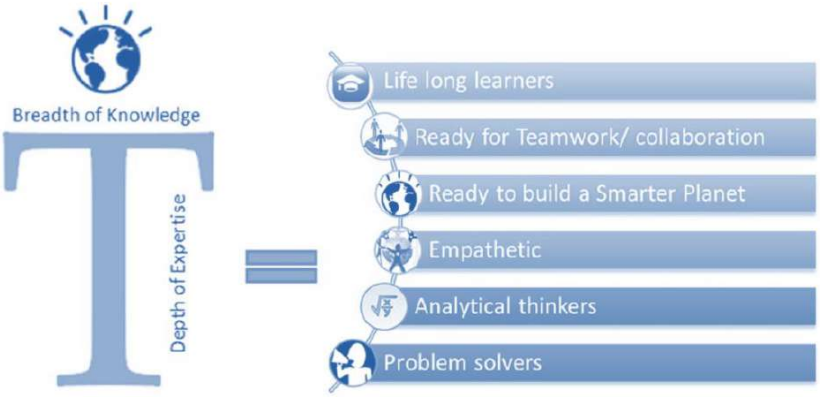
The conversation around skills gaps due to new technologies is not an entirely new phenomenon. Because of an increasing convergence of technologies, employees are needed with deep knowledge and skills in a particular area of specialisation, along with and the ability to make connections across disciplines. Two decades ago, IBM introduced in this context the metaphor of the T-shaped professional. The vertical bar of the 'T' represents depth in a single technical discipline, and the

[127] FIU Student Partnership Program, 2019, Florida Power & Light: https://www.fpl.com/community/fiu-program.html
[128] Businesses say they just can't find the right tech workers, 2017, USA Today: https://eu.usatoday.com/story/tech/talkingtech/2017/03/28/tech-skills-gap-huge-graduates-survey-says/99587888/
[129] Closing Skills Gaps: Strategy, Reporting and Monitoring, 2016, CHCO Council : https://www.chcoc.gov/content/closing-skills-gaps-strategy-reporting-and-monitoring
[130] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, chapter 2
[131] White House Launches Cyber Reskilling Program, 2018, Nextgov: https://www.nextgov.com/cybersecurity/2018/11/white-house-launches-first-cyber-reskilling-program/153171/

horizontal bar of the 'T' represents the ability to apply knowledge across disciplines and to work with others (so-called soft skills).

The figure below illustrates the IBM concept of the T-shaped individual:[132]

Figure 22. The T-shaped model inspired many organisations in the US

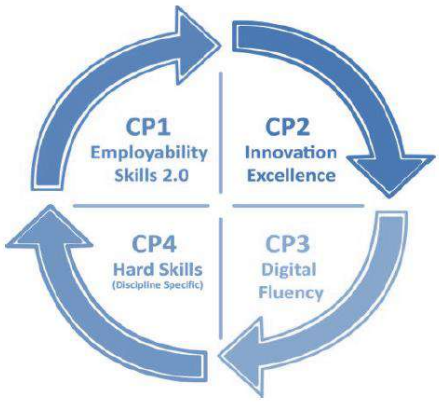


After IBM introduced the concept of the T-shaped professional, many organisations have begun developing certification programs as well as assessment tools or organizing conferences to promote T-shaped development**.** Some examples are:

- The **International Society of Service Innovation Professionals, ISSIP**: a professional association co-founded by IBM, Cisco, HP and several Universities with a mission to develop the T-shaped workforce of the 21st century. ISSIP organises trainings and workshops with various companies (such as CISCO) and invites participants to think of solutions from other disciplines and find innovative ways to solve problems.[133]
- The **INFORMS initiative developed a certification programme** where analytics professionals can be tested if they are able to bring a core set of analytics skills to a project team.[134]
- Since March 2014, **leaders from higher education, industry, government, foundations, and professional associations discuss yearly during a T-summit conference** how to design innovative educational models that foster and develop T-shaped characteristics that are in high demand today and in the future workforce.
- The **STEM connector** is an organisation involving a community of more than 3,700 national, state, local, and federal STEM organisations. The organisation introduced the STEMconnector. This model identifies Employability Skills 2.0 (CP1) as "the behaviours above and beyond technical skills that enable STEM employees to create stakeholder momentum to commercialize ideas, or in short career skills" and Employability Skills 2.0 (CP1) as "the behaviours above and beyond technical skills that enable STEM employees to create stakeholder momentum to commercialize ideas, or in short career skills.[135]

[132] *Why Do You Need to Become a T-Shaped Person*," Students for a Smarter Planet, blogpost, July 3, 2013. http://asmarterplanet.com/studentsfor/blog/2013/07/why-do-you-need-to-become-t-shaped-person.html
[133] www.issip.org
[134] The shape of analytics certification, 2012, INFORMS : https://www.informs.org/ORMS-Today/Public-Articles/February-Volume-39-Number-1/The-shape-of-analytics-certification
[135] *STEM 2.0: An Imperative For Our Future Workforce*, STEMconnector Innovation Task Force, STEMconnector: Washington, DC, June 2014. p.13

Figure 23. STEMconnector skills development model[136]



[136] *STEM 2.0: An Imperative For Our Future Workforce*, STEMconnector Innovation Task Force, STEMconnector: Washington, DC, June 2014. p.13

5.3. Parallels in high-tech T-shaped skills issues in the United States and the EU

In this section, we describe the parallels in high-tech T-shaped skills issues in the United States and the EU. We describe how technology domains in question are similar and how on both sides a need exists for cross-disciplinary work, thought and attitude. We also describe the specific challenges in the United States that share resemblance with high-tech skills challenges in Europe, matchmaking and skill articulation efforts, approaches to certification, public-sector woes in hiring high-tech talent, and private-sector initiatives for skills development activities.

5.3.1. Technology domains are similar

The technology domains referred to in discussions about the lack of qualified workers to work in high-tech jobs, are similar in the US and the EU. According to the National Research Council, a workforce with STEM capabilities is critical to sustaining the US economy, as according to the council the vibrancy of the American economy has been shown to depend heavily on advancements in science and engineering.[137] In the US the acronym, STEM is often used to address the skills needed for workers in high-tech jobs. Many organizations in the United States follow the guidelines of the National Science Foundation on what constitutes a STEM field. Although an exhaustive list does not exist, STEM includes biological sciences (except medicine and other clinical fields), physical sciences (including physics, chemistry, astronomy, and materials science), mathematical sciences, computer and information sciences, geosciences, engineering, and social and behaviour sciences[138].

The Committee on STEM of the National Academy of Engineering and the National Research Council identifies a special role for the Department of Defence to impact the STEM workforce in order to prevail in future conflicts and accomplish the US national security goals. The committee names the following specific rapidly evolving areas of science and engineering for (future) DOD operations[139]:

- ***Information technology***: capabilities in this area are data mining, cyber security cloud computing and communications technology, requiring the DOD workforce having knowledge of computer science, large database management and statistics, algorithms, hardware and software architectures and the design and engineering of complex, secure systems.
- ***Autonomous systems***: capabilities in this area require knowledge on modelling and simulation, sensor integration, energy and power, systems biology and understanding natural systems.
- ***Systems biology:*** capabilities in this area require understanding of natural systems, modification of natural systems and utilizing modified natural systems.
- ***Innovative materials:*** capabilities in this area include knowledge on innovations in materials technologies that are crossing boundaries between materials science, nanotechnology, biology, chemistry, and physics. Examples are materials for energy storage, weapons systems, lightweight structures, photonics, and electronics that have application in expanding military capabilities.
- ***Efficient manufacturing***: capabilities in these areas include direct manufacturing, micromanufacturing, and flexible robotics.

[137] National Research Council. 2007. Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Washington, D.C.: The National Academies Press
[138] National Science Foundation Research Areas, 2019, NSF: https://www.nsf.gov/about/research_areas.jsp
[139] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, chapter 2

When it comes to the technology domains predominantly in focus of the discourse around high-tech skills challenges, there appears to be ample similarity between the United States and the European Union. The technology domains listed above tend to match those named by the European Commissions as Key Enabling Technologies: Advanced Manufacturing Technologies, Advanced Materials and Nanotechnologies, Life Science Technologies, Micro&Naneolectronics and Photonics, Artificial Intelligence, and Cyber Technologies.

5.3.2. STEM disciplines need to connect with other disciplines

In 2015 the U.S. department of Education, in collaboration with American Institutes for Research (AIR) presented STEM 2026: A vision for Innovation in STEM education.[140] The vision states that the workforce needs to be equipped with a new set of core knowledge and skills to solve difficult problems. The vision stresses that STEM discipline-specific topics relate to or connect with other STEM and non-STEM disciplines, including art, history, and social studies and promotes life-long learning and fostering skills such as persistence, teamwork, and the application of gained knowledge to new situations. STEM 2026 includes six interconnected components:

- Engaged and networked communities of practice
- Accessible learning activities that invite intentional play and risk
- Educational experiences that include interdisciplinary approaches to solving grand challenges
- Flexible and inclusive learning spaces supported by innovative technologies
- Innovative and accessible measures of learning
- Societal and cultural images and environments that promote diversity and opportunity in STEM

More voices emphasized that hard STEM education is not enough to meet the 21st century challenges. Researchers and professors stated in the Washington Post that it is time to rebalance the engineering curriculum by restoring some of the emphasis on professional skills or soft skills,[141] and plead that the United States does not need more STEM majors, but more STEM majors with liberal arts training.[142] This appears to connect ideas in the United States on 21st-century STEM education to the notions multi-disciplinary and transversal skills in the concept of T-shaped professionals.

Both in the United States and in the European Union, the importance of multidisciplinary research and education is underlined by policymakers, academic researchers and employers in high-tech industries, and is seen as a key factor in addressing systemic challenges in thematic areas that cut across technology domains. Also, there appears to be overlap in the attention asked for non-technical skills, and the ambition to train non-technical skills in high-tech workers and students both in the USA and in the EU.

[140] STEM 2026, A vision for Innovation in STEM Education, US department of Education, 2015
[141] R.K. Miller, Why the Hard Science of Engineering is No Longer Enough to Meet the 21st Century Challenges, Olin College of Engineering 2015
[142] WE DON'T NEED MORE STEM MAJORS. WE NEED MORE STEM MAJORS WITH LIBERAL ARTS TRAINING, February 18, 2016, Washington Post article by Loretta Jackson-Hayes

5.3.3. Challenges in the United States

- **Shift away from engineering** – Over the last decades, American workers have shifted across occupational groups. Notably, within STEM occupations, workers in the USA have moved away from engineering jobs and into math and IT occupations.[143]

- **Difficult to fill positions** – The shift away from engineering jobs had led to difficult-to-fill positions in engineering. Vacancies are especially difficult to fill in systems engineering, aerospace engineering and mechanical engineering. Industries that are affected most are the American aerospace industry and defence industry. [144]

- **STEM job openings** – Vacancies in STEM fields are forecasted to reach over 2.8 million by 2020,[145] and to increase by 13% to close to 3.2 million by 2027.[146] Roughly 20% of these vacancies are expected to be in engineering, while about half of them would be in IT. The vacancies in engineering are expected to be mostly due to replacement of retiring engineers, while vacancies related to market growth are expected mostly in IT. [147]

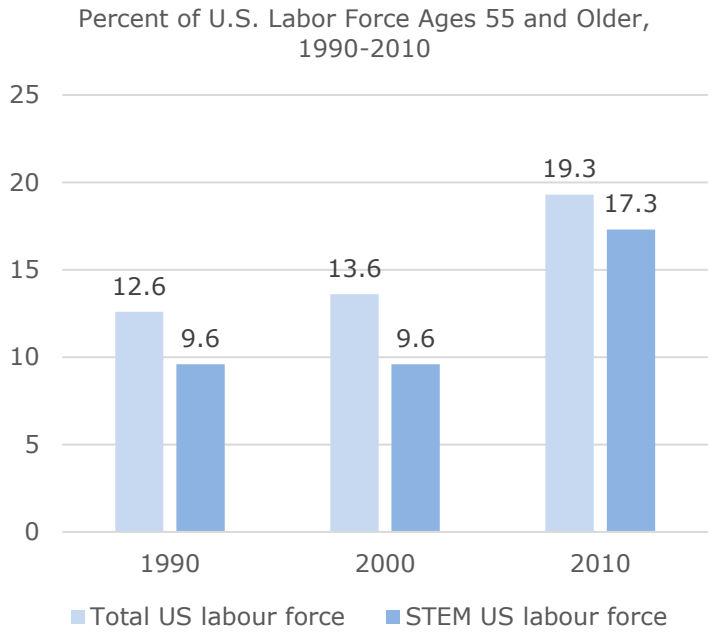
- **Ageing among physical scientists** – The American workforce shows a trend towards ageing among physical scientists. Current research associates this with large numbers of older scientists crowding out younger scientists, making it difficult for them to establish independent careers; and slower pace of scientific progress as scientists are believed to be most creative earlier in their careers. Ageing among physical scientists is a result of the aging of the large baby boom cohort of scientists.[148]

- **Ageing STEM workforce** – The STEM workforce in the USA has long been the positive outlier within the trend of an ageing American workforce. In the past decade however, this outlier has moved closer towards the main trend, and the STEM workforce now appears to be ageing in almost the same numbers as the overall workforce in the USA.[149]

---

[143] National Academy Of Engineering And National Research Council Of The National Academies, 2012, Assuring The U.S. Department Of Defense A Strong Science, Technology, Engineering, And Mathematics [STEM] Workforce, Chapter 4
[144] National Academy Of Engineering And National Research Council Of The National Academies, 2012, Assuring The U.S. Department Of Defense A Strong Science, Technology, Engineering, And Mathematics [STEM] Workforce, Chapter 4
[145] National Academy Of Engineering And National Research Council Of The National Academies, 2012, Assuring The U.S. Department Of Defense A Strong Science, Technology, Engineering, And Mathematics [STEM] Workforce, Chapter 4
[146] The State of STEM Education Told Through 12 Stats, 2017, iDTech: : https://www.idtech.com/blog/stem-education-statistics
[147] The State of STEM Education Told Through 12 Stats, 2017, iDTech: : https://www.idtech.com/blog/stem-education-statistics
[148] David M. Blau, Bruce A. Weinberg, 2017, Why the US scientific workforce is aging
[149] U.S. STEM Workforce Aging, but Younger Than Total Labor Force, 2013, PRB: https://www.prb.org/us-stem-workforce-aging/

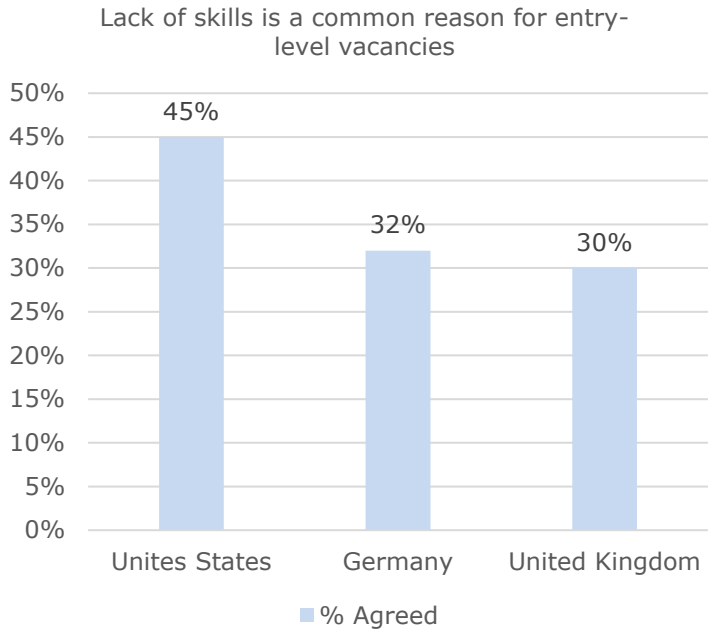
Figure 24. Percent of U.S. Labour Force Ages 55 and Older, 1990-2010[150]



- **Skills shortage as a reason for vacancies** – Employers attribute these numbers of vacancies- and the associated impact of ageing among STEM workers - to a skills shortage among workers, especially when looking at entry-level vacancies. Moreover, employers report that these vacancies give them a hard time keeping their cost down, their quality up and their processes.[151] On the following pages, we present charts and visualisations that compare the prevalence of specific skills issues in the USA to the UK and Germany. Although it would be interesting to compare these figures to other EU-28 countries and to the EU-28 total, such data is not available in currently existing sources. Subsequently, we use these charts and visualisations as somewhat inaccurate proxy indications illustrative of differences between the USA and the EU.

[150] U.S. STEM Workforce Aging, but Younger Than Total Labor Force, 2013, PRB: https://www.prb.org/us-stem-workforce-aging/
[151] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

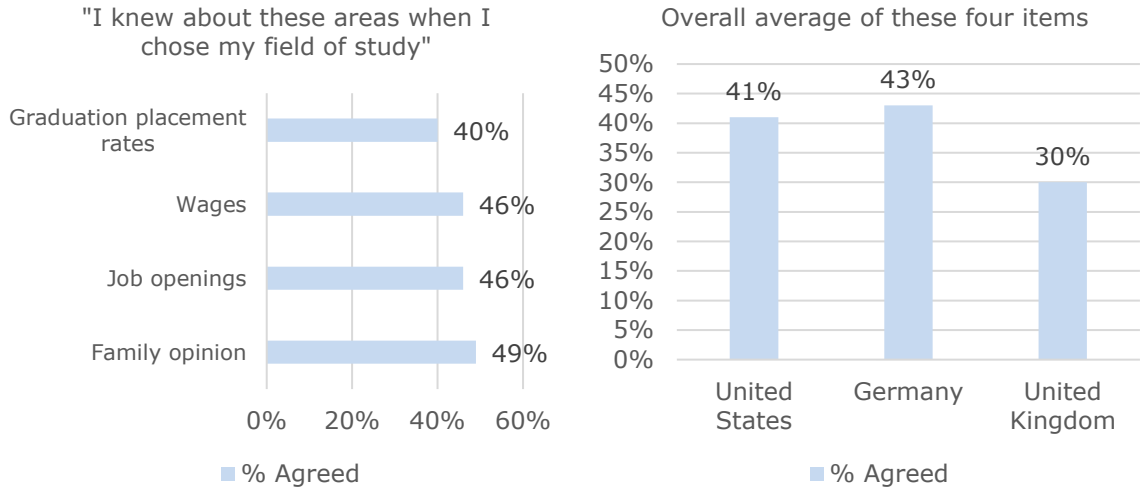
Figure 25. Employers that say lack of skills is a common reason for entry-level vacancies, 2012[152]



- **The American government and the private sector face competition from academic institutions for PhD-level scientists** – Sauermann and Roach (2012) found in a survey of PhD students that 'a faculty research career is the career path most often considered 'extremely attractive' and ranks among the most desirable careers for over 50% of life scientists and physicists'.[153]
- **Government agencies are falling behind on investments in high quality, up-to-date facilities and equipment** – The availability of such facilities and equipment is essential to recruit talented scientists and engineers.[154]
- **Young people appear not well informed** – Part of the reason for this skill gap may be found in the levels of information that young people have. Both in the United States and in Germany and the United Kingdom, less than half appear to have understanding of basic labour-market dynamics such as number of job openings, wage levels or graduation placement rates of different fields of study. [155]

[152] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx
[153] Sauermann, H., and M. Roach. 2012. Science PhD career preferences: Levels, changes, and advisor encouragement. PLoS ONE 7(5):e36307
[154] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, chapter 4
[155] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

Figure 26. Yong people that say they understand job openings, wage levels or graduation placement rates of different fields of study, 2012 [156]

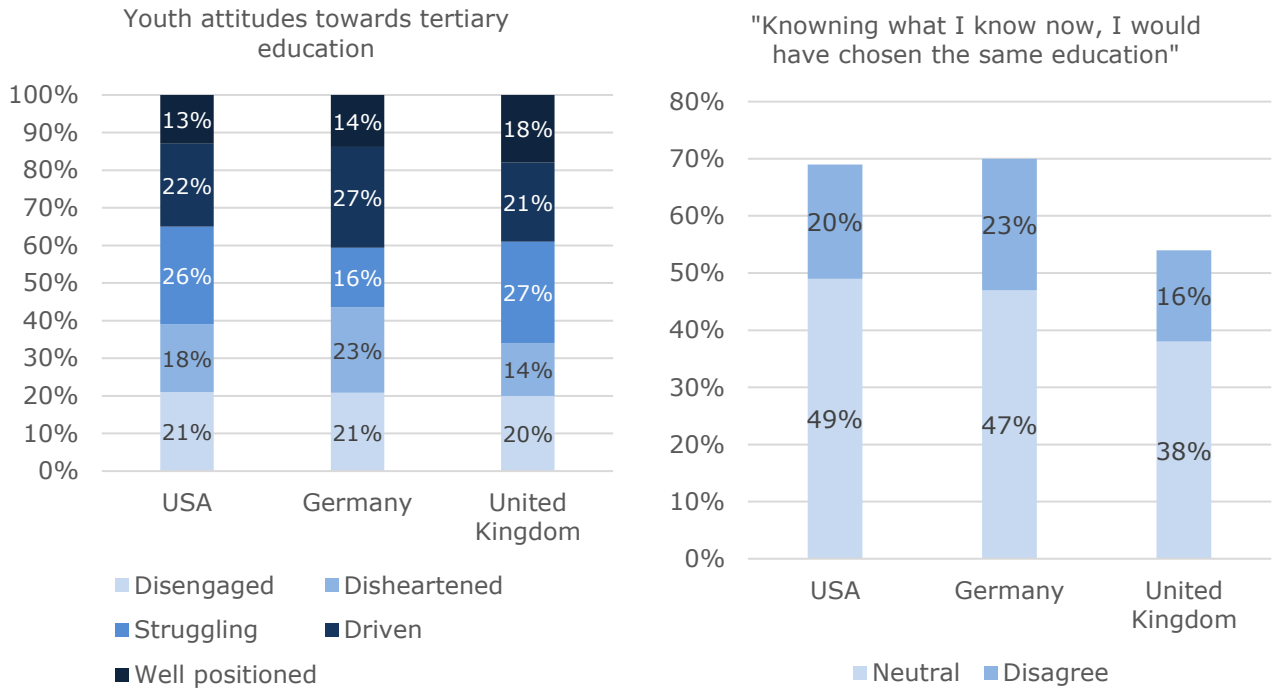


- **Young people are not well positioned** – Another part of the explanation for a skills gap is that less than half of young people consider themselves well positioned or driven to finish tertiary education. More than half of young people report to be struggling to succeed in tertiary education, to be disheartened by their prospects, or to be disengaged from any possibilities. Moreover, more than half of them report that, knowing what they know now about the labour market, are unconvinced they made the right choice of institution and field of study.[157]

[156] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

[157] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

Figure 27. Youth attitudes towards tertiary education [158]



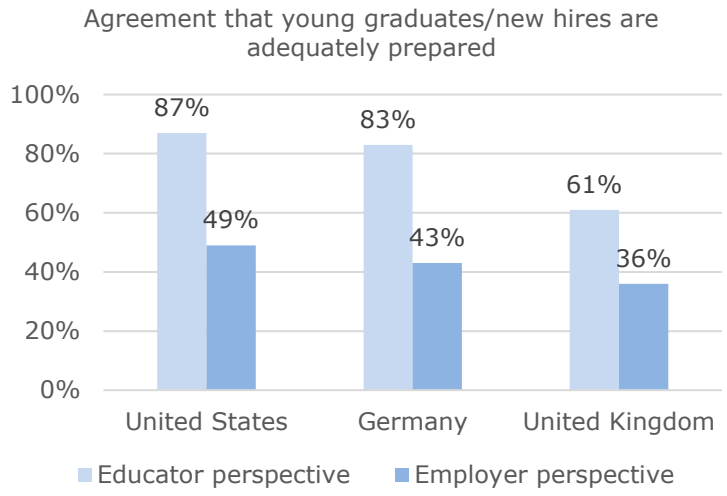
- **Young graduates seem not well prepared** – Employers and educators have different perceptions of the extent to which young graduates are ready for the job market. Typically, educators are twice as optimistic on graduate readiness compared to employers. Educators typically think that graduates from their institution are adequately prepared for entry-level positions in their field of study. Typically, less than half of employers think that employees they hired in the past year have been adequately prepared by their pre-hire educators. To explain this lack of alignment, researchers point to limited engagement and communication between employers and educators.[159]

[158] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

[159] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

•

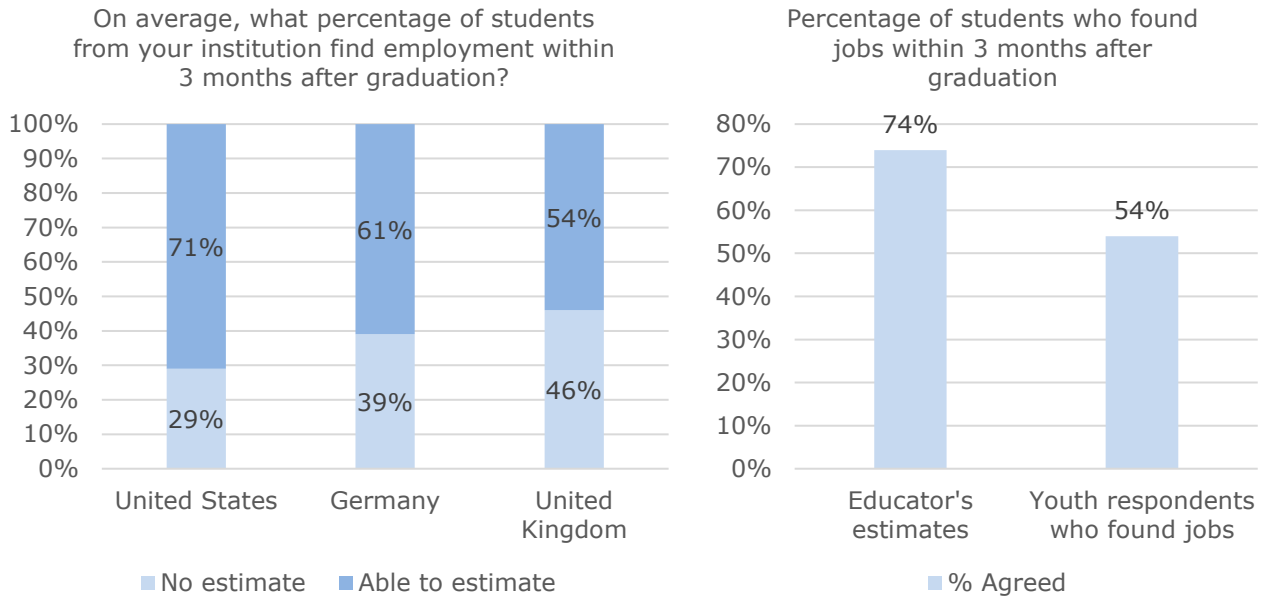
Figure 28. Agreement that young graduates/new hires are adequately prepared[160]



- **Educators do not always understand labour market dynamics** – Surveys show that, on average, educators appear to have no clear view on the extent to which their students are able to find jobs after graduation. A 2012 McKinsey survey shows that less than half to a third of educators feel confident to provide an estimation on how many of their students manage to find employment. Those that do provide information typically overestimate the labour-market success of students.[161] Similar conclusions are drawn from a 2018 survey by the Association of American Colleges and Universities among employers in the United States.[162]

[160] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx
[161] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx
[162] Fulfilling the American Dream: Liberal Education and the Future of Work, 2018, Association of American Colleges and Universities: https://www.aacu.org/research/2018-future-of-work-presentation

Figure 29. Educator's awareness of labour-market dynamics[163]



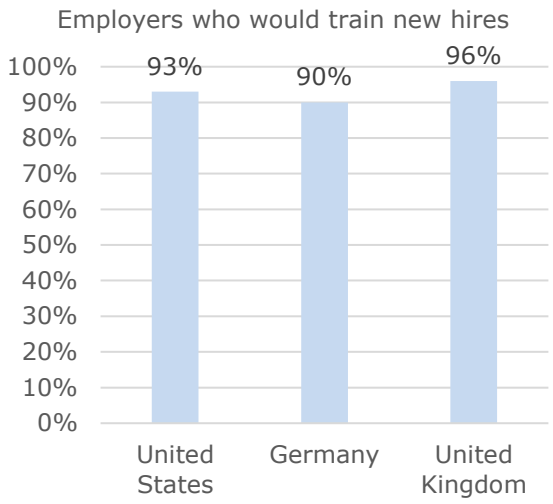
- **Employers value employees with the right skills** – Employers profess to contribute to a skills premium, as a majority of employers state they would pay more for prospects with the right talent. A vast majority also reports that they train new hires, although the number of training days does not seem to go beyond four or five weeks. [164]

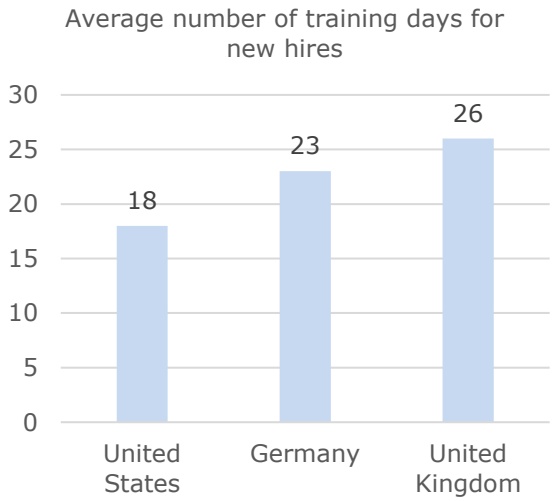
[163] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

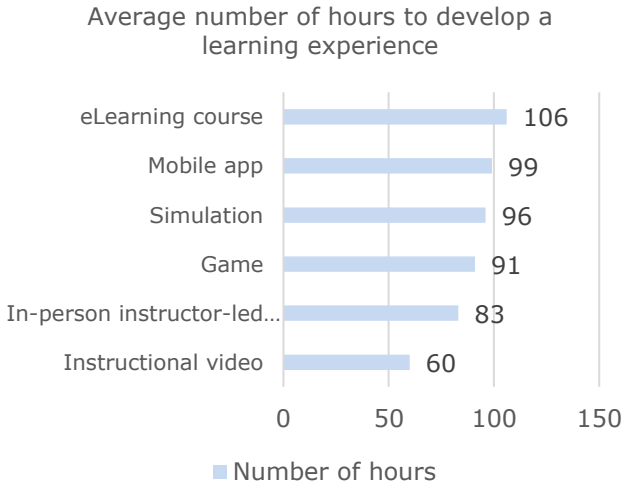
[164] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

•

Figure 30. Skills premium and investment in training new hires[165] [166]







The challenges identified in American policy thinking on high-tech skills appear to be similar to those highlighted in Europe. The challenges described above resemble the challenges targeted in EU policy making: having high-tech careers seen as attractive and prestigious; generating 'high-tech awareness' already a decade before students enter the workforce; introducing technical education early in a young student's curriculum and introducing high-tech topics to children starting from an early age; encouraging co-development of educational initiatives and materials across stakeholder groups; adapting university programmes to the human capital needs of high-tech industries; preparing a future generation of researchers, engineers, designers and business leaders to state-of-the-art technology; and promoting training activities aimed at improving transversal high-tech skills. Moreover, analysis of survey data from the USA, Germany and the UK shows only modest differences in how skills challenges are perceived.

[165] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

[166] Brandon Hall Group Training Benchmarking Study, 2016

5.3.4. Matchmaking and workforce skill articulation

Some workers have skills that employers do not know about, and do not always manage to communicate their skills to recruiters and hiring managers. To improve matchmaking between job seekers and potential employers, initiatives have been implemented that help job seekers articulate their skills in a way that is picked up by those making hiring decisions.

This is especially relevant for T-shaped skills, which are often less-easily measured and credentialed, and as such are harder to demonstrate in hiring processes. Moreover, serving in the United States armed forces is generally seen as good a way to develop communication and team works skills, leadership capabilities and a problem-solving attitude – yet developing these skills and competences does not result in a widely recognised certificate, diploma or degree.

One of the initiatives that tries to improve worker-recruiter matchmaking comes from Orion, an American recruiting firm. They help USA military veterans translate the skills they acquired on duty into terms, words and phrases that are generally recognised by American employers. As such, they actively attempt to identify specific military skills that have broader labour-market value, and connect these to job profiles outside the armed forces. They report that, for Siemens, their approach has increased the number of military veterans hired by 250%.[167]

Both in the United States and in the European Union, efforts towards matching job seekers and high-tech employers, and towards helping job seekers to better articulate their skills, are predominantly aimed at unemployed and underemployed individuals outside of the highest skills strata. The role of the military in the United States herein is different compared to the European situation, as the American armed forces have a larger labour-market footprint and can operate from a centralised organisation, while coordination of European efforts would require policy alignment across Member States.

5.3.5. Certificates to communicate skills, competences and credentials

In order to address problems of communication of skills and competences in a credentialised society, and of coordination efforts between educators and employers, several certification initiatives have sprung up in the USA. To illustrate the nature and scope of such initiatives, we will describe the WorkKeys Assessment System, the Mozilla Open Badges Initiative, and the Apprenticeship 2000 initiative.[168]

- **WorkKeys® Assessment System** – This assessment system is founded by ACT, a developer of college-admission exams. WorkKeys assesses foundational and advanced skills in areas of reading for information, business writing, applied mathematics, and soft skills such as teamwork and communication. These assessments are available for over 18.000 jobs, and results in the National Career Readiness Certificate, which is currently earned by one million people and which is recognised in 40 states across the USA.

[167] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

[168] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

- **Mozilla Open Badges initiative** – Mozilla, the creator of the Firefox web-browser software, has created an online, web-based form of credentialing. The central idea is that people learn certain skills online or outside formal settings, and that they can display these skills on Mozilla's online portal. Businesses, NGOs, clubs, schools and other organisations can award people that demonstrate these skills with digital badges that these organisations develop and maintain, in some cases tied to online learning experiences. For instance, individual users can follow an online course in JavaScript developed by Mozilla, and then demonstrate Java-scripting skills within Mozilla's portal. Subsequently, Mozilla can award such users with a Java-scripting badge of proficiency. The initiative is an open system (hence 'open badges') and free for all to use.

- **Apprenticeship 2000** – Launched by two German mechatronics companies in North Carolina, USA, this initiative is seen as a European approach. The mechatronics companies teamed up with a local community college (vocational post-secondary education) to create an apprenticeship programme. The programme awards students both an associate's degree in manufacturing technology and a journeymen's (i.e. a craft worker) certificate. Students are paid $ 9.00 per hour for studying and are guaranteed a job after graduation. Currently the initiative has eight companies in its consortium, who jointly design and maintain curricula and recruit students, and who have agreed not to poach employees. The programme takes around 8,000 hours of students' time and costs employers as much as $ 175,000 per graduate. Companies are willing to make this investment, as they require reliably skilled mechatronics workers – one mistake by a machine operator can cost these companies $ 250,000.

A similarity can be seen in policy thinking on this matter, both in the problem analysis and in the operational response. The high-tech labour markets of the United States and the European Union are highly credentialised. At the same time, credentials for transversal and non-technical skills typically do not exist. In response, relatively small-scale and scattered initiatives have sprung up to develop and implement skill and competence certificates for non-technical skills and for technical skills generated outside of formal education. The reach, coverage and recognition of these certificates can differ widely.

5.3.6. United States government struggles to hire and retain tech talent

The United States federal government will require large numbers of additional high-tech workers. The White House estimates the federal government will need 10,000 more IT and cybersecurity professionals, and also has vacancies in data analysis and cyber security.[169]

The American government has struggled to hire high-tech talent for years. Across federal agencies, for every four IT specialists at work older than 60, the agencies employ only one IT specialist younger than 30. This is not because young workers have left, they have simply stayed and became older. Nextgov finds this trend is related to the fact that hiring for tech positions is more difficult than hiring other for other types of jobs. When recruiting for IT positions, government agencies compete more directly with private-sector companies.[170]

As a result, government agencies face specific challenges in recruiting high-tech talent:[171]

1. Private companies typically have deeper pockets and more wage flexibility compared to government agencies with closely scrutinised payrolls and regimented career ladders;
2. Hiring processes in federal agencies can leave highly qualified applicants waiting for months before hearing back on their job applications, while private companies often have flexible processes that allow them to quickly offer positions to talented prospects;
3. Hiring freezes across the federal government in the recent past have made young high-tech job seekers hesitant to consider starting their careers in the public sector, and insecure on career opportunities and stability in government agencies;
4. Budget constraints on recruitment and outreach activities have hampered efforts of federal agencies to advertise and communicate their vacancies to high-tech talent that would not immediately consider a career in federal government, including minority groups.

At the same time, strategic decisions and recruitment behaviour from high-tech companies appear to pose a direct threat to chances of government agencies in the United States to retain their high-tech talent. A recent move by Amazon, a high-tech online retail company, has government hiring managers worrying that the company will poach young high-tech employees from federal agencies.[172]

Amazon has decided to open new headquarter locations, one in New York City and one in Washington D.C. Each location will have 25,000 employees each, with average wages of $150,000 per year. Those responsible for high-tech talent in the public sectors of both cities fear they cannot compete.[173]

Both in the United States and in the European Union, public-sector organisations struggle to hire and retain high-tech talent. At the same time, across the globe, governments and other public sector organisations will have increasing demand for cyber technology experts and other high-skilled high-tech workers. The struggle in the United States may appear more difficult

[169] The Government's Struggle to Hire Young Tech Talent is Worse Than You Thought, 2017, Nextgov: https://www.nextgov.com/cio-briefing/2017/12/governments-struggle-hire-young-tech-talent-worse-you-thought/144225/
[170] The Government's Struggle to Hire Young Tech Talent is Worse Than You Thought, 2017, Nextgov: https://www.nextgov.com/cio-briefing/2017/12/governments-struggle-hire-young-tech-talent-worse-you-thought/144225/
[171] The Government's Struggle to Hire Young Tech Talent is Worse Than You Thought, 2017, Nextgov: https://www.nextgov.com/cio-briefing/2017/12/governments-struggle-hire-young-tech-talent-worse-you-thought/144225/
[172] Amazon in Virginia Could Tempt Government's Top Tech Talent, 2018, Bloomberg: https://news.bloomberglaw.com/daily-labor-report/amazon-in-virginia-could-tempt-governments-top-tech-talent-1
[173] Amazon in Virginia Could Tempt Government's Top Tech Talent, 2018, Bloomberg: https://news.bloomberglaw.com/daily-labor-report/amazon-in-virginia-could-tempt-governments-top-tech-talent-1

compared to the European situation due to competitive pressures from the private-sector described above. The extent to which these pressures are more intense in the United States compared to the European Union however is not yet entirely understood.

5.3.7. Private-sector skills development activities

The interim report to this project has detailed promising and successful initiatives world-wide, government-led, industry-led and stemming from academia. In the United States, private-sector initiatives appear to be most prevalent. They can typically be categorised into coding schools, massive open online courses (MOOCs), workplace initiatives and non-profit initiatives.[174]

- **Coding schools** – Also known as hacker schools or coding boot camps, these programmes use non-traditional settings to teach participants advanced computer skills. Well known examples include Codeacademy, which is free, and General Assembly, which charges a fee.
- **Massive open online courses (MOOCs)** – Typically offered for free by universities, MOOCs allow huge numbers of students to follow academic lectures and often include assessments to gauge educational progress.
- **Workplace initiatives** – Employers offer training opportunities to their current employees and new hires. This sometimes goes as far as teaming-up with local high schools and colleges to set up apprenticeship programmes and training programmes, as was the case for BMW, a German car manufacturer, that established factories in South Carolina to find out the local workforce did not have the skills that matched BMW's job profiles.
- **Non-profit efforts** – Community-based non-profit initiatives often have great potential for community outreach, and cases can be observed where non-profit efforts succeed in training advanced computing skills to large groups of participants. However, non-profit initiatives typically do not have the financial resources to keep up with rapid technological progress in IT.

To complement initiatives from government and from educators, both in the USA and in the EU private-sector initiatives have been implemented. In the United State, these private-sector initiatives appear to be more prevalent compared to initiatives from other sectors. Code-oriented initiatives such as Codeacademy can appear to be more successful compared to similar initiatives in Europe, although this may be a product of positive media attention. Still, European code-oriented initiatives at times report to have difficulties gaining foothold in Western Europe.

[174] What Tech Companies Are Doing to Bridge the Skills Gap, 2015, Entrepreneur: https://www.entrepreneur.com/article/241297

5.4. Notable differences in high-tech T-shaped skills issues in the United States and the EU

In this section, we describe notable differences in high-tech T-shaped skills issues in the United States and the EU. Specifically, we describe the role of the defence industry in research and innovation in the United States and the labour-market footprint of the American defence ecosystem. We also describe how political support for societal challenges is more volatile and impacts the cross-thematical aspect of T-shaped skills. Finally, we describe how American public policy tends to mainly focus on the lower skilled.

5.4.1. The role of the defence industry in research and innovation

The United States research and innovation ecosystem differs from the European landscape, partly because of the role that the Unites States military plays in research and innovation activities. This also influences the encouragement of high-tech T-shaped talent, the way their curricula and education profiles are built, and their career prospects.

After World War II, military strategy in the United States was built around the notion of technological superiority in key military capabilities. In order to achieve and maintain this, the United States government committed itself to fundamental research and development in science and engineering to discover and develop weapons systems that were second to none. American policymakers decided this required:[175]

- Best-in-world STEM workforce both within the Department of Defence and within its ecosystem of private-sector contractors and academic institutions;
- Large-scale and sustained investment in research and development through contract R&D and public procurement of innovation;
- Targeted development of specific high-tech systems and associated products and services;
- A culture of continuous national support, workforce stability, workforce quality, technical challenges and national service.

Starting in the 1990s, American weapons systems shifted to rely more and more on scientific and technological developments outside of the United States.[176] Also, the technology underpinning these weapons systems increasingly became outside of the control of the Unites States military, as it originated from commercial enterprise and the associated intellectual property was held privately.[177]

[175] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, Chapter 1
[176] National Research Council, 2009; NRAC, 2010
[177] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, Chapter 1

In recent years, technology that is used heavily by the American armed forces and employed in its military equipment is no longer developed and manufactured exclusively within the United States. Globalising value chains have exposed the US military to international markets for high-tech R&D. The Department of Defence faces a combination of resource limitations and the high degree of unpredictability of the military's high-tech needs. Consequently, they select high-tech domains where the armed forces require technological superiority, and keep a close eye on emerging technologies and are prepared to quickly scale-up in promising areas through targeted R&D investments. [178]

Compared to the American defence industry, the European defence industry plays a smaller role in research and innovation in Europe. Where during the Cold War United States military invested heavily in developing nuclear and aerospace capabilities, and during the War on Terror in developing digital and cyber capabilities, Europe underwent several decennia of demilitarisation. Consequently, the American research and innovation community can be considered to have closer ties to the military and has benefited from more financial support through the Department of Defense.

5.4.2. The labour-market footprint of the American defence ecosystem

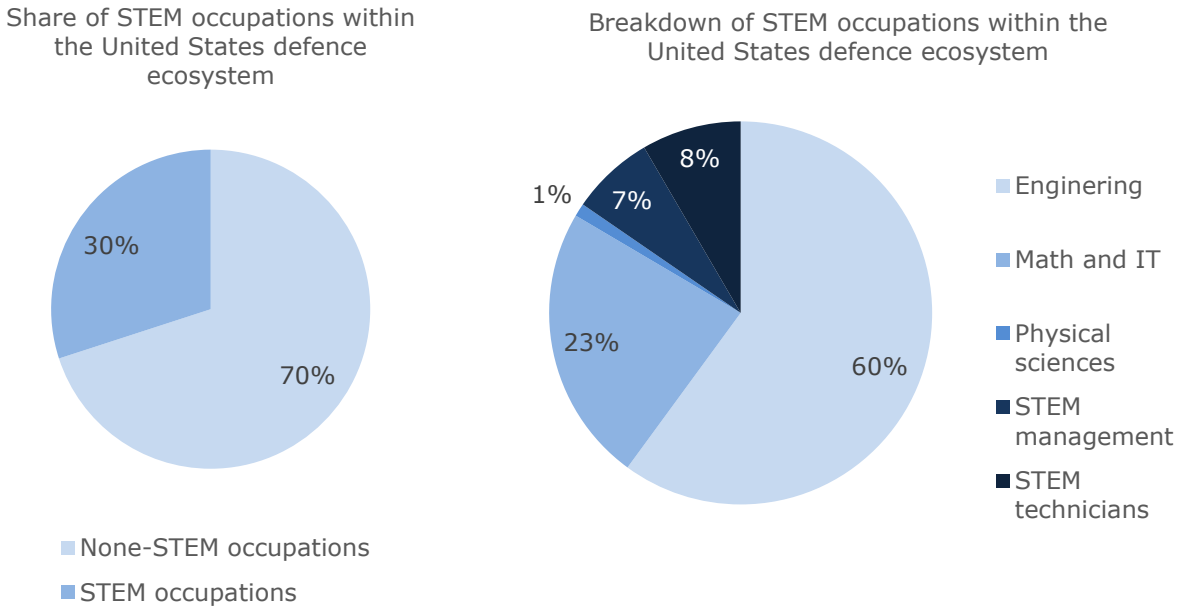
The United States armed forces, the Department of Defense and their ecosystem of defence contractors offer employment and career opportunities to high-tech talent in a way that differs from other high-tech careers in the public sector or in the private sector, encompassing work on very specific technological applications. With international competition and conflict entering new technology domains, this footprint of the defence ecosystem on the United States labour market is expected to become greater. Already, five U.S. defence contractors are among the world's top 25 cyber security companies.[179]

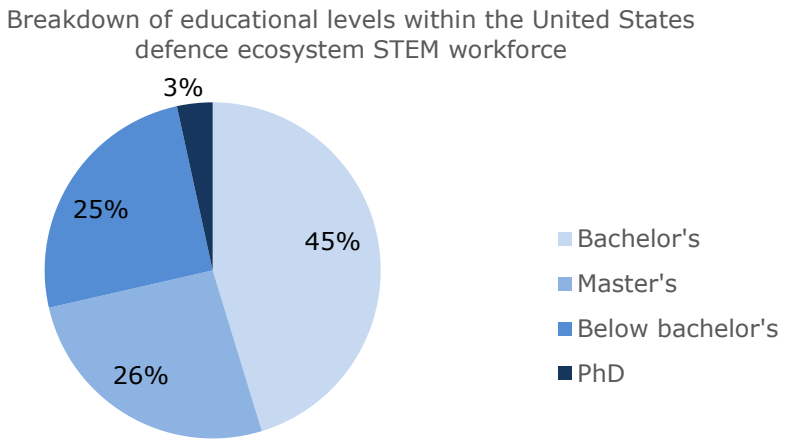
The American defence industry is estimated to employ a bit more than 1 million workers. Of these, about 300,000 are STEM workers. Within the STEM workforce of the United States defence ecosystem, engineers make up the bulk of employed (60%). Mathematicians and IT personnel constitute 23.4% of STEM workers, and 1.1% are physical scientists. STEM managers are 7% of the total, and STEM technicians 8.4%.[180]

Of this workforce, 45% is estimated to have a bachelor's degree and 26% to have a master's degree. About 25% have less than a bachelor's degree and approximately 3.4% have a PhD.[181]

[178] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, Chapter 1
[179] Five U.S. defense contractors rank among the world's top 25 cyber security companies, 2018, Military & Aerospace Electronics: https://www.militaryaerospace.com/articles/2018/06/cyber-security-trusted-computing-defense-contractors.html
[180] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, Chapter 3
[181] Assuring the U.S. Department of Defense a strong Science, Technology, Engineering, and Mathematics [STEM] Workforce, National Academies Press, 2012, Chapter 3

Figure 31. STEM occupations and educational levels in the United States defence ecosystem[182] [183]





Continuous investments in high-tech military capabilities by the United States government have generated a defence ecosystem with a substantial labour market footprint and subsequent involvement in high-tech skills development. In Europe, such an ecosystem appears to exist to

[182] Education to Employment: Designing a System that Works, 2012, McKinsey: https://www.mckinsey.com/~/media/mckinsey/industries/social%20sector/our%20insights/education%20to%20employment%20designing%20a%20system%20that%20works/education%20to%20employment%20designing%20a%20system%20that%20works.ashx

[183] Brandon Hall Group Training Benchmarking Study, 2016

a far lesser extent, and relies in part on American companies in the defence sector.[184] Recent efforts to strengthen and expand such an ecosystem appear still in the early stages.[185]

5.4.3. Political support for societal challenges is more volatile

The public policy debate in the United States can appear more volatile compared to policy discourse in the EU, especially at the European level. At times in the United States, the very nature and existence of specific grand societal challenges can become subject of heated public debate, and can have impact at the legislative and executive level.[186] [187]

The influence of political volatility on the policy apparatus of the United States government can also impact high-tech T-shaped skills adversely. While the concept of T-shaped skills promotes multidisciplinary thinking across thematic areas and societal challenges, the 2019 United States Department of Education budget appears to show a reallocation of hundreds of millions of dollars away from educational areas that include oceanic and atmospheric health and towards more traditional STEM educational tracks.[188]

In comparison, the European Commission's Horizon 2020 funding programme has a 2018-2020 Work Programme dedicating hundreds of millions of Euros to climate action, environment, resource efficiency and raw materials, which in 2019 also focuses on innovating cities, Earth observation and nature-based solutions, among other topics.

A clear difference appears to exist between the USA and the EU regarding political support for policymaking for grand societal challenges. Where the European Commission develops and implements multi-year research and innovation programmes and regional development programmes around specific societal challenges, the United States Federal Government seems to significantly adapt the direction of policymaking depending on short-term changes in the composition of its political bodies.

5.4.4. American public policy focuses on the lower skilled

Looking at direct government intervention in skills development and labour-market dynamics, public policy in the United States is primarily focused on skill levels below bachelor's degrees. An extensive 2014 OECD study into policies for employment and skills in the United States shows a network of federal and local policy instruments that together offer a multi-level and flexible

[184] See for instance the speakers list on the 2018 and 2019 European Defence Summits here http://defencesummit.eu/speakers and here http://defencesummit.eu/program
[185] 2017: A turning point for European Defence?, 2017, Clingendael Institute, https://www.clingendael.org/sites/default/files/2017-07/2017_A_turning_point_for_European_defence_DZ.pdf
[186] Jonathan M. Samet, MD, MScorresponding author and Alistair Woodward, PhD, MMedSci, MS, 2018, National Government Denial of Climate Change and State and Local Public Health Action in a Federalist System, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5922214/
[187] Climate change poses major threat to United States, new government report concludes 2018, Science.Org, https://www.sciencemag.org/news/2018/11/climate-change-poses-major-threat-us-new-government-report-concludes
[188] FY19 Budget Request: Administration Prioritizes Some STEM Education Programs, Cuts Others, 2018, American Institute of Physics:https://www.aip.org/fyi/2018/fy19-budget-request-administration-prioritizes-some-stem-education-programs-cuts-others

approach to workforce development. This network of instruments focuses mainly on skills development and labour-market opportunities for people in lower skill levels.[189]

This observation also holds for the well-researched programme for career pathways and cluster skill development. Where the European Commission has developed and implemented the Erasmus+ programme to improve opportunities for all skill levels including at bachelor's, master's and PhD levels, federal programmes in the United States appear to focus significantly less on bachelor's level or above.[190]

The most promising models from the US on skills development are, according to a 2012 OECD research[191], the introduction of career pathways and cluster skills development. In most states and regions in the US the concept of integration of education and training is introduced. Over the past ten years, the United States Department of Labour has increasingly focused on funding regional economic strategies connected to workforce solutions and industry-based sector approaches.[192]

Career pathway programmes are an articulation of knowledge, skills, and competencies, which connect education with work in an occupation. There are several categories of pathway programmes. The OECD describes these as follows: **Bridge Programmes** are designed to help people at the very front end and provide remedial education and training that help students meet pre-requisite requirements for College and Technical Education programmes. ***Education to* Job Strategies** are programmes designed to help move students all the way along an educational pathway, while keeping focus on the student completing education and getting a job. **Advancement Strategies** are programmes focused on the career progression of students, in and out of work, but with the goal of career advancement along the way.[193]

A career cluster includes broad groupings of occupations and industries based on commonalities. Within each career cluster, there can be several career pathways from secondary school to college, graduate schools, and the workplace. According to the OECD an advantage of this framework is that **it has created a common language and starting point for conversations between the workforce development and education systems**. Adopting a similar language allowed the two systems to talk to each other.[194]

The OECD writes there are some **critical lessons that can be learned from the pathway and cluster models** in the US:[195]

- **Employer involvement** – In several states, policymakers have developed sector-specific groups of employers. These advisory groups serve provide insight into the educational needs of local industrials. When a pattern of skills needs can be identified, a skills curriculum is designed in response.
- **Balancing Individual and Employer Needs** – Successful examples of cluster approaches have a long-term focus on skills development, as this appears to be most beneficial to skills

[189] Employment and Skills Strategies in the United States, 2014, OECD (Chapter 1)
[190] OECD Local Economic and Employment Development (LEED) Working Papers - Career Pathway and Cluster Skill Development, 2012, OECD: https://www.oecd-ilibrary.org/industry-and-services/career-pathway-and-cluster-skill-development_5k94g1s6f7td-en
[191] Hamilton, V. (2012), "Career Pathway and Cluster Skill Development: Promising Models from the United States", OECD Local Economic and Employment Development (LEED) Working Papers, 2012/14, OECD Publishing.
[192] Ibid. p. 8
[193] Idem p. 9
[194] Idem p. 10
[195] Idem p. 24-27

development of individual workers. This has to be balanced with skills needs expressed by employers, which often have a more short-term orientation.

- **Flexibility in programme design** –Designing programmes in a business-friendly and flexible manner is important for their uptake and successful implementation. Many training providers fail to structure their operations this way, and they reach out to firms for input yet design programmes ill-suited for business needs.

Recognizing the need for increased opportunities at bachelor's level and higher, and of T-shaped skills development and encouraging learning by doing, **non-government actors have launched initiatives that address these issues**. Several universities and engineering schools launched innovative interdisciplinary programmes for skills development for engineering students. There are no courses called T-shaped development, but experimental learning is integrated within the curriculum.

The Olin College of Engineering was established in 1997, according to their website in order to radically change engineering education with the goal of fuelling the technical innovation needed to solve the world's complex future challenges[196]. **Olin has no departments or tenured faculty, allowing for collaboration and integration of efforts between disciplines**. Olin students complete next to their engineering courses a concentration in either *Arts, Humanities, and Social Sciences* or Entrepreneurship. For example, students discover and analyse the historical context of material science in the course Stuff of History and develop technical solutions in an anthropological context in the course Engineering for Humanity.[197] Olin College has been named by The Princeton Review as one of the nation's top colleges, and recognized among the top institutions in academic rigor and student satisfaction. The results were published in the 2019 edition of The Princeton Review's popular college guide, The Best 384 Colleges.

Another initiative is the KEEN network, a network of engineering schools to educate undergraduate engineers so that they can create personal, economic, and societal value through the entrepreneurial mind-set. The KEEN network has an educational approach involving four cornerstones: business acumen, customer engagement, technical fundamentals, and societal values.[198]

Next to universities innovating their curricula, several programmes were started to stimulate interdisciplinary skills development. The National Academy of Engineering (NAE) funded two interesting programmes:

- A **Grand Challenge Scholars Program** that educates young scholars with the technical expertise, breadth of knowledge and the social, ethical and environmental awareness to find solutions for the 14 "Grand Challenges for Engineering in the 21st Century" that must be addressed in order to achieve a sustainable, economically robust, and a politically stable future for future generations. In 2009, leaders from Duke University's Pratt School of Engineering, the Franklin W. Olin College of Engineering, and the University of Southern California's Viterbi School of Engineering proposed this new education model and got funding for it.[199]

[196] www.olin.edu
[197] www.olin.edu
[198] engineeringunleashed.com
[199] NAE Recognizes 2018 Grand Challenge Scholars, 2018, National Academy of Engineering: https://www.nae.edu/MediaRoom/20095/177353/186484.aspx

- **Epicentre**, directed by Stanford University and VentureWell. Epicentre's mission was to empower U.S. undergraduate engineering students to bring their ideas to life for the benefit of the economy and society.[200]

Policy developments in the Unites Stated and the European Union appear to diverge on the topic of direct government intervention on the high-skill segment of the labour economy. While the European Commission has relatively extensive policy programmes that focus on prospective high-skilled workers, skills policy in the United States is primarily focused on skill levels below bachelor's degrees. To attempt to engage challenges in high-skill segments in the USA, non-government actors have launched initiatives, typically with a local or organisational scope.

5.5. Key areas for policy learning

In this section, we repeat the key areas for policy learning from this comparison on issues related to high-tech T-shaped skills between the United States and the EU. We describe that the United States and the EU face comparable skills challenges for similar technology domains, and the notion of a skills gap will require both precise definition and constant refinement. We also describe that the American policy landscape primarily focuses on challenges that face the lower skilled, and does not have a programme comparable to the European Commission's Erasmus+ programme. Finally, we describe that the United States defence industry matters for investments in research, innovation and the necessary high-tech T-shaped skills.

5.5.1. The United States and the EU face comparable skills challenges for similar technology domains

High- tech T-shaped skills challenges and their policy response in the United States for a good part resemble those in the European Union. High-tech areas that receive significant policy attention are similar across the United States and the European Union – technology domains that relate to 21st century IT, advanced manufacturing, systems biology and life sciences, and innovative materials. High-tech skills challenges that the United States and EU share include difficult to fill positions, scarcity of young high-tech talent, ageing high-tech workers, skills shortages, want for more academia-industry coordination, and industry demand for better-prepared graduates.

5.5.2. The notion of a skills gap will require both precise definition and constant refinement

Keeping (future) workers up with the demands of a changing economy through education and reskilling is important and necessary. In some work fields and regions in the United States, workers do not have the right skills for the available jobs. However, there is little evidence of a nationwide shortage in science and engineering workforce. Policy thinking will benefit from focussed and precise discussion on skills shortages and mismatches, as focusing exclusively on the supply side of the market (workers needing to upskill or reskill) leads to a blinkered focus and may hinder effective policymaking. Instead, policymakers should take all factors into account, including a decline in aggregate demand, regional market differences, and the role of labour-market intermediaries such as

[200] epicenter.stanford.edu

employment agencies or trade associations and employer relationships with technical colleges or other institutions. Policies may be advisable that can help increase overall economic demand. Policymakers should also focus on knitting together the supply and demand sides of the labour market and think about implementing the necessary financial and institutional mechanisms to achieve this.

5.5.3. The American policy landscape primarily focuses on the lower skilled

Both on the federal level and on state level, public policy relevant to skills challenges predominantly targets workers below bachelor's level. Key policy instruments such as Career Pathways and Cluster Skills Development are coordinated at the vocational post-secondary level by community colleges that work together with social service providers, economic development agencies, employers and labour unions, but not necessarily with universities, high-tech companies or start-up communities. US public policy does not have an equivalent to the European Commission's Erasmus+ programme.

5.5.4. The defence industry matters

A major point of difference in the high-tech T-shaped skills domain between the United States and the EU can be found in the American defence ecosystem. The United States military for decades has invested heavily in the design, development and manufacture of weapons capabilities, and has had a stake in a steady supply of a high-skilled American workforce. At the same time, investments in defence-related research and development in Europe have not been as significant, and have been decided on at the Member State level. The American approach has resulted in a sizable labour-market footprint of their defence industry, which employs high-skilled high-tech workers, which generates awareness of high-tech careers among students and prospective workers, and which teaches T-shaped skills such as communication and teamwork. In recent years, the levels of United States government investment in military R&D have faced resource scarcity and have been organised differently to increase investment efficiency and push investment risk to the private sector. However, a renewed international arms race towards cyberwarfare, enhanced nuclear capabilities or space-based weapon systems can quickly reverse this trend and can rapidly increase direct government investment in military R&D.

With the current trend in Europe towards defence cooperation and joint research and development of intelligence and strategic reconnaissance (including unmanned systems and air to-air refuelling), high-end combat capabilities including precision munitions, force protection and space-based capacities such as satellite communications,[201] European policymakers could consider to attach requirements regarding skills-oriented activities to such projects in a way similar to Horizon 2020 projects.

Moreover, as public discourse in Europe moves further towards large-scale, joint investments in development and implementation of resilient energy systems that help avert massive climate change, these also present promising opportunities for the development of high-tech talent and the promotion of high-tech careers. As demonstrated in Horizon 2020 projects and in the Erasmus+ programme, large-scale and joint investments technology development and implementation projects can generate in-project on-the-job opportunities for high-tech skills attainment.

[201] 2017: A turning point for European Defence?, 2017, Clingendael Institute, https://www.clingendael.org/sites/default/files/2017-07/2017_A_turning_point_for_European_defence_DZ.pdf

SECTION VI – STATE-OF-PLAY ANALYSIS ON STRATEGIES, POLICIES AND INITIATIVES ON SMART INDUSTRIAL SPECIALISATION AND DIGITAL TRANSFORMATION

6. STATE OF PLAY ANALYSIS ON STRATEGIES, POLICIES AND INITIATIVES ON SMART INDUSTRIAL SPECIALISATION AND DIGITAL TRANSFORMATION

6.1. Introduction

6.1.1. Future of Work: Job Disruption vs Job Creation

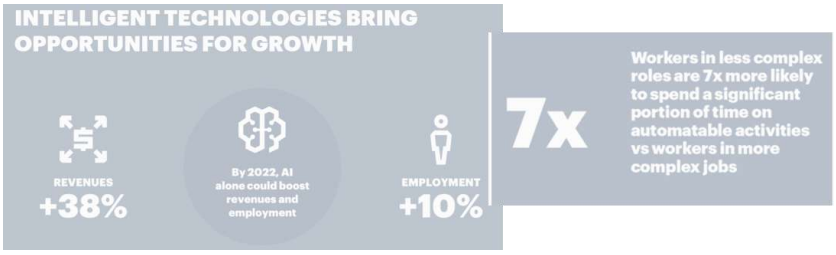
The **future of work** is amongst one of the most largely debated topics around the world due to exponential discoveries in the technology domain – mainly regarding **Artificial Intelligence and Robotics** and its varying impacts on different sectors leading to radical changes to the way we live and do business in the currently evolving era of the **Fourth Industrial Revolution.** Almost every day we read articles with reflections on the impact of automation to replace the human at work and recommended solutions[202]. One of the most recent one[203] suggests the power of technology itself to solve the skills gap by citing mainly to the **World Bank's** statement estimating the '**generation of 4.3 jobs across occupations and income groups for each technology job created'**. At the same time, the prediction of **'two in three children starting school this year will be working in professional roles that have yet to be created'** made by **World Economic Forum** is also underlined.

Some jobs are very likely to be replaced by automation and it cannot be ruled out that overall net job gain will be influenced negatively, at least not in the near future, due to the emergence of brand new jobs as well as hybrid jobs that require a combination of different skills, experience, knowledge, and abilities of each individual. The **AI predictions for 2018** study[204] supports the argument that some jobs involving repetitive tasks will be eliminated. At the same time however, the share of jobs at a potential high **risk of automation** is estimated to be only 1% by 2020. As stated by 67% of the executives contacted, AI will empower current employees to work together with the machines and to combine both artificial and human intelligence. The rise of AI will demand employees with a certain set of skills that will enable them to have **basic knowledge of AI's value** and its relevance to **big data, AI-savvy functional specialists**, not necessarily programmers. The same study also revealed that 67% of the jobs requiring **data science and analytics skills** including **data visualisation** are in the fields other than AI.

The **'Inclusive Future of Work' Initiative of Accenture[205]** aiming to have a future in which all workers have the motivation, means and opportunity to adapt to and thrive in the digital economy by creating **new skilling** pathways identified the following key findings regarding the impact of intelligent technologies on future workforce:

- **Intelligent technologies** including **Analytics, Big Data, Cognitive Artificial Intelligence (AI) and Robotics** are reshaping the future of work that will bring opportunities for growth by **automating routine tasks while augmenting activities** that **involve social/emotional or high-order cognitive skills**;
- Workers in entry-level or mid-career jobs where a high proportion of time is spent on **routine & automatable activities will experience the biggest change**.

[202] How to safeguard the labour force against AI, Feb 2018, Financial Times
[203] Skills gap? Technology itself can solve it, October 2018, Khaleej Times : https://www.khaleejtimes.com/technology/skills-gap-/technology-itself-can-solve-it
[204] 2018 AI Predictions: 8 insights to shape business strategy, 2018, PwC
[205] Accenture, Future Workforce : https://www.accenture.com/us-en/company-inclusive-future-work



Source: Accenture-Future Workforce

The **skills trend analysis** made by European Centre for the Development of Vocational Training (**CEDEFOP**) covering 42 sectors, 41 occupations, 3 qualification levels for all EU Member States in addition to Iceland, Norway and Switzerland highlighted the slow economic growth, aging population, immigration and skills mismatch as **key challenges** that EU is facing at the dawn of the Fourth Industrial Revolution. The **skills forecast**[206] **until 2030** prevailed the fact that basic manufacturing will reduce while **high-value added sectors** will continue to grow in which **80% of new jobs** will require **high-skilled occupations** as illustrated below. This will require **massive replacement** on existing workforce where most in-demand future occupations are forecasted to be in the **service sectors** over the next decade.

Source: CEDEFOP Skills Forecast

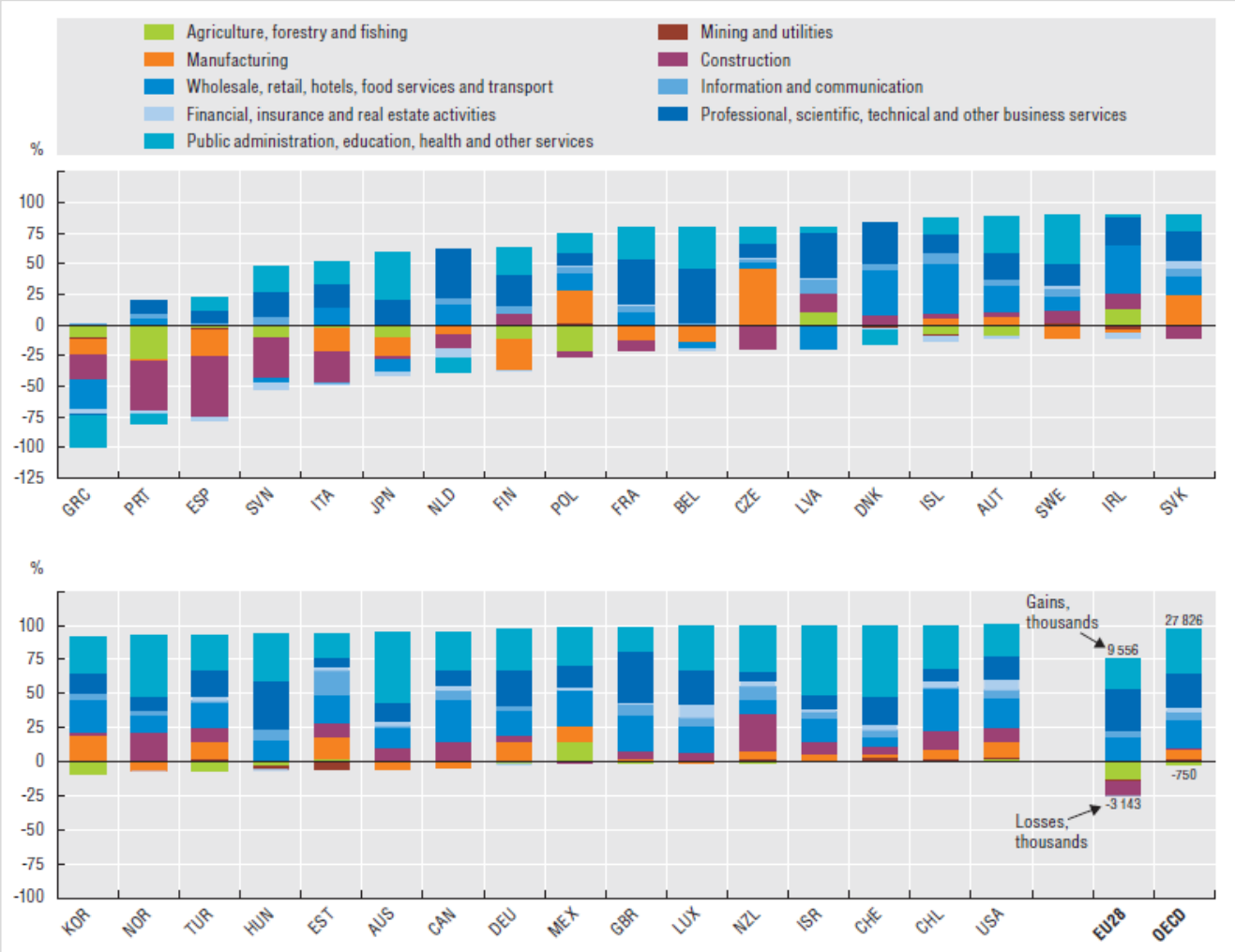
The **future workforce predictions made by Nesta in US and UK for 2030**[207] suggest that the job market will look dramatically different where approximately **10% of workers are in occupations that are likely to grow** as a share of the workforce and **20% will experience a fall** while the **remaining jobs remain uncertain**. The forecasts confirm the future importance of **21st century skills** as the **combination of interpersonal and cognitive skills** and **learning strategies**. In addition, a number of **knowledge fields**, such as **English Language, Administration and Management, and Biology** are associated strongly with occupations predicted to see rising demand where **future workforce will have generic knowledge** as well as skills requirements. **System skills** such as Judgment and Decision-making, Systems Analysis and Systems Evaluation are found to feature prominently. Nesta analysis points to the opportunities for boosting growth if the education and training systems are agile enough to respond appropriately so that highlighting the importance of placing investments in skills at the center of any long-term strategy for adjusting to structural change.

When looked at **OECD** findings as it can be seen from below figure, **between 2010 and 2015**, **total employment in the OECD area grew by 4.9%** corresponding to a net gain of about 27 million jobs. **Service sectors** accounted for the majority of net gains with an increase of 24.8 million, while **manufacturing activities** added a further 2 million jobs. In 2016, the **EU** experienced solid gains for the third year running, with an overall net gain for the period 2010-16

[206] CEDEFOP: https://skillspanorama.cedefop.europa.eu/en/useful_resources/cedefop-presents-2018-skillsforecast
[207] THE FUTURE OF SKILLS EMPLOYMENT IN 2030, Nesta, 2017: https://media.nesta.org.uk/documents/the_future_of_skills_employment_in_2030_0.pdf

of 6.4 million jobs, including a **notable rise in "Professional, scientific, technical and other business services"** with 3.9 million jobs. However, this trend masks significant variation with **Germany** and the **UK** both experiencing net gains of about 2.5 million jobs, while **Greece, Portugal and Spain** struggled to return to pre-crisis levels of employment collectively suffering a net loss of 1.5 million jobs over the same period.

Figure 32: Job gains and lost over *2010-16* across major sectors of the economy and countries



Source: OECD Science, Technology and Industry Scoreboard 2017, The Digital Transformation

As a response to these labour market changes and challenges, the combination of **technical** (i.e. STEM based) and **non-technical skills** (i.e. quality, risk and safety assurance; management and entrepreneurship; communication; innovation related and emotional intelligence) - so called **T-shaped skills** are expected to be in high demand to ensure **sustainable knowledge-based economic development** via the development and deployment of knowledge-intensive technologies that enable process, goods and service innovation through the deployment of **KETs.** KETs have the capacity to develop entirely **new industries** while **transforming existing industrial bases** including the **modernisation of manufacturing** processes by reducing cost, raw materials, and energy consumption in addition to tackling waste and pollution[208]. All those advances taking place under advanced manufacturing processes are named as **Industry 4.0** based

[208] Boosting the potential of KETs: Addressing skills needs in EU. Prepared by PwC on behalf of EC, 2016.

on network-centric production using **Advanced Manufacturing Technologies (AMT)** and cyber-physical systems **leveraging on KETs.**

Thus, **individuals** have to engage in life-long learning not only to remain employable but also to achieve fulfilling and rewarding careers. Likewise, **employers** should not solely rely on new workers with the right ready-made skills but invest in workforce up/re-skilling as a beneficial investment even in the absence of skills-shortages. For **policy makers**, fostering continuous reskilling and lifelong learning across the economy is critical in order to maintain a labour force equipped with the right skills needed to boost sustainable, smart and inclusive economic growth. Additionally, the labour markets are not only influenced by automation but also by other factors such as globalisation, urbanisation, aging population, and the climate change that places sustainability high on the agenda[209]. To stay competitive in this volatile and demanding industrial era, an **Educational and Skilling Revolution** aligned at regional, national and supra national levels is indispensable and represents a shared responsibility between public-private and public-citizen stakeholders as stated by the WEF[210].

Considering the urgency to take **coordinated actions across EU for tackling skilling issues** and keep the competitive positioning of EU industry at the global level by having future proof skills in place, the **EC launched this new initiative on** '**Skills for SIS&DT**' as a complementary action to other ongoing EU initiatives, such as Blueprint for Sectoral Cooperation on Skills, Grand Coalition for Digital Jobs, and Industrial Modernisation Platform among others.

The ultimate goal is to support Corporates, Cities, Regions and Member States in designing and implementing ambitious skill S/P/Is for shaping the workforce transformation in EU successfully in order to achieve SIS&DT around the EU 2030 Common Vision on High-tech Skills.

This section of the report aims to illustrate the state-of-play on strategies, policies and initiatives on SIS&DT. Since there are numerous terminologies being evolved over the past couple of years to describe the industrial trends in parallel to the evolution of advanced technologies and their adoption by the industry, key definitions on the **Smart Industrial Specialisation (SIS), Digital Transformation (DT), Key Enabling Technologies (KETs)**, **Industry 4.0, Advanced Manufacturing (AM), Fourth Industrial Revolution (4IR)** etc. together with the role and dependencies between technologies on SIS&DT for better understanding the following chapters will be presented below.

6.1.2. Key definitions on SIS & DT

6.1.2.1. Smart Industrial Specialisation (SIS)

Smart Industrial Specialisation refers to the concept of coordination within specific geographical regions in Europe between industrial, governmental and academic actors to develop a strategy collectively for the regional economic development through prioritisation of the industrial sectors where the region has key strengths and advantages.

It is a concept merged in parallel to the '**Smart Specialisation Strategy**' of the European Commission where Regions were supposed to develop their Regional Smart Specialisation Strategies (**RIS3)** based on their strong **key industrial sectors** with competitive advantage for

[209] The future of Skills: Employment in 2030. Pearson, Nesta, Oxford Martin School, 2017.
[210] Towards a Reskilling Revolution: A Future of Jobs for All. WEF in collaboration with Boston Consulting, Jan 2018.

ensuring high growth accompanied by job creation. In this process, the **European Cluster Observatory** provided invaluable evidence by defining **newly emerging industries** and relevant **sector specific framework conditions** needed for boosting further development of these industries. Thus, **Industry Clusters** became one of the key catalysers in support of industrial specialisation. Given the limited financial resources and the need for critical mass on RD&I, the **Industrial Modernisation Platform[211] under the S3 platform** has been launched to allow for cross-border and cross-sector partnerships all across the EU and for the establishment of strong industrial capability and specialisation for EU, namely **Smart Industrial Specialisation (SIS).**
In parallel, **Vanguard Initiative[212]** has been launched by EU in support of 'New growth through smart specialization' following the commitment of **leading regions under Milan Declaration**[213] in 2015 to join forces for investment in the Future of Europe. The Initiative brings together regions where there is a political will to play an active role in the renaissance of industry and to transform regional clusters into world-class clusters. Partner regions seek to lead by example in developing interregional cooperation and multi-level governance for supporting clusters and regional eco-systems to focus on smart specialisations in priority areas for transforming and emerging industries. Vanguard regions want to build the synergies and complementarities in smart specialisation strategies to boost **world-class clusters and cluster networks**, in particular through **pilots and large-scale demonstrators.** These investments are believed to strengthen Europe's competitive capacity to lead in new industries in the future and develop lead markets that offer solutions to common challenges. The **European Observatory for Clusters and Industrial Change (EOCIC)** has been just launched in January 2018 to put higher focus on key enabling technologies, digitalisation, creativity and eco-innovative, resource-efficient solutions as the key drivers of industrial change.

6.1.2.2. Digital Transformation (DT)

Digital transformation[214] is the profound and accelerating transformation of business activities, processes, competencies and models to fully leverage on the changes and opportunities of **digital technologies and their impact across society** in a strategic and prioritized way, with present and future shifts in mind. Digital transformation in the integrated and connected sense requires, among others, the transformation of:

- Business activities/functions;
- Business processes;
- Business models;
- Business ecosystems;
- Business asset management;
- Organisational culture;
- Ecosystem and partnership models;
- Customer, worker and partner approaches.

The importance of digital transformation is highlighted under the **digitisation of EU industry strategy** so that in order to support the industry in this adoption, **Digital Innovation Hubs (DIHs)** have been established under DEI Initiative recently, also aiming to foster **synergies between digital** and **KETs,** among other services.

[211] http://s3platform.jrc.ec.europa.eu/industrial-modernisation
[212] http://www.s3vanguardinitiative.eu/
[213] http://www.s3vanguardinitiative.eu/sites/default/files/contact/image/final_declaration_of_milan_final_27_10.pdf
[214] https://www.i-scoop.eu/digital-transformation/#Digital_business_transformation_8211_a_holistic_approach

6.1.2.3. Key Enabling Technologies (KETs)

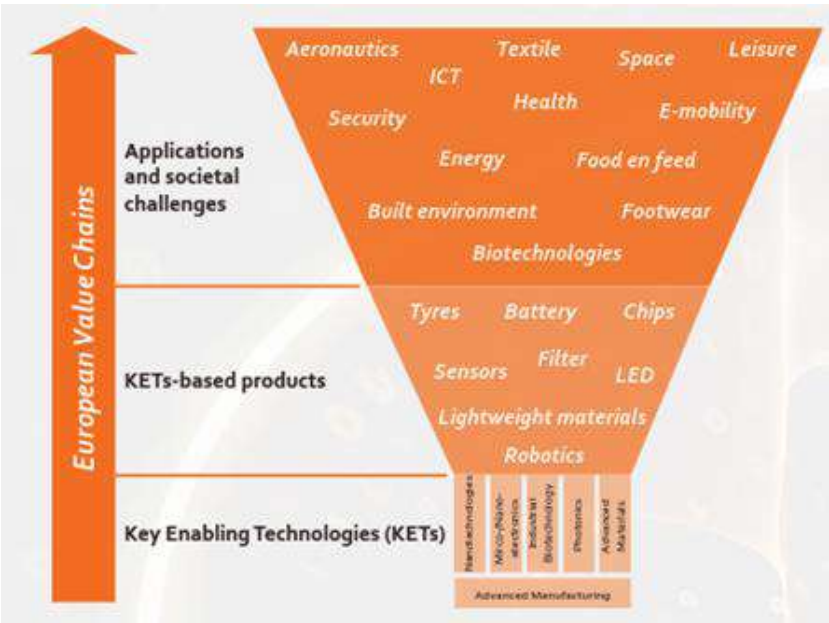
Key Enabling Technologies are technology domains with the potential to strengthen the industrial and innovation capacities of the EU first defined by the EC in 2009. The former and the most recent definitions are explained below.

2009 Definition

In 2009, the EC has identified six technologies as **Key Enabling Technologies (KETs)** which are **Advanced manufacturing technologies, Advanced materials, Industrial biotechnology, Micro and Nanoelectronics, Nanotechnology and Photonics** under its 2009 Communication "Preparing for our future: Developing a common strategy for key enabling technologies in the EU"[215].

KETs enable process, goods and service innovation throughout the economy. These technologies are characterised as knowledge-intensive that require high R&D intensity, rapid innovation cycles, high capital expenditure and **highly skilled employment**. KETs have the potential for **application across almost all sectors and industries** as shown in below Figure. KETs drive the development of entirely new industries as well as transforming the existing industrial base in EU. KETs have the potential to **modernise the manufacturing processes** by reducing production costs, raw materials and energy consumption while tackling waste and pollution.

Figure 33: Deployment of KETs across value chains and sectors



Source[216]

[215] COM (2009) 512 Final: Preparing for our future: Developing a common strategy for key enabling technologies in the EU: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0512:FIN:EN:PDF
[216] Boosting the potential of Key Enabling Technologies: Addressing Skills Needs in EU, Prepared by PwC on behalf of the EC, 2016

2018 Definition

Most recently, the **High Level Strategy Group (HLSG) on Industrial Technologies** highlighted the importance of KETs as an engine for the reindustrialisation of EU since the manufacturing is the backbone of the industry and the KETs are indispensable technology building blocks of manufacturing across different sectors – especially in automotive, aeronautics, engineering, space, chemicals, building & infrastructure, and pharmaceuticals where EU industry is a world-leader[217].

In addition to grand societal challenges such as ageing population, decrease in natural resources for food, feed and energy, climate and environmental changes, European industry have to face with the following challenges of **Growing knowledge-intensive production; Digitisation; Globalisation** (particularly competition from a variety of emerging countries, e.g. China).

Considering these challenges, HLSG suggested a novel and extended definition for KETs, built on four criteria:

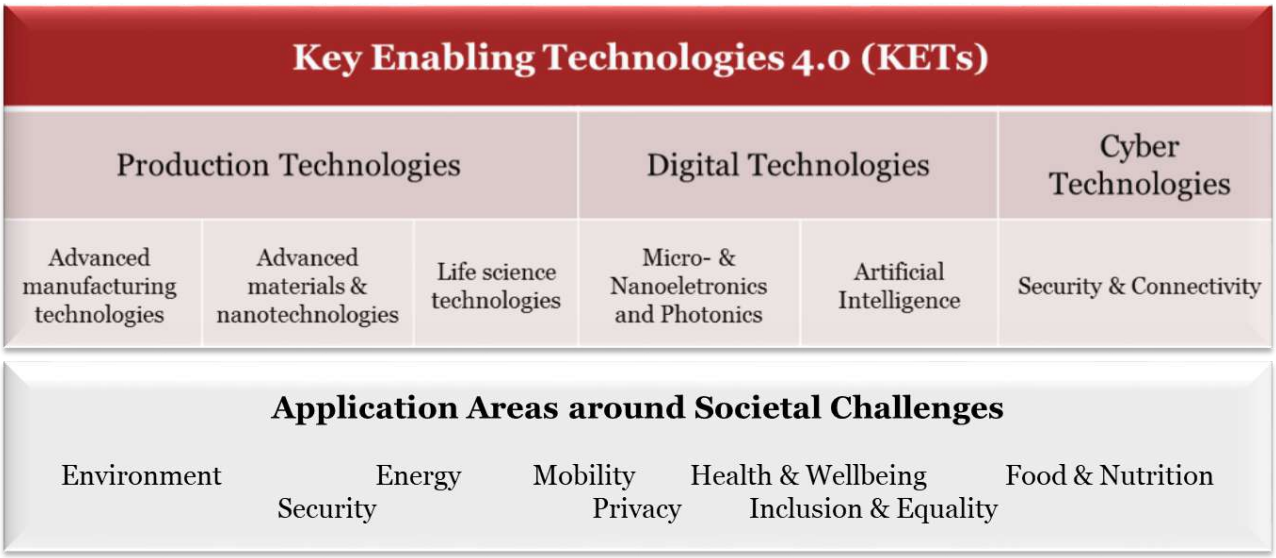
- **Impact** (in terms of providing high quality jobs, enhancing peoples' lives and future prosperity);
- **Relevance** (for all stages of product creation, guarantying that Europe is in the lead across industrialized value chains);
- **Main capacity** (to enhance health, security and safety, fostering sustainable progress and protected connectivity among individuals and systems)**;**
- **Enabling power** (for manifold and cross-industry applications, leading to generate worldwide excellence, knowledge and shapes of participation.

Finally, the HLSG defined **KETs 4.0**[218] as illustrated in below figure by:

- Keeping existing six **KETs described above**;
- Extending 'biotechnology' to '**Life Sciences technologies'**;
- Adding two new ones, which are **Artificial Intelligence** and **Digital security and connectivity**.

[217] KETs: Time to Act: Final Report by HLG-KETs, EC, June 2015
[218] RE-FINDING INDUSTRY Report from the High-Level Strategy Group on Industrial Technologies, Conference Document ,23 February 2018

Figure 34: Definition of KETs 4.0



Source: PwC interpretation of HLSG definition

Within the scope of this SoP analysis, we used this most recent definition only with the exclusion of digital connectivity since it is covered in detail by DG-CONNECT.

Below, we describe the technology domains covered under these three groups as **production, digital** and **cyber technologies.**

Production Technologies

Production technologies are comprised of Advanced Manufacturing Technologies, Advanced Materials and Nanotechnologies, and Life-Science Technologies.

Advanced Manufacturing Technologies cover smart, high performance, high precision and additive manufacturing and processes, Robotics, Process Industry, Green Propulsion Technologies, Integrated Bio-refineries.

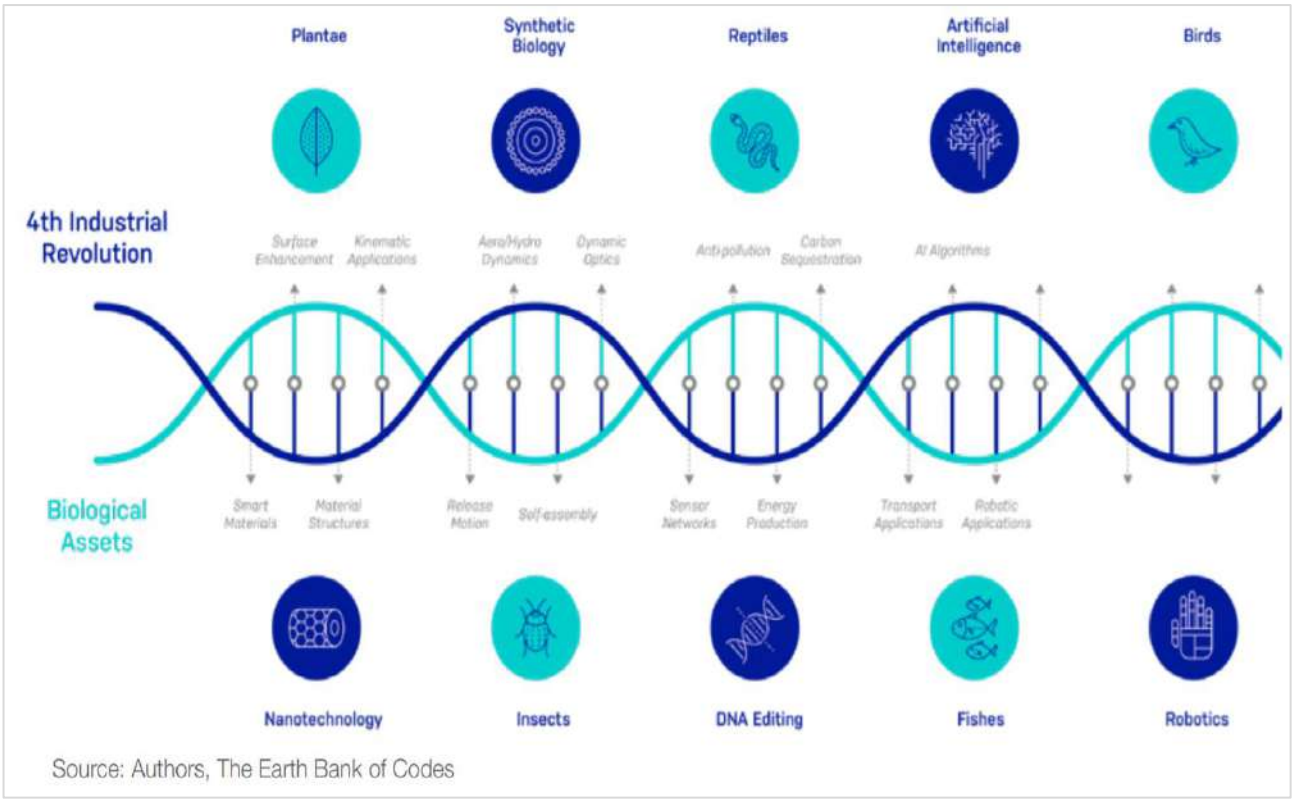
Advanced Materials and Nanotechnologies cover high performance, smart sustainable materials, Nanomaterials, Nanotechnology, Biomaterials, 2D Materials, Light Weight Technologies, New Chemistry.

Life Science Technologies cover industrial biotechnology, high throughput biology, automation for biology, synthetic biology, genomics, cell & tissue engineering, biologification of manufacturing, biosensors, bio activators, bio actuators, lab on a chip, new chemistry, neurotechnologies.

The **'synthetic biology' -** re-engineering nature, is propelling scientists into an uncharted period of powerful and rapid biological design-build-test-learn cycles that may reveal uses of nature and natural processes. Analysts suggest almost 10 fold increase on its value from $3.9 billion in 2016 by 2020 due to the transformative nature of the Fourth Industrial Revolution.

Below figure exhibits some of these new biology innovations and applications, illustrating how Fourth Industrial Revolution technologies can intersect with biology to derive new bio-economy opportunities.

Figure 35: New bio-economy powered by the Fourth Industrial Revolution



Source: WEF[219]

Digital Technologies

Digital technologies are comprised of Micro- & Naneolectronics and Photonics, and Artificial Intelligence.

Micro&Naneolectronics and Photonics include IoT, smart/intelligent sensors, quantum technology, supercomputing (high power, high performance, neuro computing, beyond CMOS), displays (LCD, Plasma) & Lighting (LED, OLED), photonics integrated circuits, and biophotonics.

Artificial Intelligence covers data generation and handling, big data analytics, machine learning and deep learning, smart robots, virtual agents, software technologies, and decision-making technologies.

[219] Harnessing the Fourth Industrial Revolution for Life on Land, January 2018, WEF: http://www3.weforum.org/docs/WEF_Harnessing_4IR_Life_on_Land.pdf

Cyber Technologies

Within the group of cyber technologies, Security and Connectivity has been included. However, within the scope of this assignment, as agreed with the DG-GROW, only Cybersecurity will be considered under KETs, since the Connectivity falls under the scope of DG-CONNECT.

Security covers secure and authenticated communication, avoiding identify theft, data protection and privacy, IoT, Data/Connectivity Safety and Security, Human-Machine Interfaces, Human-Computer / Robot Interaction, 5G, and baseband/processor platforms.

Connectivity includes e-Governance, e-Administration, e-Voting, Cyber-Physical Systems, e-Safety and e-Security, Technology Assessment, and Blockchain.

6.1.2.4. Industry 4.0, Advanced Manufacturing and KETs

Industry 4.0 is the strategic initiative developed by Germany under its High-tech 2020 Strategy, aiming to create **network-centric production** by using new manufacturing technologies and **cyber-physical systems.**

The terms '**Smart Factory/Industry**', '**Smart Manufacturing**', '**Intelligent Factory'**, '**Factory of the Future**' etc. are all derived to describe more or less the same vision for the modernisation of the manufacturing industry by the implementation of '**Industry 4.0'.**

The manufacturing industry is challenged by trends in **advanced manufacturing processes**. Advanced Manufacturing encompasses all production activities applying cutting edge knowledge and/or non-technological innovation leading to improvements of existing products, processes and business models and to the production and diffusion of new ones.

Advanced Manufacturing includes production activities able to improve production speed, productivity, energy and materials consumption, operating precision, waste, pollution management and enabling resource-efficient and low emission production. The retained definition is not linked to any particular industrial sector. The Commission staff working document[220] provides broad classification of **Advanced Manufacturing Technologies** as:

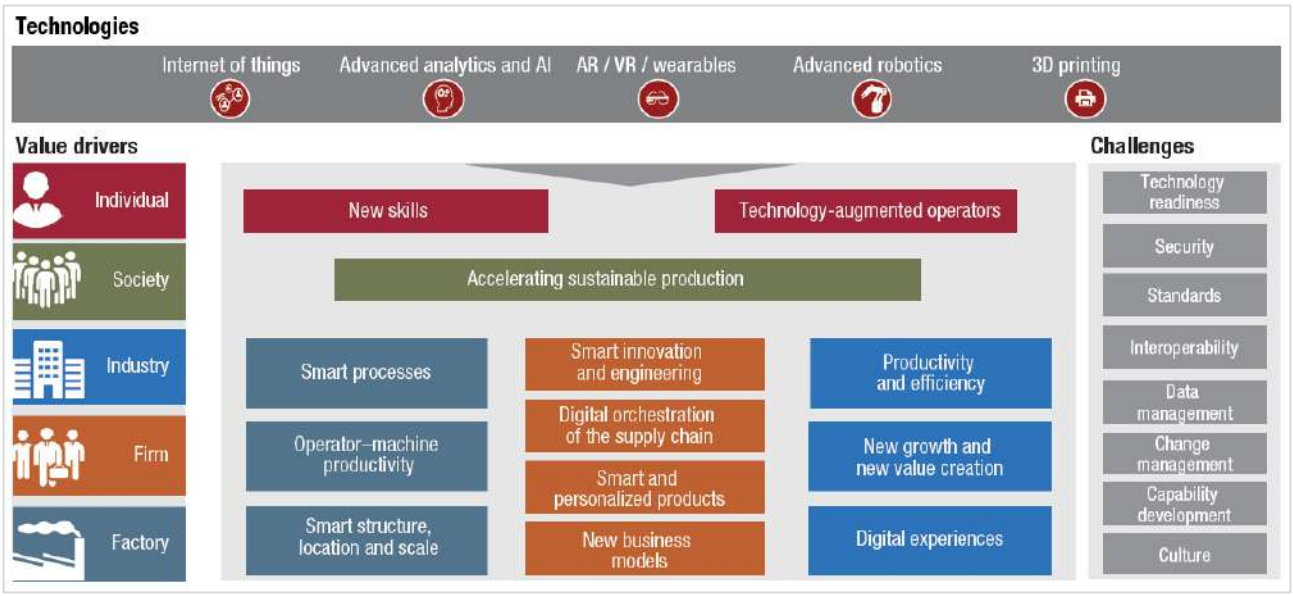
- **High-performance manufacturing** (e.g. advanced sensors, 3D printers, and high precision machine tools);
- **ICT-enabled intelligent manufacturing**;
- **Sustainable manufacturing** focusing on energy, materials and emission reduction, which are **all key enablers for industrial modernisation.** [221]

Devices and embedded computing sensors that integrate **KETs** communicate and deliver real-time responses in order to speed up monitoring and fabrication processes. Thus, **KETs are an indispensable driver for the Industry 4.0**, which is believed to boost **industrial modernisation** and so competitiveness of the EU industry. It represents a paradigm shift from '**centralised**' to '**decentralised'** customised mass production.

[220] Report of the Task Force on advanced manufacturing for clean production: Advancing manufacturing – advancing Europe. Brussels (2014).
[221] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/link/european-task-force-advanced-manufacturing

As stated in the white paper released by WEF in 2017 on 'Technology and Innovation for the Future of Production', **five key technologies** that **lever on KETs** (i.e. **Internet of Things, Artificial Intelligence, Advanced Robotics, Wearables** including **augmented and virtual reality, and 3D printing**) stand out by their broad applications and impact in countries, industries and value chains and have unleashed competition within **production systems**, forcing companies to rethink and retool everything that they do internally. Combined and connected, these five key technologies are opening up opportunities and changing decades-old mechanisms for creating and distributing value in 13 important ways as shown in below Figure.

Figure 36: Creating value from converging technologies

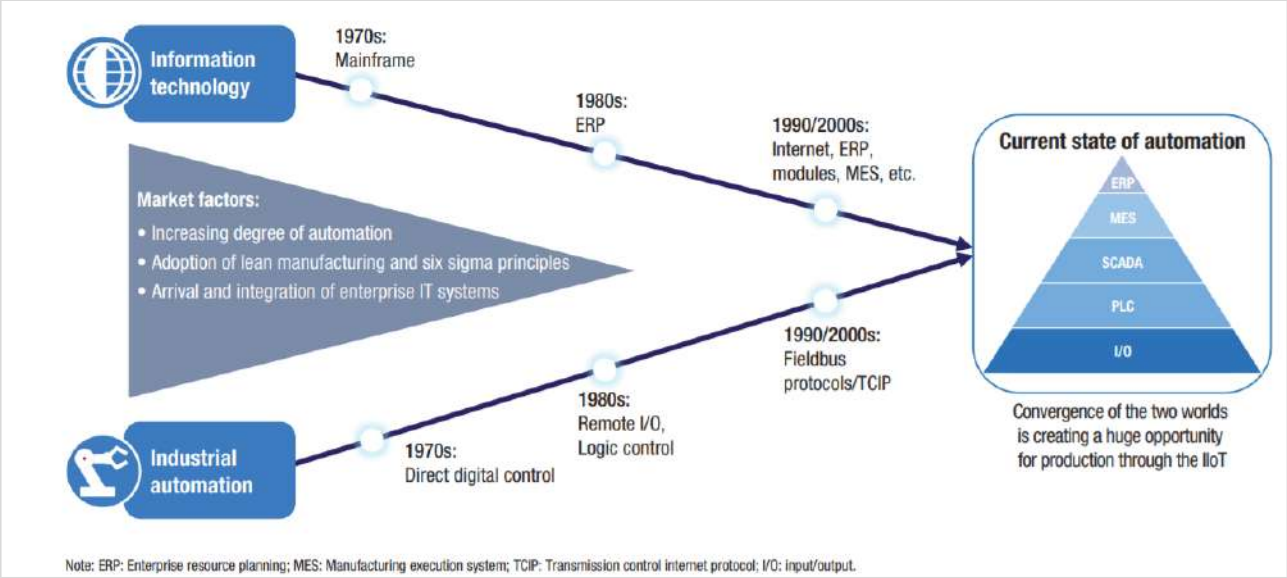


Source: WEF[222]

In parallel, as illustrated in below figure, the **convergence of ICT technologies together with operational technologies** found major applications under **manufacturing** through the **Industrial Internet of Things (IIoT)** which is a key enabler for **Industry 4.0.**

[222] WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf

Figure 37: Convergence of information technology with operational technologies



Source: WEF[223]

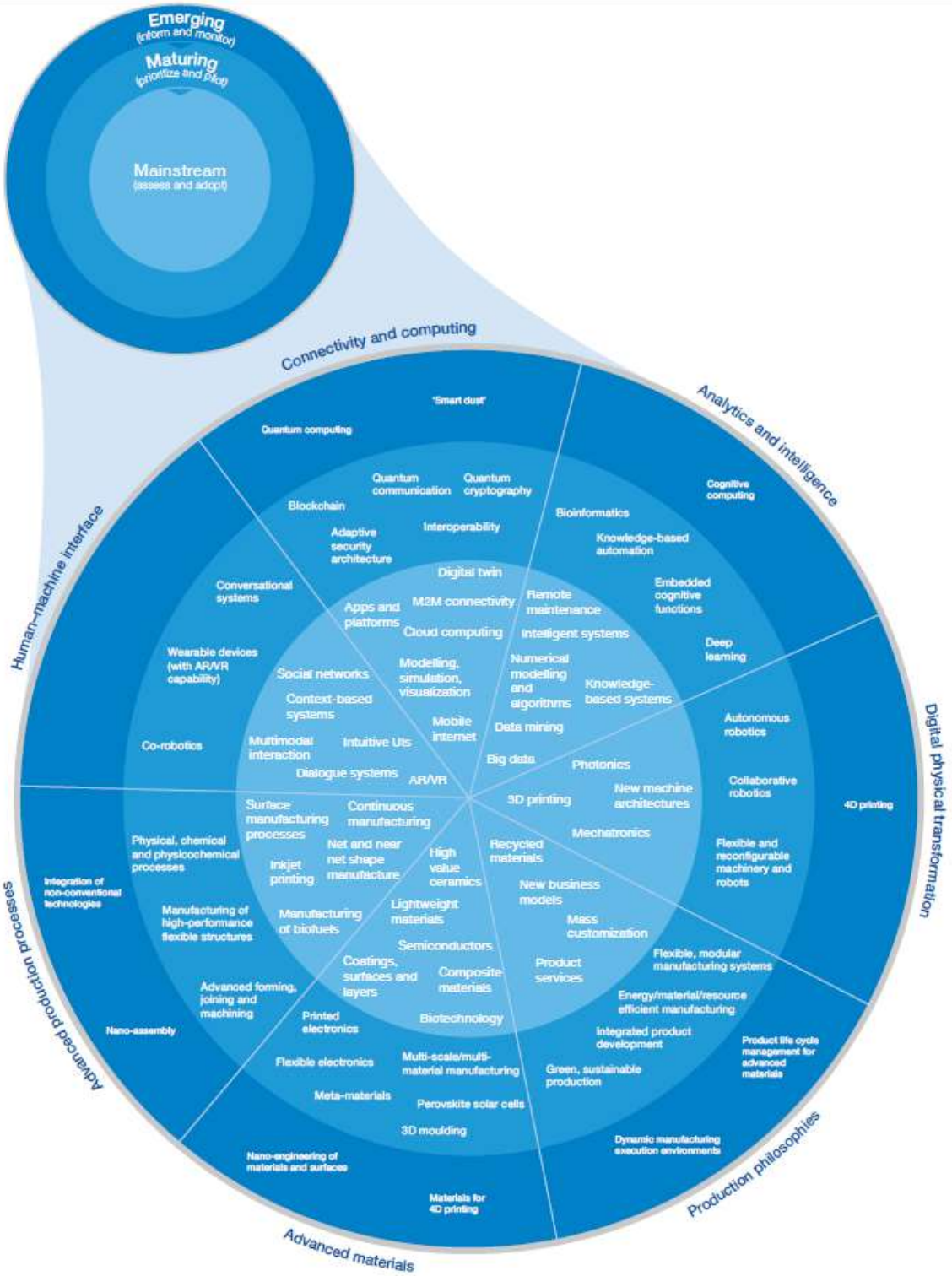
Production Technologies

The '**Production Technology Radar'** developed by the WEF[224] aims to guide business leaders and policy-makers on taking an action through vast range of mainstream, maturing and emerging technologies and philosophies impacting production systems as shown in below figure.

The high-level categories selected for this graphical representation is mainly based on **information and communication technology (ICT)-enabled technologies** such as connectivity and computing, analytics and intelligence, human machine interface and digital physical transformation. The additional topics covered on this radar are **advanced materials** (encompassing various branches of both nanotechnology and biotechnology); **advanced manufacturing processes**; **manufacturing philosophies**, which would include things such as design approaches and mindsets geared towards sustainability.

[223] WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf
[224] WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf

Figure 38: Production technology radar



Source: WEF[225]

[225] http://www3.weforum.org/docs/WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf

6.1.3. Relevance between technologies, SIS & DT and Fourth Industrial Revolution

In this section, first digital and industrial technologies will be introduced briefly as key enablers of KETs and so SIS&DT underpinning the Fourth Industrial Revolution. The correlation in between those technologies and transformation will be explained with an emphasis on key challenges for EU, its competitive positioning, followed by stakeholder perspectives collected via the survey being conducted under this assignment.

6.1.3.1. Role of Digital and Industrial Technologies on SIS&DT

Digital transformation of business activities, processes, competencies and models mainly leverage on the changes and opportunities brought by digital and industrial technologies. Below, intelligent, digital, and mesh technologies will be explained building on a strategic review by Gartner.[226]

Intelligent Technologies

Intelligent technologies based on the **implementation of AI across advanced manufacturing** can be categorised under four pillars: **automated intelligence systems, assisted intelligence systems, augmented intelligence systems and autonomous intelligence systems** as explained below. [227]

- ***Automated intelligence systems*** that take repeated, labour-intensive tasks requiring intelligence, and automatically complete them;
- ***Assisted intelligence systems*** that review and reveal patterns in historical data, such as unstructured social-media posts, and help people perform tasks more quickly and better by using the information gleaned by use of techniques such as deep learning, natural language processing and anomaly detection;
- ***Augmented intelligence systems*** that use AI to help people understand and predict an uncertain future scenario;
- ***Autonomous intelligence systems*** that automate decision-making without human intervention.

These different manifestations of **AI** is expected to transform business activities, processes, competencies and models radically in different ways through **intelligent apps, analytics, and intelligent things**.

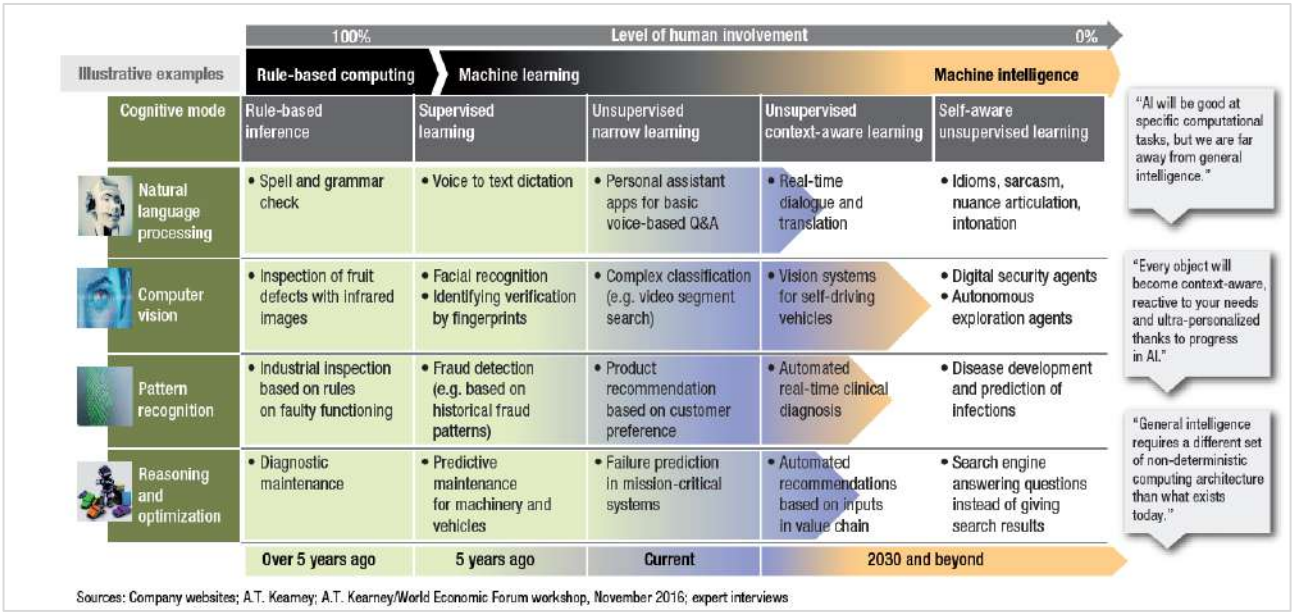
Intelligent Apps & Analytics based on AI formed the basis for machine learning to automate data preparation, insight discovery and insight sharing as a field of increasing strategic significance.

Intelligent Things that emerged through the wide implementation of IoT into growing number of things coupled with machine learning and AI allowing these objects to run semi-autonomously or autonomously.

Below figure illustrates the **development of AI including future foresights**.

[226] Gartner Top 10 Strategic Technology Trends for 2018, October 2017
[227] Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf

Figure 39: Development of AI and its future state



Source: WEF[228]

AI can engage in **all aspects of industries**, in fact, in everything, which uses digital data.[229] The following industries are forecasted to experience the greatest impact:

- Advanced Manufacturing;
- Finance;
- Automotive;
- Communication;
- Energy.

[228] Technology and Innovation for the Future of Production, WEF in collaboration with A.T. Kearney, March 2017: http://www3.weforum.org/docs/WEF_White_Paper_Techning-the-prize-report.pdf

[229] PwC, 2017, "Sizing the prize, what's the real value of AI for your business and how can you capitalize?": www.pwc.com/gx/en/issues/analytics/assets/pwc-aianalysis-sizing-the-prize-report.pdf

Ultimately, all this culminates in the quest for **Artificial General Intelligence (AGI)** where AI begins to master reasoning, abstraction, communication and the formulation and understanding of knowledge. Thus, there is a growing need of understanding on the **safety and ethical use of AI** for further progress. This will involve the development of algorithms with safety considerations at their core. Future advances in AI is heavily depend on the **advanced computing power** so that advances in **quantum computing, distributed computing** and **deep-learning chips** are essential.

Digital Technologies

Digital Twins are digital reproductions of real-life systems. They comprise information on the status of their real-world counterpart. These reproductions are able to react to changes or enhance operations so that bring enormous savings in maintenance and operations.

Edge Computing reduces the bandwidth of communication needed and removes the latency among the cloud and sensors compared to cloud computing. Edge computing pushes computation in the direction of the user/thing (edge of the cloud network). Especially with the increasing growth and maturity of drones, autonomous vehicles, and robotic technologies, the demand for real-time computing of large amounts of data is expected to increase further.

Conversational Platforms are expected to become a main design interface for interaction. Unlike before, conversational interfaces enable the user to transport their intent using regular language, which is a completely new way for humans to interact with the digital environment.

Immersive Experiences brought by **Virtual Reality (VR)** that puts the user in a digitally rendered world and **Augmented Reality (AR)** overlaying digital information on the real world are expanding the limitations between physical and digital ecosystem. Recently, **mixed reality** (MR) combining both is the technology of choice.

Mesh Technologies

Blockchain is a decentralized, shared, distributed, and tokenized register that eliminates business friction by being autonomous of individual requests or participants. Although there is substantial long-term potential for untrusted groups to transfer commercial transactions, the upcoming years will be rather hype than actual benefit.

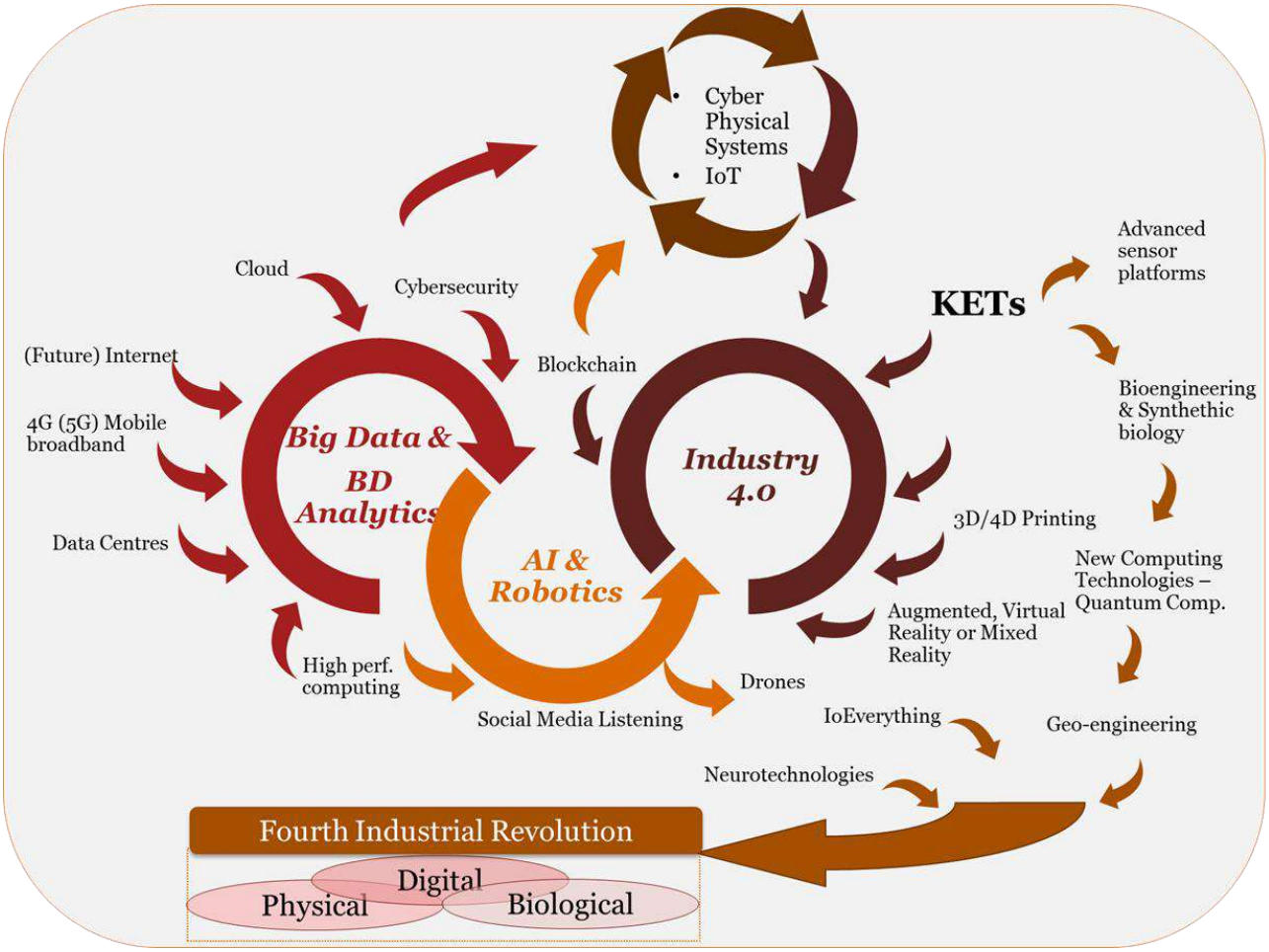
Event Processing is expected to drive digital enterprises even more as suggested by Gartner, event-based, real-time focus will be on top the agenda for 80% of digital enterprise solutions, and 80% of new enterprise ecosystems will need support for event processing by 2020.

Continuous Adaptive Risk & Trust *is* advancing more and more importance as the security industry is continuously reshaping itself as threats and risk protection progresses, as evidenced by the sequence of high profile hacks.

In addition to above listed technologies, there are some other **technologies acting as enablers for other technologies particularly AI to evolve.** Among those, big data and big data analytics, increasing processing and computing power through super and quantum computers, open-source software and data, improved algorithms, 5G, Cloud Computing, Smart Sensors, and Cyber Physical Systems can be mentioned.

As illustrated in below Figure, we are at an era of **transition from Third towards Fourth Industrial Revolution** by multi-modal adoption of different advanced technologies explained above together with constantly emerging new ones connecting digital, physical and biological spheres to one another as illustrated in below Figure.

Figure 40: Multimodal deployment of KETs and other digital technologies: transition from 3rd towards 4th Industrial Revolution



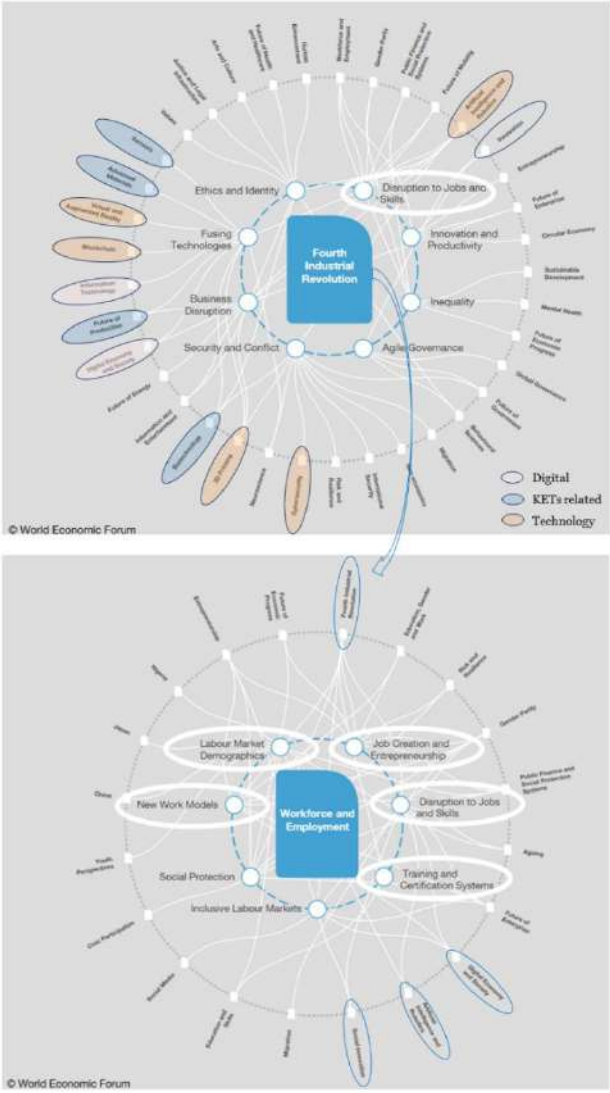
Source: PwC

This figure shows the transition from **Third Industrial Revolution** in which Big Data and Big Data Analytics enabled by advances in data centres, big data platforms, high performance computing, future internet, 4/5 G mobile broadband, cybersecurity, cloud computing, sensors, networks lead to wider implementations of AI and Robotics. All these combined with KETs, IoT, Cyber Physical Systems, Blockchain, 3D Printing, AR&VR, Drones etc. collectively gave birth to the emergence of **Industry 4.0.** Currently we are at a point of emergence between all these technologies and bioengineering and synthetic biology, new computing technologies, geo-engineering, neurotechnologies and Internet of Everything towards **Fourth Industrial Revolution (4IR).**

Figure below comprised of two images being developed by WEF depicts the **interdependency between different KETs and other technologies towards 4IR** and the impact of 4IR on Workforce and Employment.

Considering these mutual dependencies and impacts together with other factors, it is key for policy makers to better understand the particular **specificities of each technology and interdependence between other technologies** when designing and implementing policies for high-tech skills development in order to bridge the skills mismatch as well as to have right skills that is needed in EU to make 4IR happen.

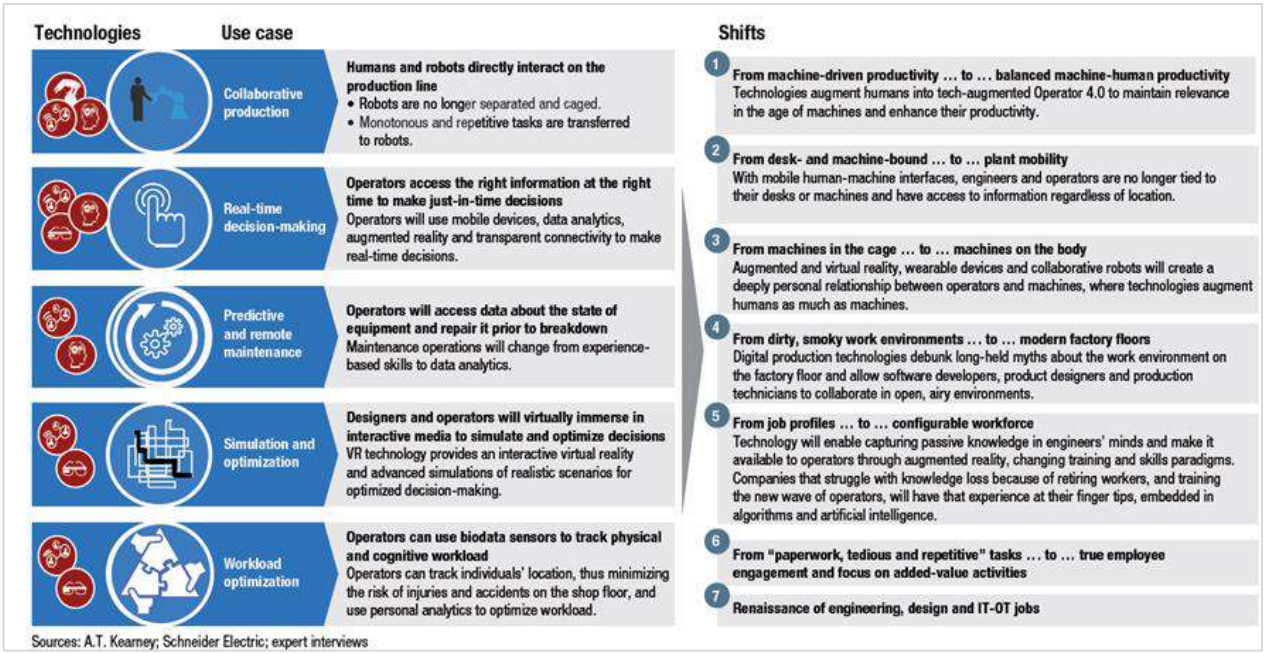
Figure 41: Technologies leading to 4th Industrial Revolution and its impact on Workforce and Employment



Source: PwC analysis based on WEF Findings

The impact on workforce and employment can easily be seen in below figure for the employees allocated under factories of the future (see next Figure).

Figure 42: Shifts in the nature of work on the factory floor



Source: WEF[230]

Figure 43: Characteristics of the hyper efficient and flexible factories of the future

Source: WEF[231]

As it can easily be seen, it is a quite complex process for all stakeholders (individuals, entrepreneurs, researchers, policy makers, investors etc.) to comprehend the collective impacts of all the technologies on business models, value chains, services etc. simply the way we live and do business. It is even much harder to stay up-to-date with constantly evolving technological breakthroughs and develop relevant skills for being able to innovate and/or deploy. To have the right physical and digital infrastructures to allow these technologies function properly is another

[230] http://www3.weforum.org/docs/WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf
[231] http://www3.weforum.org/docs/WEF_White_Paper_Technology_Innovation_Future_of_Production_2017.pdf

challenge to meet at the company, local, regional and national levels. Thus, it requires **collective thinking and planning at each level for collaborative investments** for building up right infrastructure first and then investing on **capacity building including skills development** in areas where relevant technologies have to be learned and deployed around the particular sectoral priorities. This lead to the emergence of **SIS concept** to be connected at the regional level first for defining **RIS3 including skills development strategy** to be followed by collaborations **across sectors, cross-borders and across value chains.** This latter lead to the emergence of **EU level initiatives** such as **S3-Industrial Modernisation Platform, Vanguard Initiative, contractual Public Private Partnerships (c-PPPs), EIT-Knowledge and Innovation Communities (KICs), Digital Innovation Hubs (DIHs), European Strategic Cluster Partnerships for Smart Specialisation Investments (ESCP-S3)** aiming to boost industrial competitiveness and investment within the EU.

6.1.3.2. Key challenges of EU Industry towards SIS & DT

Industry is often the major source of business R&D in modern economies as it possesses greater economic and technological multipliers than other sectors, and is closely related to knowledge-intensive practices. Industry activities thus significantly affect developments in SIS & DT.

While efforts are being made across the EU to facilitate the development and adoption of key digital and industrial technologies, **Europe's industry still encounters several challenges**, of which those listed below have to be highlighted:

- **Already-established and emerging technologies spread slowly**. Even in Germany as the leader in industrial manufacturing, it is stated that 'the full shift to Industry 4.0 could take 20 years'. The matter is twofold. In one hand, the amount of new market entrants and their growth within the market is low. These businesses require further support to increase their growth and thus secure their future development. On the other hand, established firms often find that their productivity gains following the implementation of new technologies do not perform as expected. This underachievement of productivity gains inclines especially SMEs to implement key enabling technologies to a smaller degree than larger companies. Only 36% of surveyed companies in Europe with a headcount of 50-249 workers use **industrial robots**, in comparison to 74% of firms with a headcount of 1000 workers. To this day, merely 20 % of EU firms are highly digitised. Only 20% of manufacturing companies have already experimented innovative manufacturing solutions. Further efforts are thus required to encourage the uptake of key digital and industrial technologies among businesses for fully unlock the full potential.

- **Increased global competition resulting in growing pressure on EU businesses**. China, among other global players, is focusing on specific – usually highly advanced – technologies and smart value chains. It aims to upgrade its industrial base by focusing on **10 key industries** as part of the **Made in China 2025 strategy.** This strategy can develop attractive opportunities for a variety of European businesses to supply technology, management skills and critical components. In the long term however, market access for European firms is expected to decrease, especially for the industries in which Chinese firms are able to bridge the technology gap. The deterioration of total manufacturing employment in modern economies mirrors the **increased international competition**. Thus, it is essential for the EU to strengthen its competitive advantage across strategic domains leveraging on particular KETs.

- **Globalised value chains and the digital transformation impacting workforce.** The workforce needs to adapt to these changes and continuously acquire new skills. The types of work available are changing and businesses need to upskill their employees to introduce them to new working routines and to allow them to grow with the needs of the company. The continuous automation and digitisation of processes requires the continuous adaptation of the workforce to new technologies and their smart utilisation.

All of the above highlighted challenges require **significant investments in the skilling of the workforce** to meet the high-tech skill needs introduced by SIS & DT mainly based on **deployment of KETs together with other digital technologies**. Universal competition for talent is increasing and the European labour force has to obtain advanced skills, which will have to persistently improve, to increase its competitiveness and employability. Latest estimates show that around 70 million adults in the EU will be impacted by gaps in basic skills.[232] Simultaneously, firms find it increasingly difficult to find employees with the skills they require. Automotive firms, for example, lack technology, science, mathematics, and engineering profiles and are encountering rigid rivalry for talent from other industries.

6.1.4. Competitive positioning of EU industry and corresponding skill needs

KETs are indispensable building blocks in boosting the competitiveness of EU Industries in sectors such as **automotive, aeronautics, engineering, space, chemicals, building and infrastructure and pharmaceuticals** where the EU industry is a world-leader. In terms of contribution to the EU economy, **manufacturing** remains the backbone providing 32M jobs in 25 industrial sectors with over 2 million companies[233]. In order to keep its leading position on those key sectors as well as achieving industrial modernisation not only by digitisation but also through seminal transformations, strengthening the manufacturing sector is key by the deployment of AMT and so KETs.

Where does the EU stand regarding the skills needed for the deployment of advanced manufacturing technologies and KETs?

Almost half of the surveyed EU manufacturing firms by Fraunhofer ISI[234] indicated **lack of skilled employees** required to adopt these AMT technologies as one of the main barriers among other factors.

According to the Innobarometer 2016 survey[235] results, when EU manufacturing firms were asked about the **use of different categories of advanced manufacturing technologies**, **66% found not using any of the three AMT categories** that showed 14% increase compared to former survey. Among three categories, high performance manufacturing technologies were the most commonly implemented ones (17%) followed by sustainable technologies (16%) and IT-enabled intelligent technologies (11%). The users are found to be the ones with larger (> €2M) or growing

[234] Driving the Sustainability of Production Systems with Fourth Industrial Revolution. Fraunhofer ISI, ITIA, IDEA and VTT, Feb 2017
[235] Innobarometer 2016-EU Business Innovation Trends: Use of advanced manufacturing technologies, EC February 2016

turnover and the ones using **design as a central element** of their strategy and the **innovative ones** compared to non-innovative and non-design based counterparts.

When looked at the **outlook for KETs skills** demand and supply in EU for **2013-2025**, a **43% increase** expected in demand for KETs skills equals to **approx. 1.4 M additional KETs professionals and associates** with technical skills will be needed to satisfy the demand until 2025. The breakdown on this future demand is mainly asks for **high-skilled KETs** employment (62%) followed by medium and low-skilled KETs, 30 and 8% respectively[236].

When looked at the **digital skills of EU labour force** reported under European Digital Progress[237], **37%** of the EU labour force had an **insufficient level of digital skills** while **11% had no digital skills** at all, as they did not use the internet.

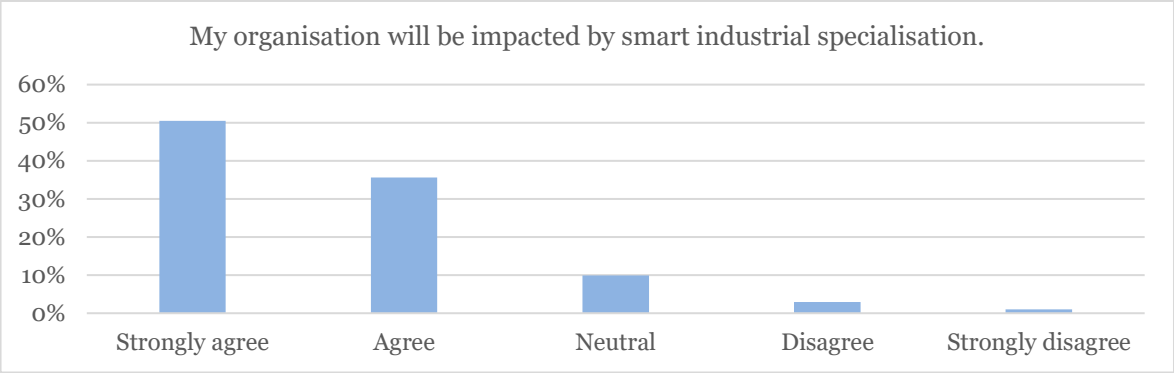
As underlined under renewed **EU Industrial policy**[238], a prosperous Europe needs a successful industry with a strong manufacturing base, and a strong manufacturing requires modernisation embracing digitisation and technological change, integrated products and services, development of less polluting and less energy-intensive technologies, the reduction of waste and so **investments in a workforce with the right skills**. This imperative have also been underlined in other EU policies such as Digital Single Market, Energy Union Package, Climate and Environment, Resource Efficiency, Circular Economy, Bioeconomy, RD&I and Education & VET with a special emphasis on skills development for KETs & other digital technologies collectively and strategically.

6.1.5. Stakeholder perspectives on SIS & DT

The importance of **investing in the up/re-skilling of the workforce** is seen as an increasing interest to the stakeholders consulted through **PwC Survey** conducted under this project. The responses from consulted representatives from different stakeholder groups all across EU, suggest the presence of **significant awareness** regarding the **impact of SIS & DT** will have on the industries and their workforce.
Approximately **86% of the respondents agreed** that their organisations will be **impacted by SIS**. Similar results were observed regarding the **impact of DT** to be seen on their businesses agreed by approximately **90% of the respondents**. These findings suggest that the majority of the stakeholders consulted are aware that the rise of **SIS & DT will affect their businesses** and that they **need to adapt a pro-active approach to prepare their businesses for the Fourth Industrial Revolution.**

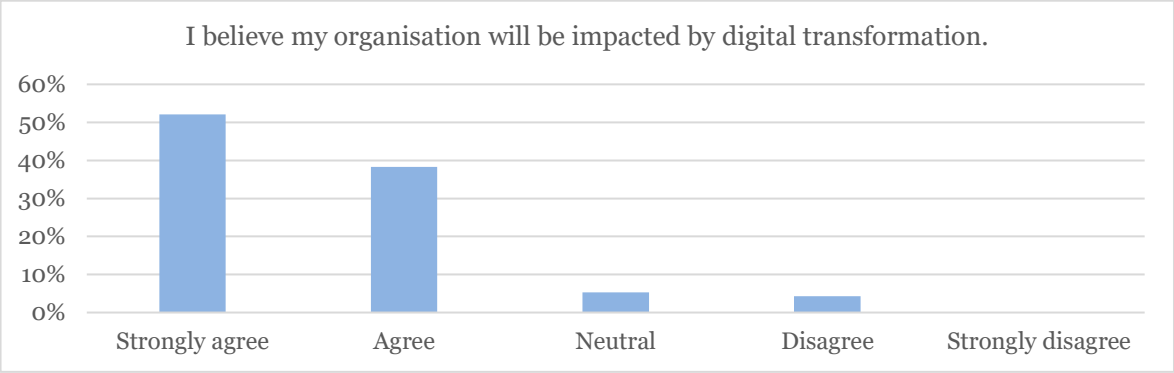
[236] Skills for KETs in EU: Vision for the development of Skills for KETs. Conducted by PwC for EC, March 2016
[237] EDPR 2017: https://ec.europa.eu/digital-single-market/en/news/europes-digital-progress-report-2017
[238] EU Renewed Industrial Policy Strategy, COM(2017) 479 final

Figure 44: Impact of smart industrial specialisation on organisations



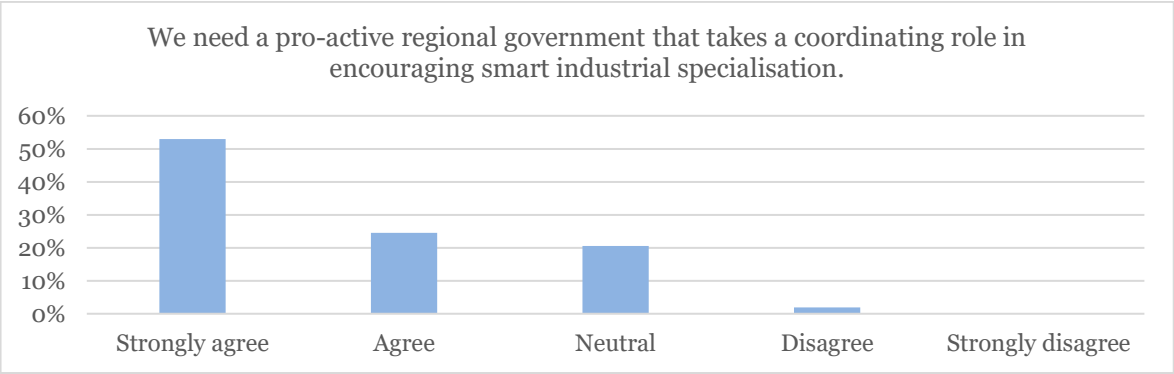
Source: PwC Survey, 2018

Figure 45: Impact of digital transformation on organisations



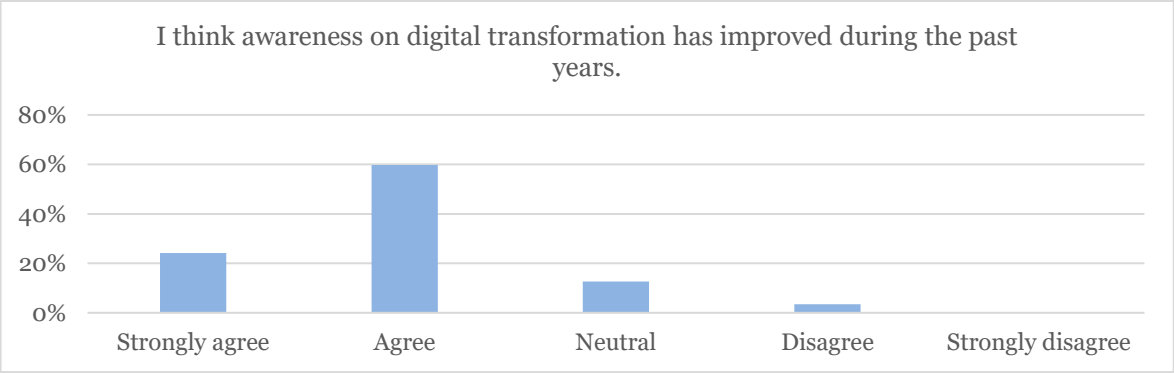
Source: PwC Survey, 2018

Figure 46: Regional Government Involvement



Source: PwC Survey, 2018

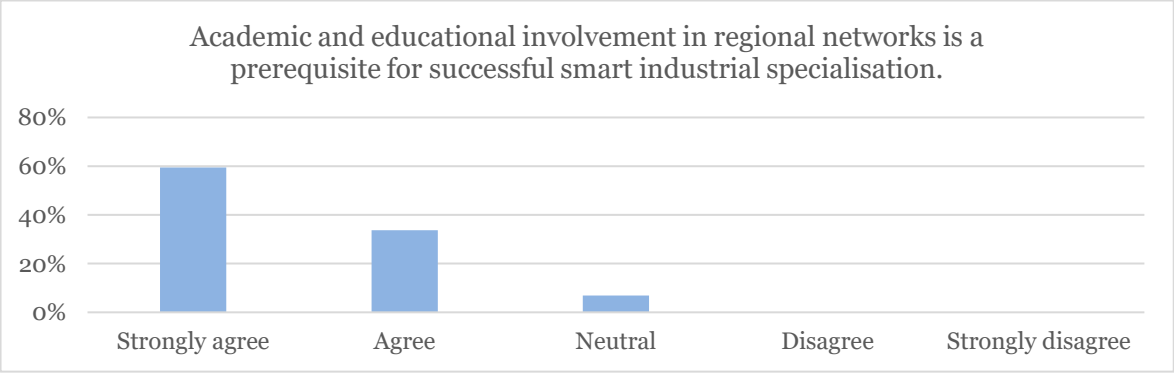
Figure 47: Digital Transformation Awareness



Source: PwC Survey, 2018

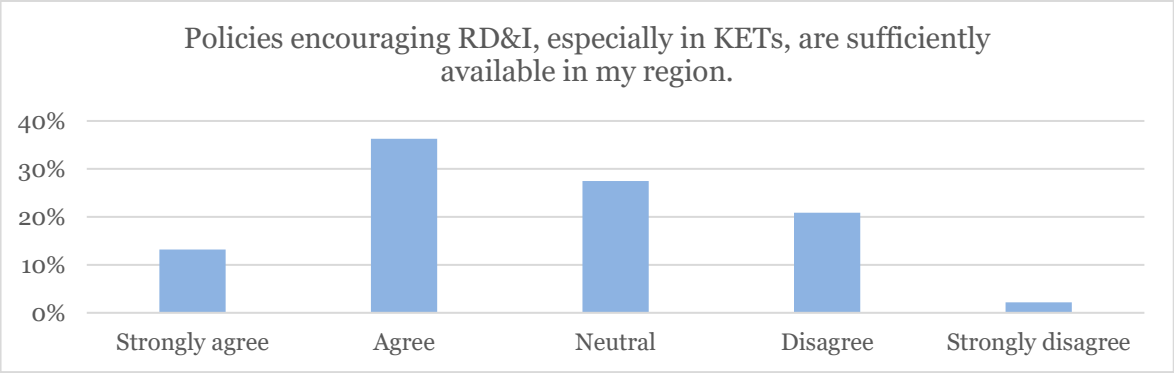
While many highlighted the increasing awareness regarding the effects of digital transformation in recent years, **53% of the respondents strongly** agreed with the **need for regional governments to become actively involved in the SIS & DT efforts** in their region. **Regional governments** are thus expected to drive efforts in this transformation and act as orchestrator between key stakeholder groups for co-design and implementation of their regional economic development, industrial, educational and skilling strategies for bridging the gaps between labour market needs and the education and training curricula for having properly skilled labour force equipped with the right skill sets demanded by the key priority sectors of the region. The stakeholders consulted underlined the need for businesses to proactively invest in getting involved in regional networks and partnerships for successful implementation of SIS. Similarly, **involvement of academic, research and educational stakeholders in regional networks** have also been highlighted as a prerequisite for successful SIS. It is only by bringing together regional governments, industries and academia that a successful SIS & DT strategy can be developed. Policies encouraging RD&I, especially with regards to KETs, should thus be further supported as mixed opinions collected regarding the availability of such policies in their respective regions.

Figure 48: Academic and education involvement in regional networks



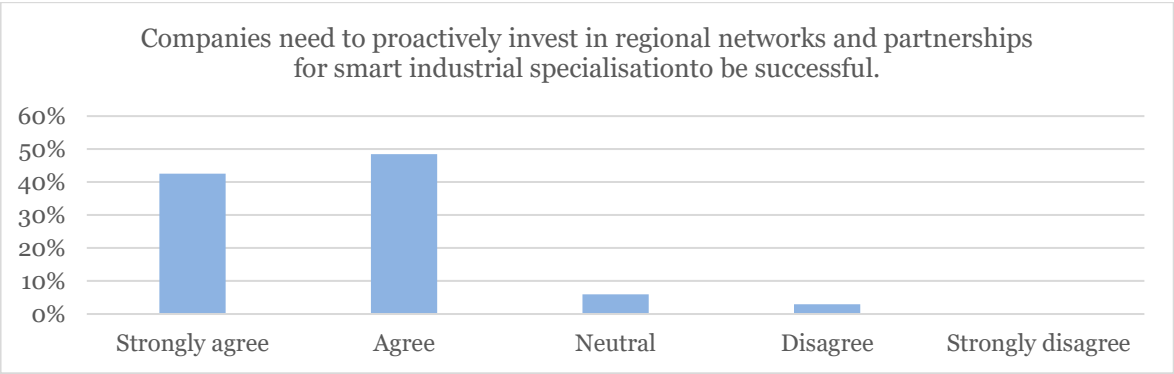
Source: PwC Survey, 2018

Figure 49: Availability of policies encouraging RD&I in the region



Source: PwC Survey, 2018

Figure 50: Company investments in regional networks and partnerships for SIS



Source: PwC Survey, 2018

6.2. Overview of the latest scientific and academic publications on SIS&DT

6.2.1. SIS & DT trends in EU

In this section, we will describe the most important trends relevant to SIS&DT in Europe. We describe the global presence of European Industry, the SoP for KETs in Europe, and the competitive positioning of EU compared to China, the US and Japan. Also, we analyse the readiness of EU Member States for the adoption of advanced manufacturing concepts and compare their readiness to other relevant countries.

6.2.1.1. Global Presence of European Industry

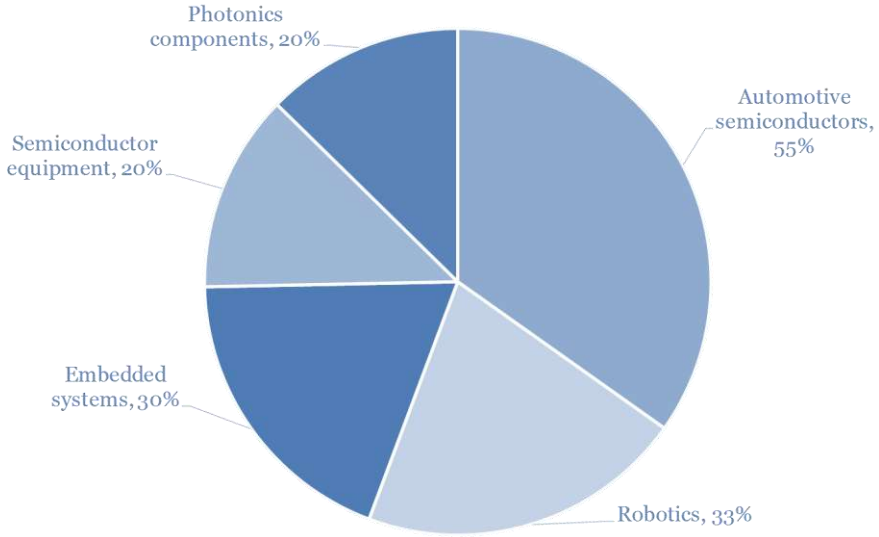
In this section, we highlight the diffusion and uptake of KETs in Europe. We touch upon the global market share of European companies in KETs-heavy industries, and offer some insights in the diffusion of technology and innovation at country level.

KETs are the backbone behind the global leadership role of the EU in a highly diversified field of industries[239]. Of these KETs, the EU focuses mainly on five specific areas: **Automotive**

[239] Re-finding industry, Report from the High-Level Strategy Group on Industrial Technologies Conference Document 23 February 2018

semiconductors, robotics, embedded systems, semiconductor equipment and photonic components. In each of these areas, the EU holds a significant global market share. This is depicted in below figure, and underlined by value chain analysis performed by the KETs Observatory.[240]

Figure 51: KETs European global market share



Source241

Furthermore, ambitions to diffuse and adopt KETs across different sectors is diverse at national level[242]. For instance in **France**, the government supports KETs R&D by providing knowledge, finance and network under the "Alliance Industrie du Future"[243]; the **German** government seeks to prevent tensions between traditional and innovative companies by having implemented "Ju-RAMI", a platform to support old and new companies[244]; **Italy** showed strong ambitions for the forefront of developing the Internet of Things (IoT) in the EU[245]; and the **UK** demonstrated the first integration of 3D printing in education programs. In many cases, such ambitions are coordinated by overarching public-private **Industry 4.0 programmes**, which facilitate policymaking, networking and capacity building for RD&I on KETs, Cybersecurity and Artificial Intelligence.[246] Figure below provides examples of how individual countries attempt to diffuse

[240] https://ec.europa.eu/growth/tools-databases/kets-tools/kets-observatory/value-chains
[241] Re-finding industry, Report from the High-Level Strategy Group on Industrial Technologies Conference Document 23 February 2018
[242] Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation, WEF in collaboration with McKinsey & Company, Jan 2018. See: http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf
[243] Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation, WEF in collaboration with McKinsey & Company, Jan 2018. See: http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf
[244] Readiness for the Future of Production Report 2018. See: https://www.weforum.org/reports/readiness-for-the-future-of-production-report-2018
[245] Impact of the Fourth Industrial Revolution on Supply Chains. See: https://www.weforum.org/whitepapers/impact-of-the-fourth-industrial-revolution-on-supply-chains
[246] Readiness for the Future of Production Report 2018. See: https://www.weforum.org/reports/readiness-for-the-future-of-production-report-2018; Re-finding industry, Report from the High-Level Strategy Group on Industrial Technologies Conference Document 23 February 2018

technology and innovation, focusing on awareness, financial incentives, the legal framework, accreditation, connectivity and data security, RD&I, talent and education.

Figure 52: Diffusion of technology and innovation at the country level

	Examples	Other countries analysed
Awareness	Over 225,000 visitors joined the Hannover Messe's 2017 edition Over 2,300 events organized during "Industry Weeks"	
Financial incentives	A two-year plan valued at €3.3 billion for boosting the transformation of SME manufacturing capabilities towards Industry 4.0 technologies Manufacturer-led outbound investment in technology, with €20 billion to acquire German-based companies	
Legal framework	Ju-RAMI 4.0, a framework for understanding the main legal aspects of most common use cases Regulated drone operations via introduction of the Drone Operator Safety Act in the US Senate	
Accreditation	Alliance Industrie du Futur: Agency coordinating relevant industry stakeholders (private and public sectors, academia and civil society)	
Connectivity and data security	Cybersecurity for the Future, a research project of the Frauenhofer-Gesellschaft, with a dedicated taskforce for the industrial security of networks and systems	
R&D&I	Technology development test beds: Internet of things Artificial intelligence Augmented and virtual reality	
Talent & education	Primary and secondary school curriculum updated, including programming skills and piloting the inclusion of 3D printing New curriculum at universities: Massachusetts Institute of Technology's (MIT) Industry 4.0 massive open online course; the Stanford Program in Law, Science and Technology	

Source: WEF[247]

[247] The Next Economic Growth Engine: Scaling Fourth Industrial Revolution Technologies in Production, WEF in collaboration with McKinsey & Company, Jan 2018

6.2.1.2. State of Play for KETs in the EU

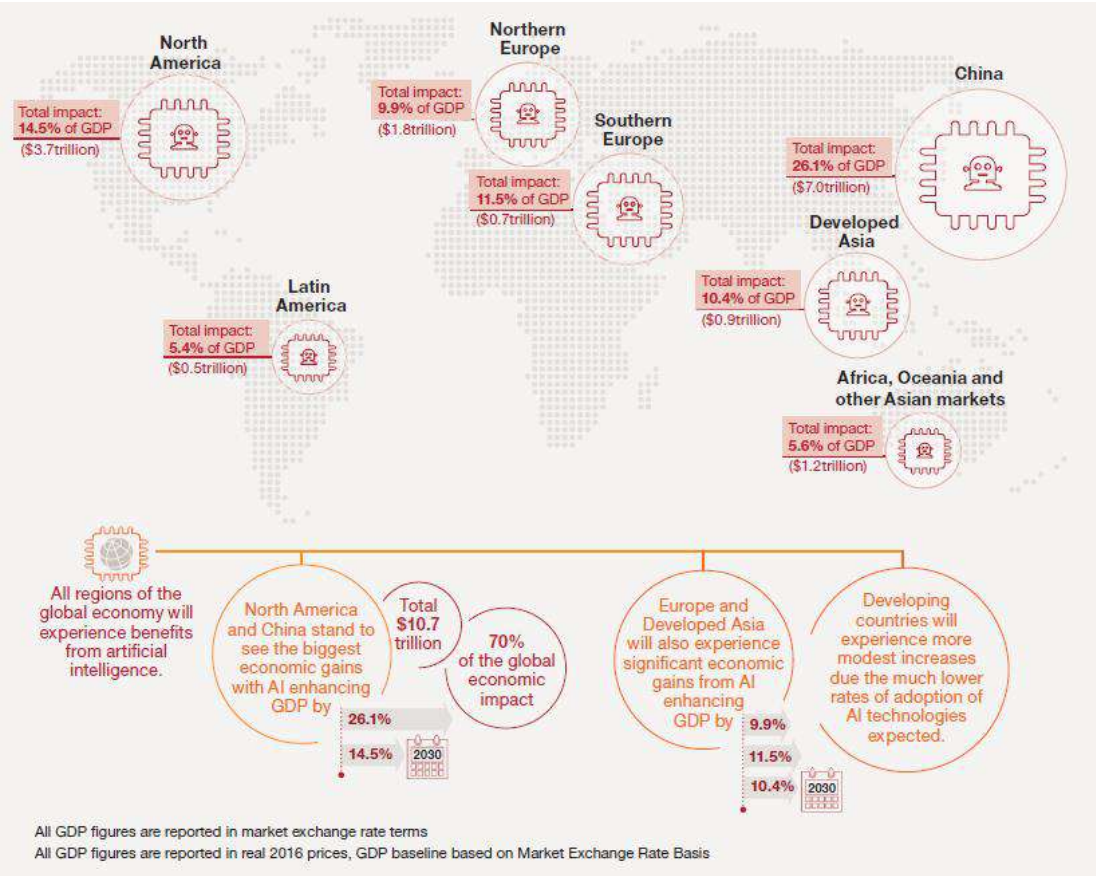
In this section, we focus on the deployment of individual KETs across EU Member States and at aggregated EU level.

Also, we show that across the globe, consumers are being driven away from digital services due to **inadequate control over their personal data**. This highlights the importance of development and uptake of cybersecurity technologies, especially as multi-billion Euro sectors can be encouraged and supported through progressive developments in **cybersecurity**.

Artificial Intelligence

According to a recent study published by PwC, AI could contribute up to $15.7 trillion to the global economy in 2030, more than the current output of China and India combined. Of this, $6.6 trillion is likely to come from increased productivity and $9.1 trillion is likely to come from consumption-side effects. Below figure shows which regions would gain the most of these figures, with **China and North America benefiting most significantly** – both in absolute and in relative terms[248].

Figure 53: Which regions across the world will gain most from AI



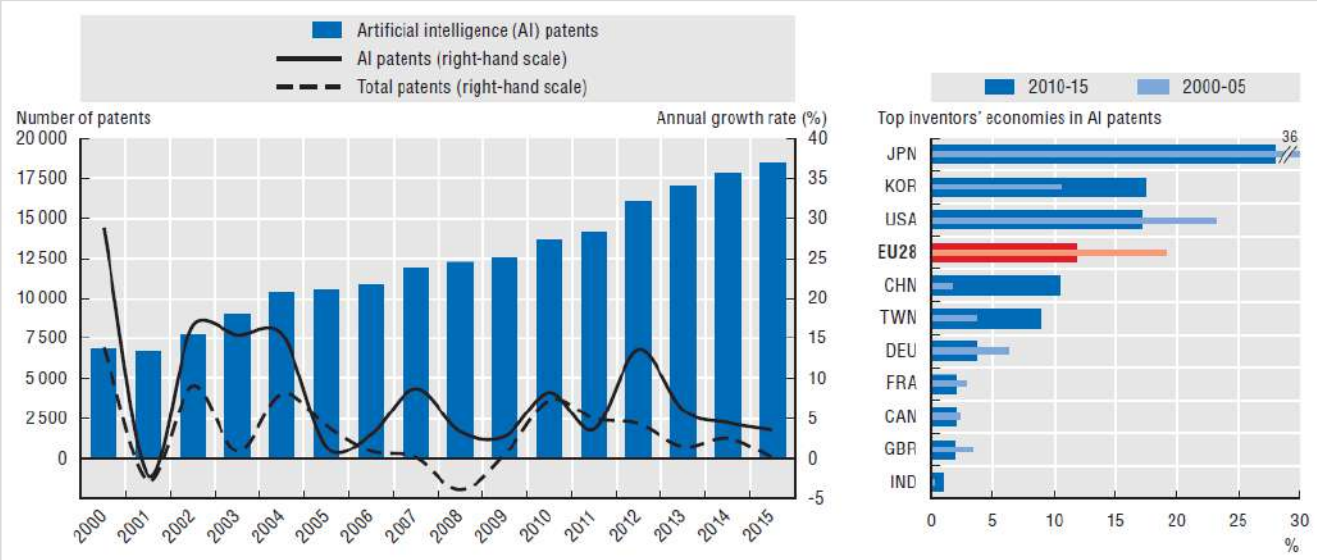
Source: PwC[249]

[248] PwC, 2017, "Sizing the prize, what's the real value of AI for your business and how can you capitalize?", Available at: www.pwc.com/gx/en/issues/analytics/assets/pwc-aianalysis-sizing-the-prize-report.pdf
[249] www.pwc.com/gx/en/issues/analytics/assets/pwc-aianalysis-sizing-the-prize-report.pdf.

AI has the power to overcome physical barriers of capital and labour; thus, must be considered as a **new way to create growth** rather than a mere productivity enhancer. The AI impact can comprise **solutions for a wide spectrum of businesses**, ranging from clean energy to cancer research and deep learning services. More than **70% of business leaders believe that AI will be the business advantage of the future.**[250]

As it can be seen from below figure, **Japan, Korea and the US account for over 62% of AI-related patent applications during 2010-15**, down from 70% in 2000-05. Over the same period, Korea, China and Chinese Taipei increased their number of AI patents compared to rates observed in 2000-05. EU 28 countries contributed to 12% of the total stock of IP5 AI-related inventions in 2010-15, down from 19% in the previous decade[251]. R&D corporations based in Japan, Korea, Chinese Taipei and China account for about 70% of all AI-related inventions belonging to the world's 2000 top corporate R&D investors and their affiliates, while it is 18% for US-based companies.

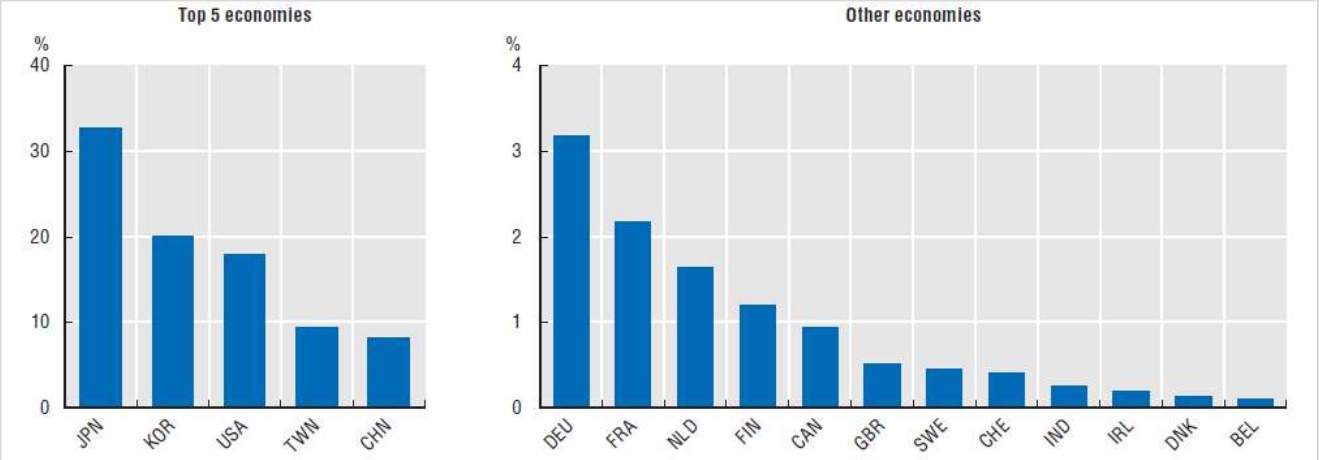
Figure 54: Patents in artificial intelligence technologies, 2000-15



Source: OECD Science, Technology and Industry Scoreboard 2017, The Digital Transformation

[250] PwC, 2017, "Accelerating innovation: How to build trust and confidence in AI", Responsible artificial intelligence study 2017, Available at www.pwc.co.uk/auditassurance/assets/pdf/responsible-artificial-intelligence.pdf
[251] http://www.oecd.org/sti/oecd-science-technology-and-industry-scoreboard-20725345.htm

Figure 55: Artificial intelligence patents by top R&D companies, by headquarters' location, 2012-14



Source: OECD Science, Technology and Industry Scoreboard 2017, The Digital Transformation

Currently, Canada is leading the global ambitions of AI, as well as US and China, having developed a comprehensive roadmap for AI leadership.[252] In **US**, huge investments in AI are made by the private sector, and a substantial governmental plan was launched in 2016, which includes significant long-term investments in AI research. Similarly, the **Canadian government** has started making major investments in AI research in 2017, focusing mostly on existing strength in deep learning. In 2017, **China** released its Next Generation AI Development Plan, with the explicit goal of attaining AI supremacy by 2030.

However, in terms of investment in talent, research, technology and innovation in AI, **Europe lags far behind its competitors.** As a result, the EU and associated countries are increasingly losing talent to academia and industry elsewhere. In **April 2018**, 25 countries pledged to increase national research funding for AI as part of a common "European approach". In parallel, the **European Commission[253]** laid out a preliminary plan for strengthening AI across Europe by:

- Being ahead of technological developments and encouraging uptake by the public and private sectors;
- Preparing for socio-economic changes brought about by AI;
- Ensuring an appropriate ethical and legal framework.

This urgent sense of need for action was also clearly expressed in a recent **open letter by a number of AI researchers**, who proposed the '**European Lab for Learning and Intelligent Systems-ELLIS'[254]**, with major centres in a handful of countries, by employing hundreds of computer engineers, mathematicians and other scientists with the express aim of keeping Europe at the forefront of AI research. Following the recent EC Communication on AI, the **community of European AI researchers** suggest to define broad and ambitious **vision for European AI** research to thrive and for Europe to stay competitive with other major players. This AI community recently launched an initiative for establishing a "**Confederation of Laboratories for Artificial**

[252] Re-finding industry, Report from the High-Level Strategy Group on Industrial Technologies Conference Document 23 February 2018
[253] COM(2018) 237 final: Artificial Intelligence for Europe: https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe
[254] https://www.theguardian.com/science/2018/apr/23/scientists-plan-huge-european-ai-hub-to-compete-with-us

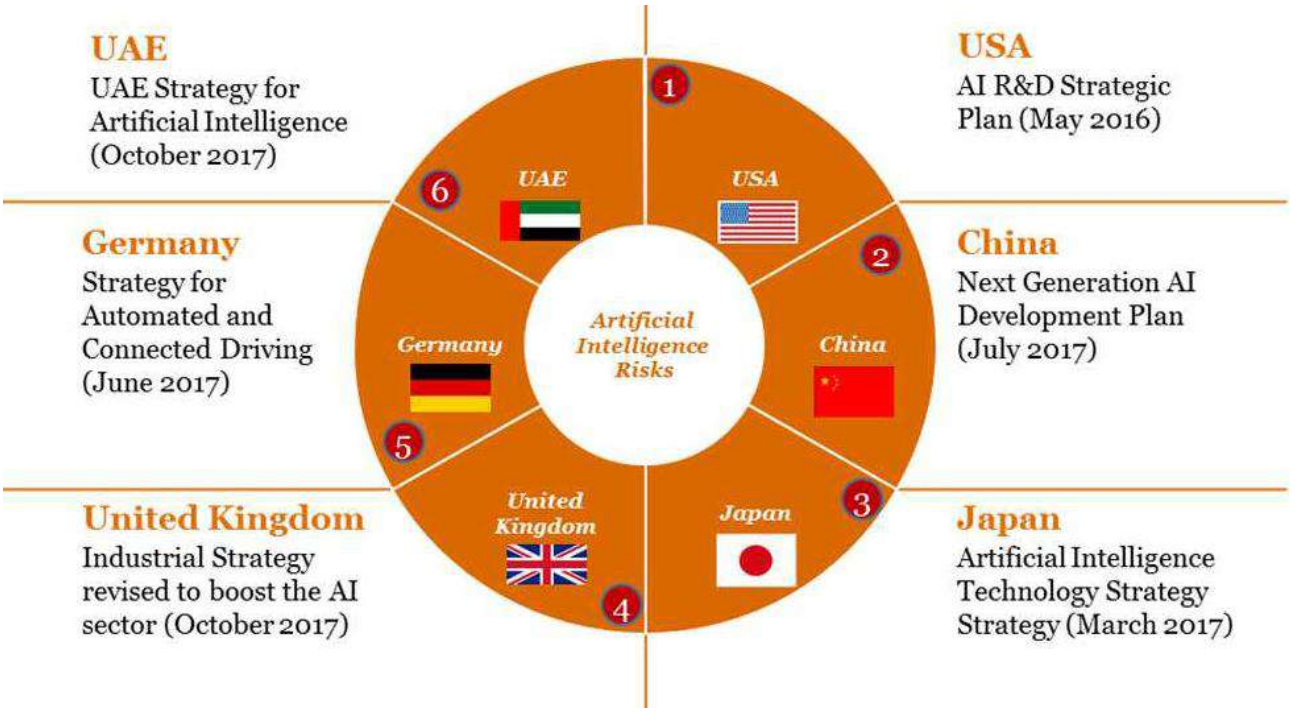
Intelligence Research in Europe", also called "**CLAIRE**"[255] in **June 2018**. Since its launch, CLAIRE has been endorsed by over 2000 stakeholders from academia, industry and public administration from all across Europe, including more than 1100 experts on artificial intelligence, as well as seventeen of Europe's national AI societies and research institutes. The CLAIRE initiative aims to establish a European network of centres of excellence in artificial intelligence, strategically located throughout Europe, and a new, central facility with state-of-the-art, "Google-scale" infrastructure that will promote new and existing talent, and provide a focal point for exchange and interaction of researchers at all stages of their careers, across all areas of artificial intelligence. The goal is to achieve impact and brand-recognition in the area of artificial intelligence similar to that of CERN- Europe's world-leading laboratory for particle physics[256]. The initiators of CLAIRE are Prof Holger Hoos, Machine Learning at Universiteit Leiden (The **Netherlands**), Morten Irgens, Vice Rector at Oslo Metropolitan University (**Norway**), and Philipp Slusallek, Scientific Director at the German Research Centre for Artificial Intelligence (**Germany**).

When looked at the **national efforts within EU**, we see individual AI programmes lead at the national level to compensate the lacking supranational strategic plan. For instance, "**FranceIA**" was implemented to foster the structuring of a fully rounded French industrial AI sector, set by defining guidelines on the protection of privacy data, transparency, accountability and the contribution to the collective wellbeing.[257]

Also, the **United Kingdom** revised its Digital Strategy in favour of AI, conducted a review of its critical success elements for the UK and adopted a funding of EUR 17.3 million to support the new AI and robotics technologies in universities across the UK.[258]

[255] https://claire-ai.org/
[256] https://claire-ai.org/wp-content/uploads/2018/09/CLAIRE-Vision-Document-2-2.pdf
[257] https://www.economie.gouv.fr/France-IA-intelligence-artificielle
[258] https://www.gov.uk/government/publications/uk-digital-strategy/uk-digital-strategy

Figure 56: Long-term AI strategies and initiatives launched by major economic powers



Source: Digital Transformation Monitor (2017), AI Policy Seminar: Towards an EU strategic plan for AI

In **Germany**, considerable steps that have been already been within the context of the **Federal Government's High-Tech Strategy**, dealing with mobility, health, autonomous systems, production and smart home. The Industrie 4.0 platform has successfully improved networking and cooperation in the field of Industrie 4.0, earning global recognition for this work and setting standards. The **Federal Government Strategy on Artificial Intelligence** has just been announced in **June 2018**. These are to serve as a basis for ensuring Germany attains leading global excellence in the research, development and use of artificial intelligence. The Cabinet submission was jointly prepared by the Federal Ministry for Economic Affairs and Energy, the Federal Ministry of Education and Research, and the Federal Ministry of Labour and Social Affairs[259].

Key actions points of this AI strategy are as follows[260]:

- Strengthening research in Germany and Europe in order to be drivers of innovation
- Transfer to business
- Setting up an initiative to foster breakthrough innovations
- Fostering the founding of start-ups and leading new businesses to success
- Investing on labour market for shaping structural change through skills development
- Boosting vocational training / attracting skilled workers and experts
- Utilising AI for public-sector responsibilities and adapting the skills offered by the Administration
- Making data available and usable
- Revising the regulatory framework and ensuring legal certainty
- Setting standards

[259] https://www.bmwi.de/Redaktion/EN/Pressemitteilungen/2018/20180718-key-points-for-federal-government-strategy-on-artificial-intelligence.html
[260] https://www.bmwi.de/Redaktion/EN/Downloads/E/key-points-for-federal-government-strategy-on-artificial-intelligence.pdf?__blob=publicationFile&v=4

Finland also put a comprehensive national strategy in place with the aim of becoming a top country in AI and appointed a dedicated **steering group in the Ministry of Economic Affairs** to pursue the following strategic plan[261]:

- Make Finland a frontrunner in the age of AI
- Make bold decisions and investments
- Effectively use data across all sectors
- Build the best public services in the world
- Enhance business competitiveness with AI
- Ensure a quick and easy adoption of AI technologies
- Attract top experts to ensure top-level expertise
- Establish new models for collaboration.

Advanced Manufacturing Technologies (AMT)

As shown by the EU study [262] that analysed the drivers, barriers and readiness factors of EU companies for adopting AMT and products, there is a **strong need remains to accelerate their uptake, in particular amongst SMEs**. So far, the spread of AMT has remained too focused on specific countries and certain sectors to spur meaningful, broad-based industrial modernisation across the continent. In particular, this holds true both for complex technologies and for even basic capabilities. This study identified the following as **main drivers and barriers** for the EU Industry:

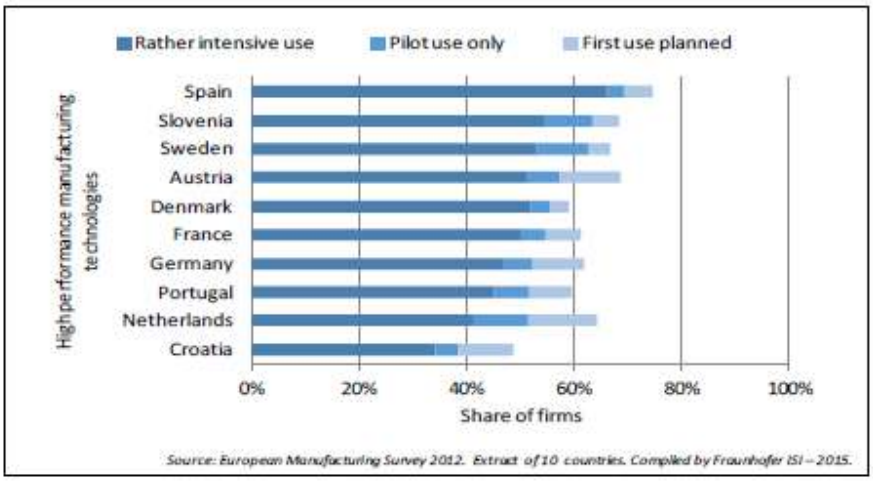
- Main drivers for investing in AMT were found to be largely internal, resulting from a combination of commercial and technological considerations: reducing production costs, improving the quality of products and services, improving the firms' employees' productivity and the reduction of production lead time. With the partial exception of sustainable manufacturing technologies, the use of AMT seems not to have been prompted by favourable external framework conditions so far;
- Key barriers to AMT investments are made up by a mix of internal and external factors. For nearly three quarters of the firms, the most important barrier is the high cost of investments in AMT acquisition and the lack of financial resources. Moreover, about half of all firms indicate difficulties in assessing the performance and the potential business return of such technologies and/or the lack of skilled personnel required to adopt and adapt relevant AMT. Additionally, market uncertainty and turbulences create barriers.

Below figure shows the share of EU companies at national level regarding the level of adoption (i.e. intensive use, pilot use, planned use) for three groups of AMTs.

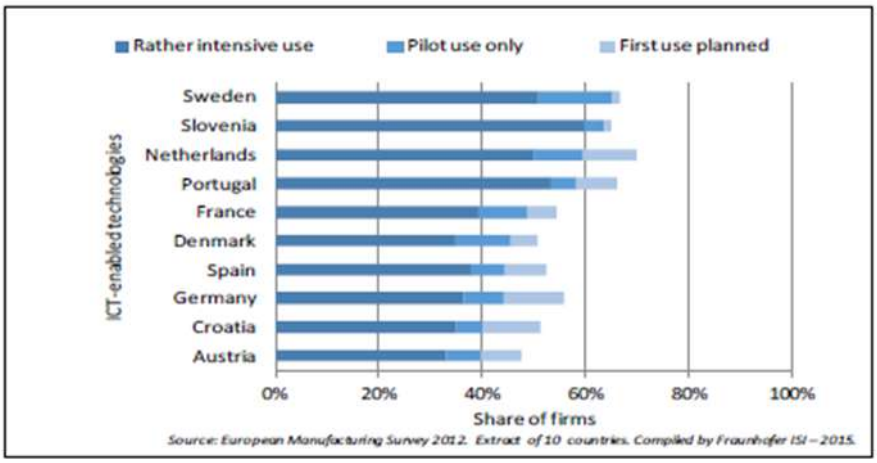
[261] https://tem.fi/en/article/-/asset_publisher/tyoryhmalta-kahdeksan-avainta-nain-teemme-suomesta-tekoalyn-huippumaan
[262] An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies, EC, 2016: https://publications.europa.eu/en/publication-detail/-/publication/29e4d66e-dd4a-11e6-ad7c-01aa75ed71a1

Figure 57: Adoption of different AMTs by European companies, by country

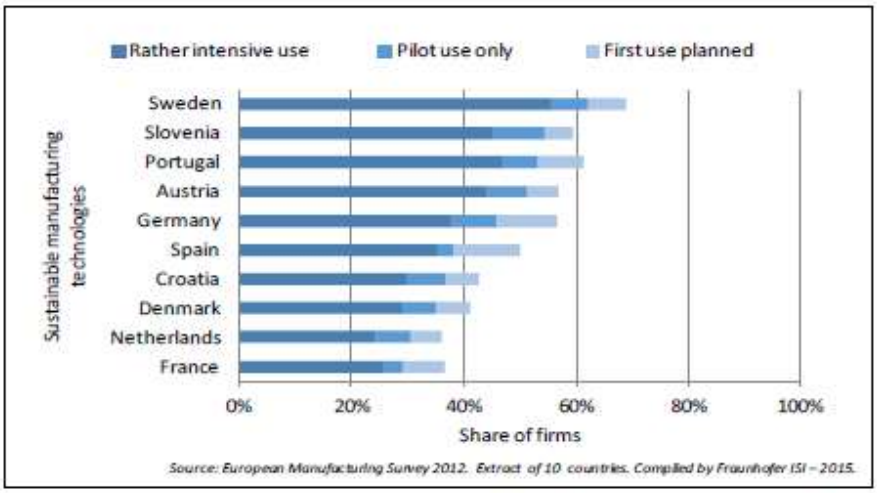
A) High Performance Manufacturing Technologies



B) ICT-enabled technologies



C) Sustainable Manufacturing technologies

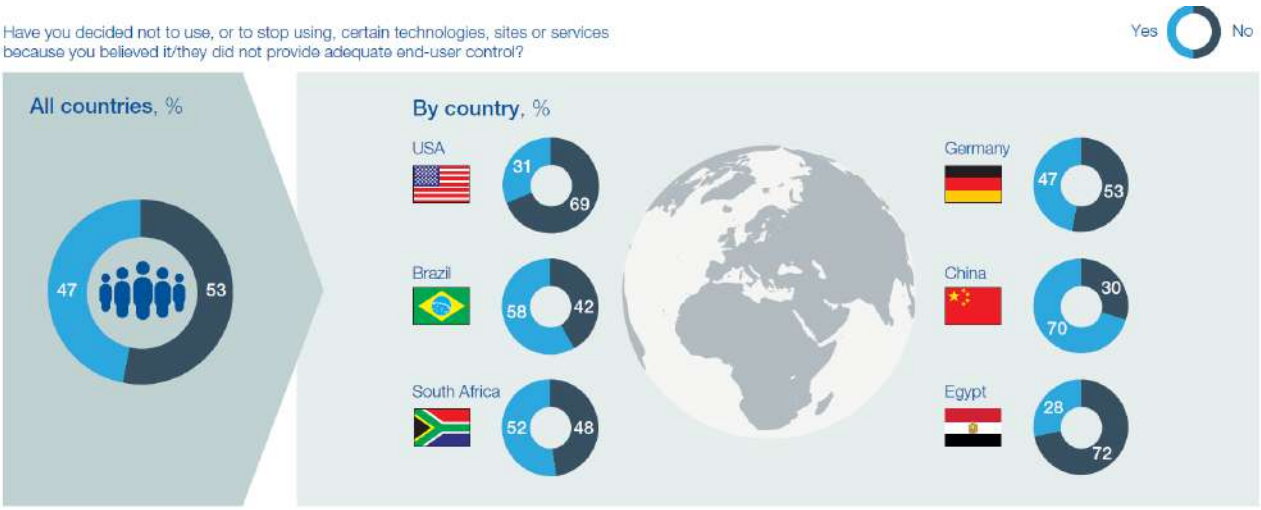


Cybersecurity

Cybersecurity is essential for KETs innovations across all cases.[263] New technologies and processes are challenged, as well as end-users who are required to trust multiple new digital systems, in particular in regards to private data.[264]

Figure below shows that across the globe, consumers are being driven away from digital services due to inadequate control over their personal data. This highlights the importance of development and uptake of cybersecurity technologies.

Figure 58: Consumers are being driven away from digital services due to inadequate control over their personal data



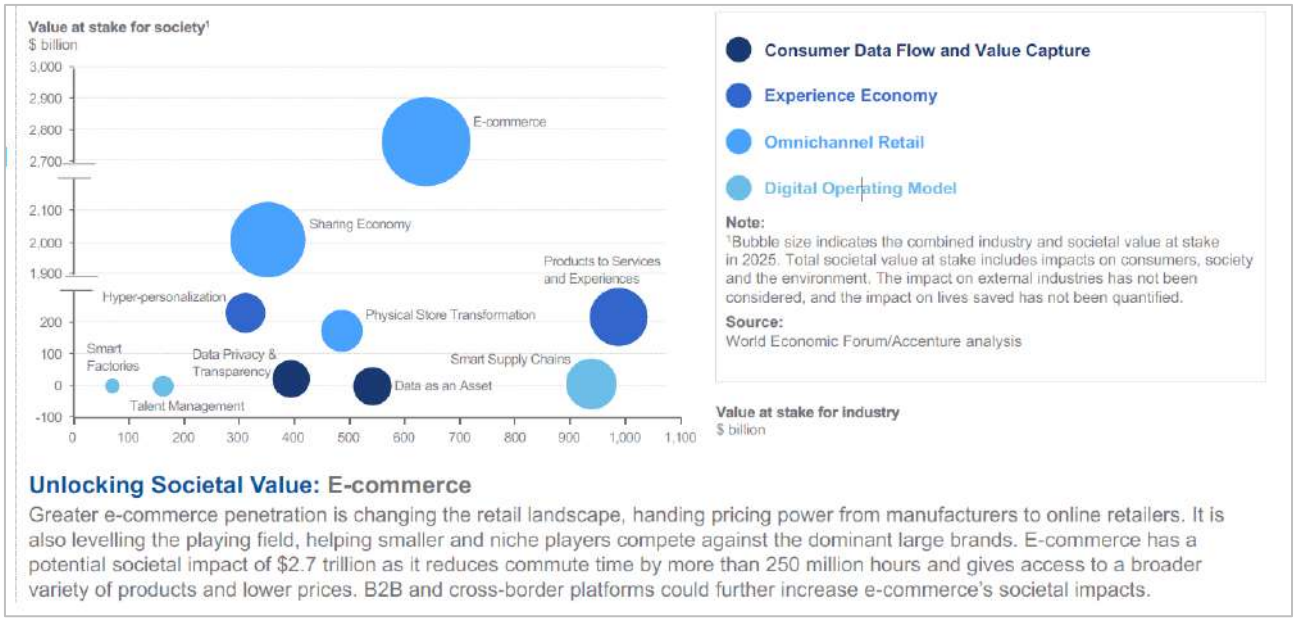
Source[265]

Inevitably, all data must be protected; thus, Cybersecurity is of highest priority for both large industrial actors and SMEs. Moreover, the latter have limited resources to protect against cyber-attacks.266 In the first half of 2017, industries were "most susceptible to cyber threats"267. Especially through e-commerce, consumers can have an impact on digital transformation development.

Figure below shows the value at stake for industry and society, highlighting that multi-billion Euro sectors can be encouraged and supported through progressive developments in cybersecurity, including E-commerce and the sharing economy.

[263] Re-finding industry, Report from the High-Level Strategy Group on Industrial Technologies Conference Document 23 February 2018
[264] Readiness for the Future of Production Report 2018. See: https://www.weforum.org/reports/readiness-for-the-future-of-production-report-2018
[265] Creative Disruption: The impact of emerging technologies on the creative economy, WEF in collaboration with McKinsey & Company, Feb 2018
[266] Readiness for the Future of Production Report 2018. See: https://www.weforum.org/reports/readiness-for-the-future-of-production-report-2018
[267] Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation, WEF in collaboration with McKinsey & Company, Jan 2018. See: http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf

Figure 59: Value at stake for industry and society by digitalization of consumption



Source[268]

Cooperation between governments and companies is essential. Furthermore, governments implemented "highly defensive policies designed to limit their exposure to cyber-based vulnerabilities"[269].

On policy side, the European Commission[270] adopted a **cybersecurity package** on September 2017 building upon existing instruments and presenting new initiatives to further improve EU cyber resilience and response.

Advanced materials and nanotechnology

The use of **advanced materials** is widely spread throughout the EU due to their unique properties and extended applications. Advanced materials are at the heart of many technological developments such as electronic materials for communication and information technology, energy materials for renewable energy or biomaterials for improved health care. Advances in nanotechnology have led to the development of **nanomaterials**, which allow for the production of highly resistant, light materials that show greater chemical reactivity and increased control of light spectrum.

Nanotechnology is being widely used across the EU may it be in the context of ICT, manufacturing, transport, health or construction. ICT manufacturers, for example, are always looking for new methods and technologies to reduce the size of the chips they use or to increase computing speed

[268] WEF Digital Transformation Initiative in collaboration with Accenture, Jan 2017
[269] Shaping the Future of Production: Four Contrasting Perspectives in 2030, WEF in collaboration with A.T. Kearney, March 2017. See : http://www3.weforum.org/docs/WEF_White_Paper_Shaping_Future_Production_.pdf; Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation, WEF in collaboration with McKinsey & Company, Jan 2018. See: http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf
[270] JOIN(2017) 450 final: Resilience, Deterrence and Defence: Building strong cybersecurity for the EU: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017JC0450&from=EN

and capacity.[271] Manufacturers, on the other hand, tend to focus on the use and/or production of nanotools or nanomaterials.[272] In the health industry, nanotechnology is being used to diagnose or treat diseases in line with Europe's goal to increase the length of the average lifespan of Europeans by 2 years by 2020.[273] While under pressure from China, Japan and the US, Europe, and more specially **Germany, France, the United Kingdom, Spain and Italy are very active** with regards to R&D efforts in this field and regularly patent their findings. To further strengthen the growth of activities in the field, specific national policies per sub-category could be envisioned to concentrate research and implementation efforts in each industry. National policies to support nanotechnology tend to be rather generic at Member State level as they are often part of bigger science and technology programmes. By targeting their efforts on specific nanomaterials, Member States could strengthen their position in specific industries or fields of expertise.

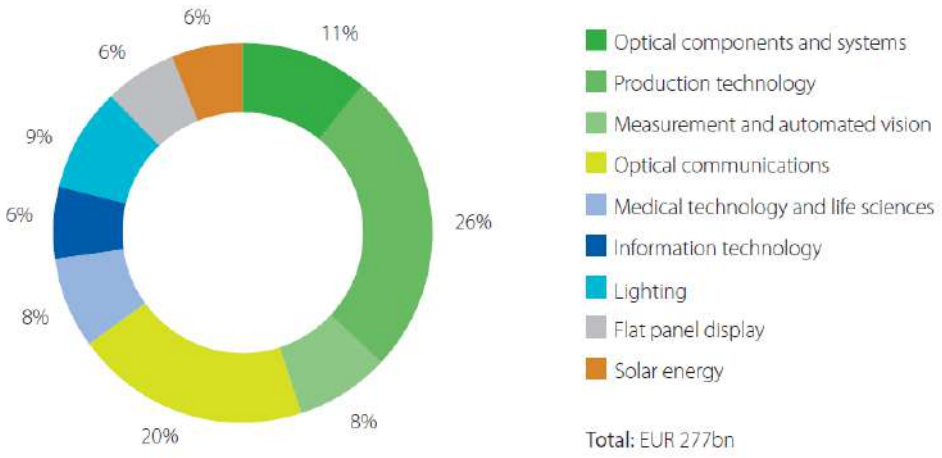
Main challenge of the sector is stated to be the **potential safety concerns** regarding the use of nanomaterials as stated by the Nanotech Industries Association. Again, as stated by the Association, it is important to intensify RD&I efforts on this domain to unlock the full potential of nanomaterials possibly through the implementation of the blockchain technology across whole value chain for traceability reason.

Microelectronics & Photonics

The microelectronics and photonics sectors are high-technology fields with a diverse range of applications across multiple sectors and industries as demonstrated in below Figure. Photonics, for example, are used by the health industry to produce lasers for eye surgery or in point-of-care diagnostics.[274] The food safety and security industry, on the other hand, uses scanning technologies to scan the barcodes on their produce and this assure the quality of the production line. In the energy fields, the use of LEDs has greatly reduced energy consumption. The same can be said for microelectronics, which are used in the creation of mobile phones or the aerospace industry.

[271] Nano Data Landscape Compilation Report – Information and Communication Technologies, June 2017. See: https://publications.europa.eu/en/publication-detail/-/publication/d01a963e-4cbe-11e7-a5ca-01aa75ed71a1
[272] Nano Data Landscape Compilation Report – Manufacturing, June 2017. See : https://publications.europa.eu/en/publication-detail/-/publication/eebb7b25-4cc2-11e7-a5ca-01aa75ed71a1
[273] Nano Data Landscape Compilation Report – Health, June 2017. See: https://publications.europa.eu/en/publication-detail/-/publication/684d2ef2-4cc0-11e7-a5ca-01aa75ed71a1
[274] Nano Data Landscape Compilation Report – Photonics, June 2017. See:

Figure 60: Breakdown of photonics production by application sector in %

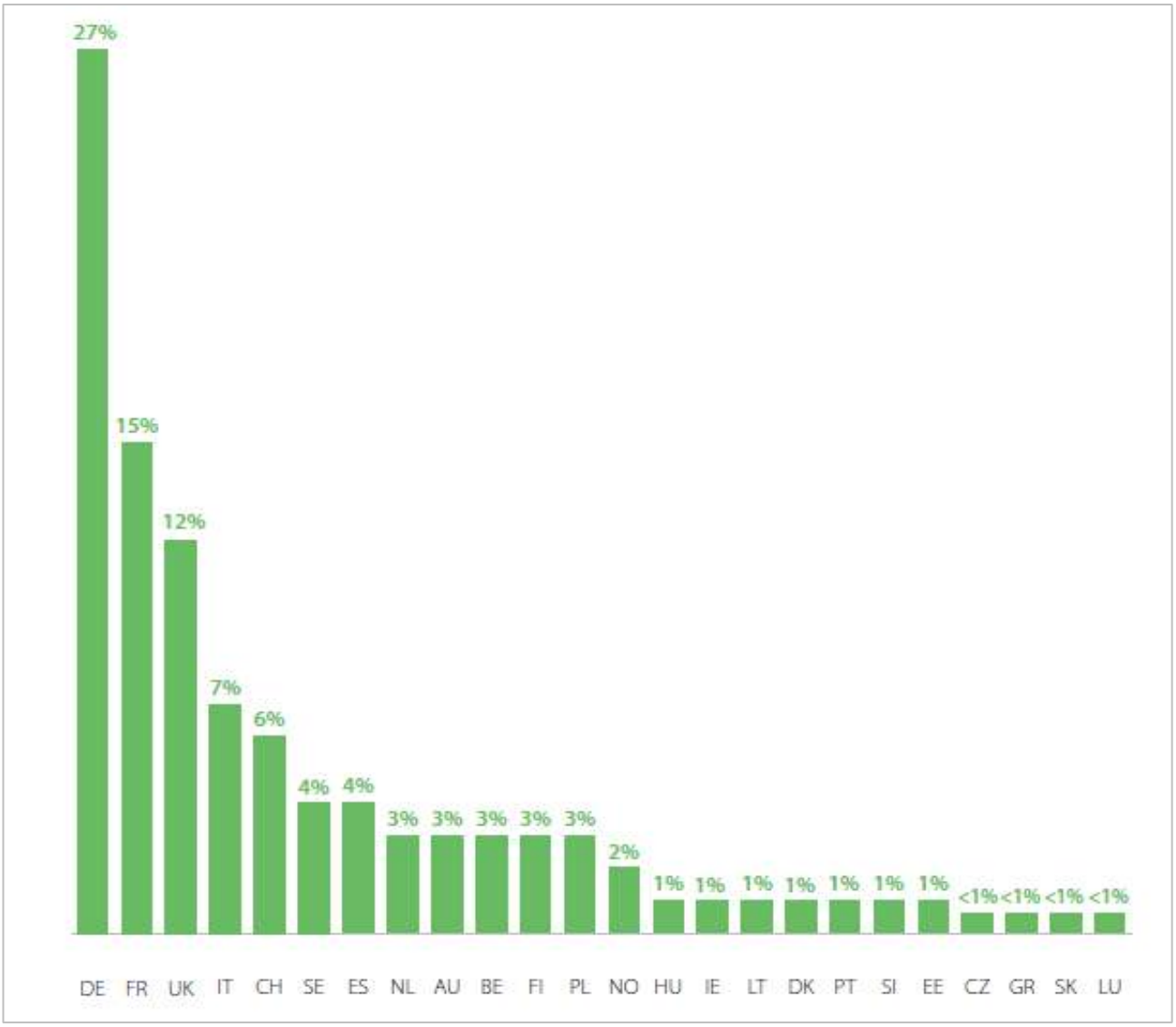


Source: Photonics21, The Leverage Effect, March 2011

Due to the multi-disciplinary application of the technologies, the development and growth of this KET is being supported by numerous national initiatives across the EU (e.g. New Materials and New Industrial Processes (SANST), NanoNextNL). **Germany, France, UK and Italy are leaders in both photonics and semiconductors** as demonstrated in below figures. Microelectronics and photonics are expected to play a crucial role in the further development of the Deep Tech revolution with the photonics industry estimated to bring a positive leverage impact of 10% to the European economy, between the photonics market size and the total market size impacted. To further strengthen the development of these KETs, access to funding will need to be facilitated and existing financial instruments adapted.[275]

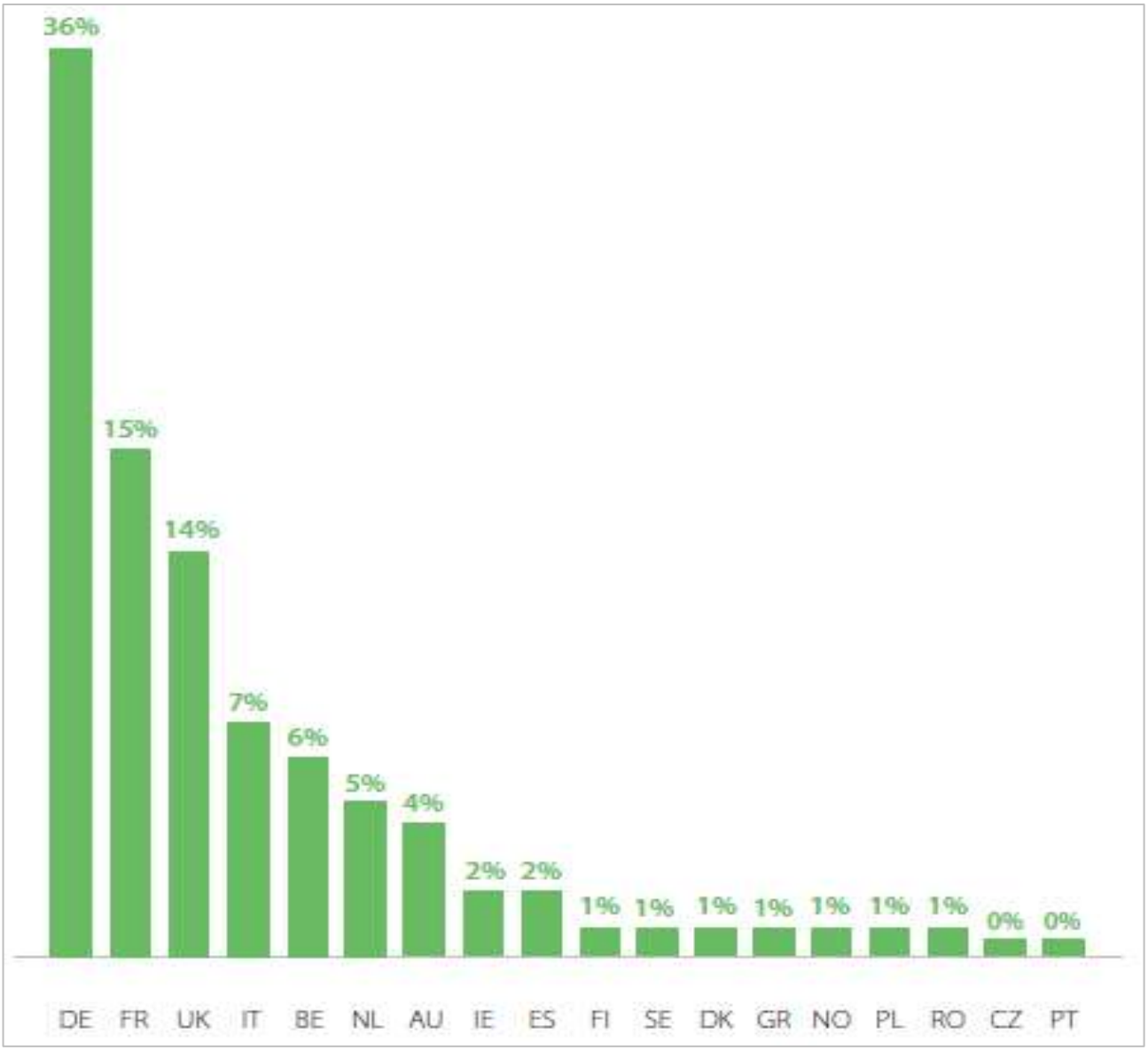
[275] EIB, Unlocking the value of photonics and microelectronics, 2018. See: http://www.eib.org/attachments/pj/financing_the_digital_transformation_en.pdf

Figure 61: Distribution of photonics companies by country in %



Source: EIB, Unlocking the value of photonics and microelectronics, 2018

Figure 62: Distribution of semiconductor companies identified by country in %



Source: EIB, Unlocking the value of photonics and microelectronics, 2018.

Life Sciences

With applications in a broad variety of sectors, life sciences and biotechnology are main innovation drivers in the European Union. This KET includes industrial biotechnology, high throughput biology as well as automation for biology. As shown in below figure, **Germany, UK and France keep the lead** on this KET when looked at the number of companies functioning on this domain. Regarding the potential market value of life sciences and biotechnology, the market for industrial biotech derived products alone is expected to reach EUR50 billion in 2030 by almost doubling its size compared to 2013 values[276].

[276] Bio-TIC, A roadmap to a thriving industrial biotechnology sector in Europe, June 2015. See: file:///C:/Users/jwenger009/Downloads/bio-tic-roadmap_light.pdf

Figure 63: Number of companies in the life sciences industry

Number of companies in the Life Sciences industry

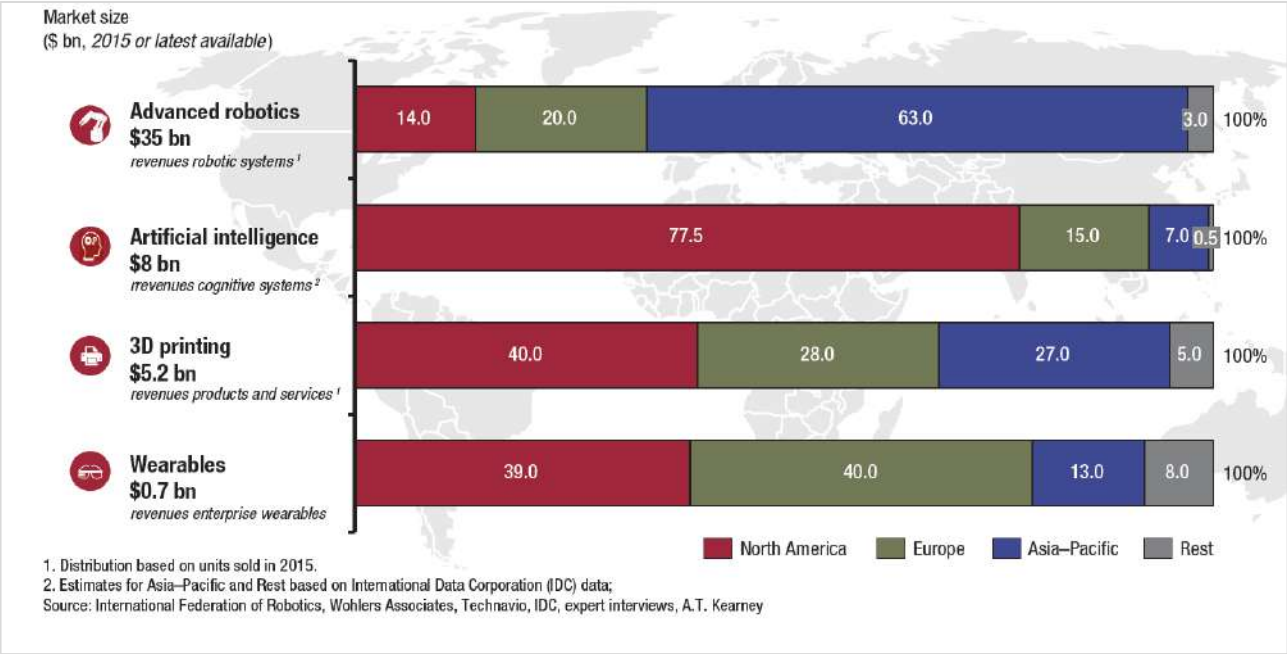
Country	Biotechnology	Biotech – therapeutics	Medtech	Pharmaceutical
Austria	119	44	23	18
Belgium	260	47	60	40
Denmark	171	68	93	12
Finland	83	21	41	6
France	802	180	182	85
Germany	1,073	178	531	102
Ireland	119	28	59	49
Italy	437	58	97	83
Netherlands	459	112	114	41
Norway	151	32	43	7
Spain	525	89	113	94
Sweden	500	170	282	46
Switzerland	463	159	264	76
UK	1,180	328	319	121
Australia	219	106	65	31
Canada	940	248	370	111
Israel	275	134	449	28
Singapore	75	19	27	25
Taiwan	194	55	85	41
US - CA	1,718	794	506	56

Source: www.biotechgate.com 2018

6.2.1.3. Competitive positioning of EU mainly against China, US, Japan

Currently, North America, Europe and some Asian countries as China, Japan and South Korea, are leading in technological transformation. In 2015, 80 % of the wearables market was made in North America and Europe and nearly 70% of industrial 3D printing units was made in those two parts of the world as it can be seen from below figure. North America dominates Artificial intelligence (77.5 %) and Asia-Pacific dominates advanced robotics market (63 %).

Figure 64: Adoption of technologies regarding its location

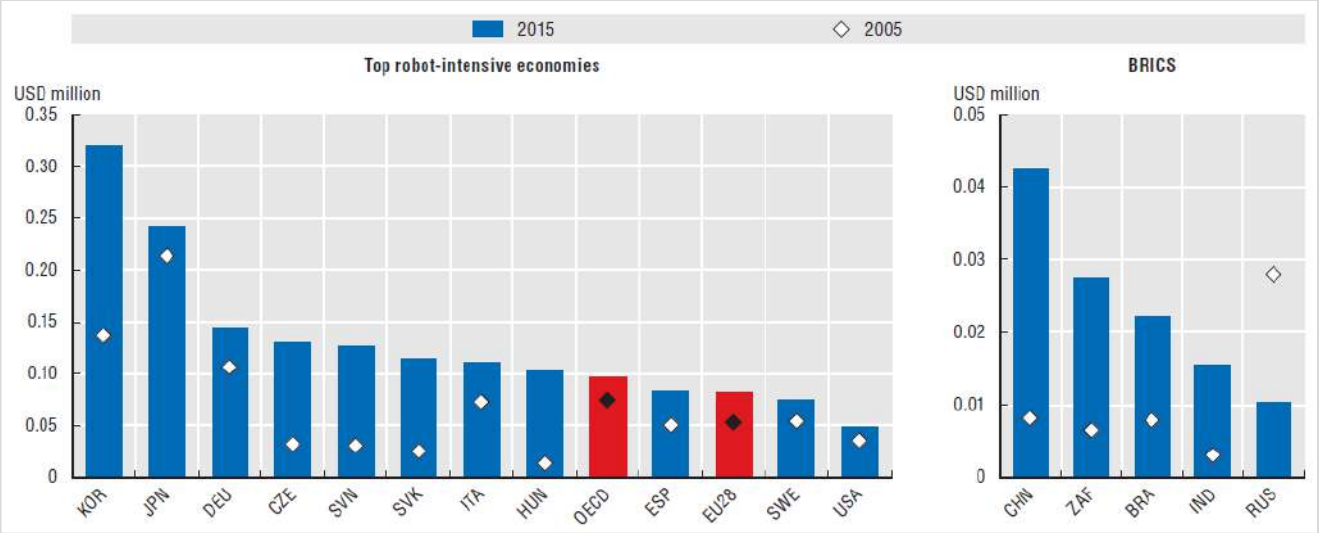


Source: Technology and Innovation for the Future of Production, WEF in collaboration with A.T. Kearney, March 2017

Considering that most of the production transformation is located in those continents, the world is polarized and have "two-speed" production. This two-speed production is getting more realistic considering that only 25 countries shared between Europe, North America and East Asia are either leading the production transformation or they are benefiting first from this "changing nature of production". Moreover, these countries are currently representing over 75% of global Manufacturing Value Added (MVA) and will increase their share in the future. Some countries are however already specialised in some technologies as China, Germany, Japan, Republic of Korea and the United States. These countries made approximately 70% of robot sales. Regarding their share in this specific market, Germany, Japan and the United States are dominating "**the landscape of high-value industrial robots**" and China represents the fastest growing market.

As it can be seen from below figure, **Korea and Japan** lead regarding the **deployment of industrial robot technologies**, measured as robot intensity where it is about three times that of the average of OECD in these economies. However, selected Eastern European countries such as **Czech Republic, Hungary, the Slovak Republic and Slovenia** also emerge as intensive robot users, perhaps mirroring their specialisation within manufacturing value chains and their possible role as suppliers of large multinational corporations. Robot intensity in **BRICS economies** has also increased, while remaining relatively low compared to OECD countries. In particular, robot intensity in **China** increased from 23% to 88% of that of the **United States.**

Figure 65: Top robot-intensive economies and BRICS, 2005 and 2015



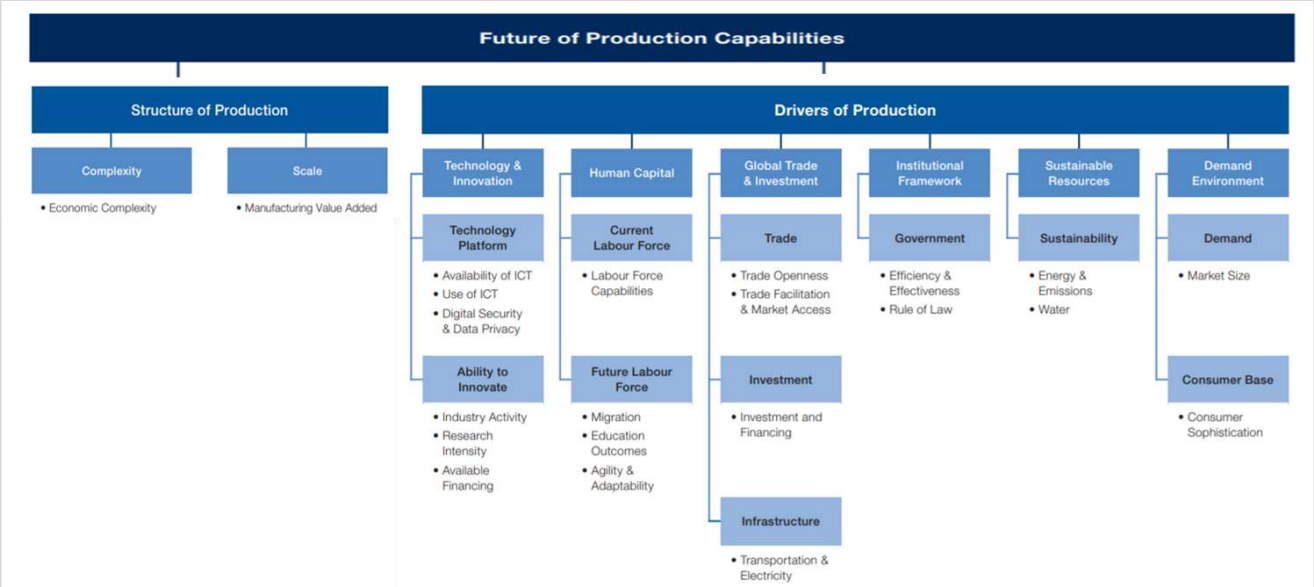
Source: OECD Science, Technology and Industry Scoreboard 2017, The Digital Transformation

6.2.1.4. Readiness of European Union for 'Future Production'

Readiness for the **Future of Production assessment tool** being developed and released by **WEF in 2018**[277] for the first time aims to measure readiness for the future of production where a confluence of technology and trends will reshape the way things are made. **Readiness** is defined as the ability to capitalize on future production opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown future shocks. The assessment measures **readiness for the future of production**, rather than production performance today measured at the entire country level without any differentiation between sectors and regions. By design, **100 countries** being covered are placed into one of the **four archetypes** that provide a new dimension for benchmarking against countries in a similar position. Additionally, it is not prescriptive, but provides elements of analysis in the form of comparable and reliable indicators that must be further interpreted within the context of a given country to inform **agenda setting and decision-making**. As it is seen from the below Figure, the assessment measures readiness for the future of production across two different components: **Structure of Production** and **Drivers of Production**.

[277] Readiness for the Future of Production Report, WEF, 2018. See : https://www.weforum.org/reports/readiness-for-the-future-of-production-report-2018

Figure 66: 'Future Production Readiness' Assessment Framework



Source: WEF Readiness for the Future of Production Report, 2018

6.2.1.4.1. Structure of Production

Production is one of several catalysts for growth that depends on several variables such as strategic decisions a country makes to prioritize sector development across different industries. It is measured in terms of **scale** of a country's current production base and **complexity**.

Complexity assesses the mix and uniqueness of products a country can make as a result of the amount of useful knowledge embedded in the economy and the ways in which this knowledge is combined. **Scale,** on the other hand, assesses both the total **volume of manufacturing output** within a country (**Manufacturing Value Added**) as well as the **significance of manufacturing** to the economy (Manufacturing Value Added, % of GDP).

6.2.1.4.2. Drivers of Production

Drivers of production are **key enablers** that position a country to capitalize on twelve **key emerging technologies including KETs** and opportunities in the future of production as listed in below table.

Countries that perform well across this axes are considered to be more 'ready' since the mix of enablers will make the adoption and diffusion of technology to accelerate transformation of production systems. After a consultative process, **six main pillars** have been identified as explained below:

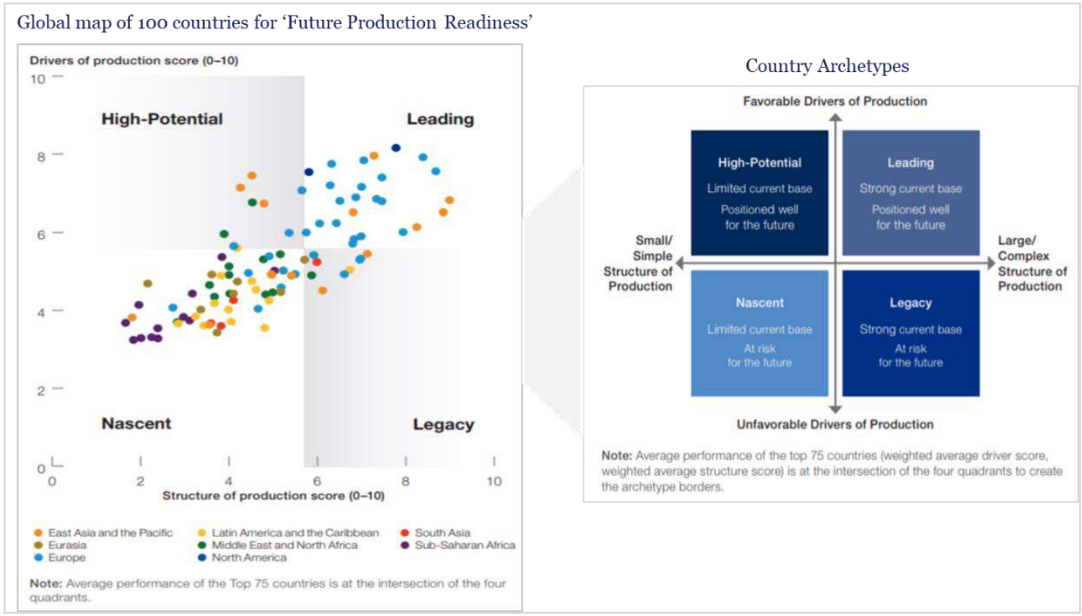
Technology	Description
Artificial intelligence and robotics	Development of machines that can substitute for humans, increasingly in tasks associated with thinking, multitasking and fine motor skills.
Ubiquitous linked sensors	Also known as the "Internet of Things." The use of networked sensors to remotely connect, track and manage products, systems and grids.
Virtual and augmented realities	Next-step interfaces between humans and computers involving immersive environments, holographic readouts and digitally produced overlays for mixed-reality experiences.
Additive manufacturing	Advances in additive manufacturing, using a widening range of materials and methods. Innovations include 3D bioprinting of organic tissues.
Blockchain and distributed ledger technology	Distributed ledger technology based on cryptographic systems that manage, verify and publicly record transaction data; the basis of "cryptocurrencies" such as bitcoin.
Advanced materials and nanomaterials	Creation of new materials and nanostructures for the development of beneficial material properties, such as thermoelectric efficiency, shape retention and new functionality.
Energy capture, storage and transmission	Breakthroughs in battery and fuel cell efficiency; renewable energy through solar, wind, and tidal technologies; energy distribution through smart grid systems; wireless energy transfer; and more.
New computing technologies	New architectures for computing hardware, such as quantum computing, biological computing or neural network processing, as well as innovative expansion of current computing technologies.
Biotechnologies	Innovations in genetic engineering, sequencing and therapeutics, as well as biological computational interfaces and synthetic biology.
Geoengineering	Technological intervention in planetary systems, typically to mitigate effects of climate change by removing carbon dioxide or managing solar radiation.
Neurotechnology	Innovations such as smart drugs, neuroimaging and bioelectronic interfaces that allow for reading, communicating and influencing human brain activity.
Space technologies	Developments allowing for greater access to and exploration of space, including microsatellites, advanced telescopes, reusable rockets and integrated rocket-jet engines.

- **Technology & Innovation** assessing the extent to which a country has an **advanced, secure and connected ICT infrastructure to support the adoption of new technologies in production** as well as country's **ability to foster innovation and its commercialization** that have potential application in production;
- **Human Capital** assessing the **country's ability to respond to shifts in the production labour market triggered by the Fourth Industrial Revolution** by looking at both current labour force capabilities as well as the long-term ability to cultivate the right skills and talent in the future work force;
- **Global Trade & Investment** measuring country's **participation in international trade** to facilitate the exchange of products, knowledge and technology, and to establish global linkages in addition to the availability of **financial resources** to invest in production-related development and the **quality of infrastructure** to enable production related activities;
- **Institutional Framework** assessing the effectiveness of government institutions, rules and regulations in support of technological development, novel businesses and advanced manufacturing;
- **Sustainable Resources** assessing the impact of production on the environment, including a country's use of natural resources and alternative energy sources;
- **Demand Environment** measuring a country's access to **foreign and local demand to scale production** as well as the sophistication of the **consumer base.**

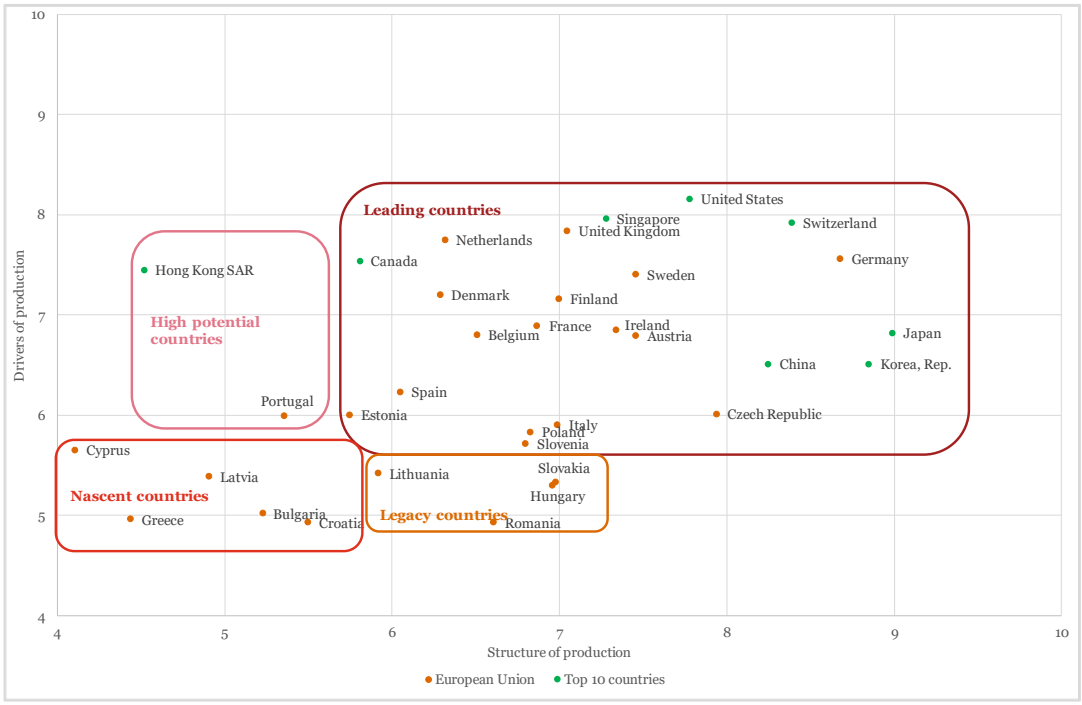
Below, we illustrate both the comparative distribution of countries across the world (below Figure A) according to their readiness scores under four archetypes and the comparative positioning of each EU Member State (below Figure B) compared to the countries listed under top-10.

Of the 100 countries and economies included in the assessment, there are **25 Leading countries, 10 Legacy countries, 7 High-Potential countries/economies and 58 Nascent countries.** The global results show that there is room for improvement for all countries to prepare for and shape future production paradigms as none of the leading countries has achieved the highest score of 10 on either of the assessment axis as shown in below Figure-A.

*Figure 67: **A)** Global Positioning of EU across 100 countries around four Archetypes **B)** Comparative positioning of each EU Member State for 'Future Production Readiness' against top 10 countries*



A)



B)

Source: PwC analyses based on WEF Readiness for the Future of Production Report[278]

[278] Readiness for the Future of Production Report, WEF, 2018. See : https://www.weforum.org/reports/readiness-for-the-future-of-production-report-2018

The countries with the highest score are concentrated in **Europe, North America,** and **East Asia**. All Leading countries are **high-income countries** except for China and Malaysia. Since labour is typically a significant production cost in high-income countries, these countries are expected to realize the highest productivity gains from the emerging technologies. Highest combined scores for Structure and Drivers of Production go to **Germany, Japan and the United States.** On the other hand, the majority of countries in the assessment exhibit a low level of readiness for the future of production, as **58 of the 100 countries** fall under the **Nascent group** majority coming from **Latin America, Middle East** and **North Africa**, **Sub-Saharan Africa** and **Eurasia**.

Since the countries labelled as EU within the assessment framework are not all necessarily EU Member States (e.g. Albania, Bosnia and Herzegovina, Israel, Norway, Serbia, Switzerland), we did further assessments to position **28 EU MSs** (UK is considered under EU MS) in **Figure-B** to see the comparative positioning against top-10 well performing countries.

Four categories of countries are presented below to highlight their strength and weakness regarding their capacities to deploy emerging technologies.

Leading countries

Fifteen Member States are considered among top 10 leading countries. They have favourable drivers of production and a large or complex structure of production. The similarity between those countries is that they are mainly high-income countries and they have highest productivity gains from the new technologies. Those countries are supposed to do also well for the future.

They all manage to score higher than 5.7 in both category (structure of production and drivers of production). Part of the member state only Germany manages to have a score above eight for its structure of production. **Germany** is ranked third in the world for its structure of production after Japan and South Korea but above Switzerland and China.

Regarding its drivers of production, it is ranked sixth in the world after United States, Singapore, Switzerland, United Kingdom and Netherland. **United States** has the best drivers of production and the **United Kingdom** is ranked fourth in this category. It is the first European country.

In comparison of the top 10 countries, EU Member States (MSs) are currently well placed and have the capacity to improve their performance in the future.

Legacy countries

The legacy countries within the EU are **Slovakia, Hungary, Romania** and **Lithuania**. Those countries are characterised by a **good structure of production** for emerging technologies but this structure can be at risk in the future, if the drivers of production are not strong enough. Thus, those countries need to "carve out a strategy for the future". Indeed, those countries have difficulties regarding three drivers of production: **Institutional Framework, Human Capital, and Technology and Innovation**. Countries' scores related to their structures of production are higher than the score they manage to obtain for their drivers of production. For instance, Slovakia is the best MS of this group. It is ranked 16th regarding its structure of production but 40th regarding its drivers of production.

High-potential countries/ economies

Portugal is considered as a high potential country. This designation means that it has a limited structure of production but it has **good drivers of production** that will give it the opportunity to be well positioned in the future. Portugal has high-income economy but it is less diversified in terms of production. Thus, it has to clarify first the national position in terms of industry and then set up a strategy to seize opportunities. It has the advantages to be able to adopt quickly new technologies with a minimum level of capability. Portugal is ranked 39th because of its structure of production but 28th regarding its drivers of production. Hong Kong is also a high-potential country. It is ranked 58th on the structure of production ranking but it is ranked eight thanks to its drivers of production.

Nascent countries

Croatia, Bulgaria, Latvia, Greece and **Cyprus** are countries that have a limited structure of production and unfavourable drivers of production. Those countries show a low level of readiness regarding deployment of emerging technologies on production. Nevertheless, they are considered as attractive countries because of their low-cost manufacturing locations. It can be an opportunity for this group to capture traditional manufacturing in the short term but it can also be a risky strategy. Indeed, the structure of production required to keep industries and to develop them is not yet ready in these countries. However, the main drivers that they have to work on it are institutional frameworks and human capital.

Strong **institutional framework** is the key of success for the adoption of emerging technologies. A legal framework and regulations dedicated to technologies will reduce uncertainty about those and will give norms and standards. Moreover, it also has to encourage industries to invest and produce new technologies. This can be decided at the state level as well as at the international level to establish global standards.

Human capital is the second driver of production that needs to be developed. A skilled workforce will benefit to the country, as it will allow a fast growth for the current industries and advanced manufacturing. The production facilities depend on human capital, as the production cannot evolve without appropriate skilled employees. However, considering the evolution of the production the employees' skills have to be improved to follow technical transformation of production and process.

6.2.2. SIS & DT trends in US

6.2.2.1. Key Facts and Figures on KETs in the US

In this section, we describe key facts and figures on KETs in the United States. We show that the US features high investment levels in artificial intelligence, a leading position in industrial biotechnology, while they appear to be losing ground to East Asia and the EU on micro- and nano-electronics, nanotechnology, photonics, advanced materials and advanced manufacturing.

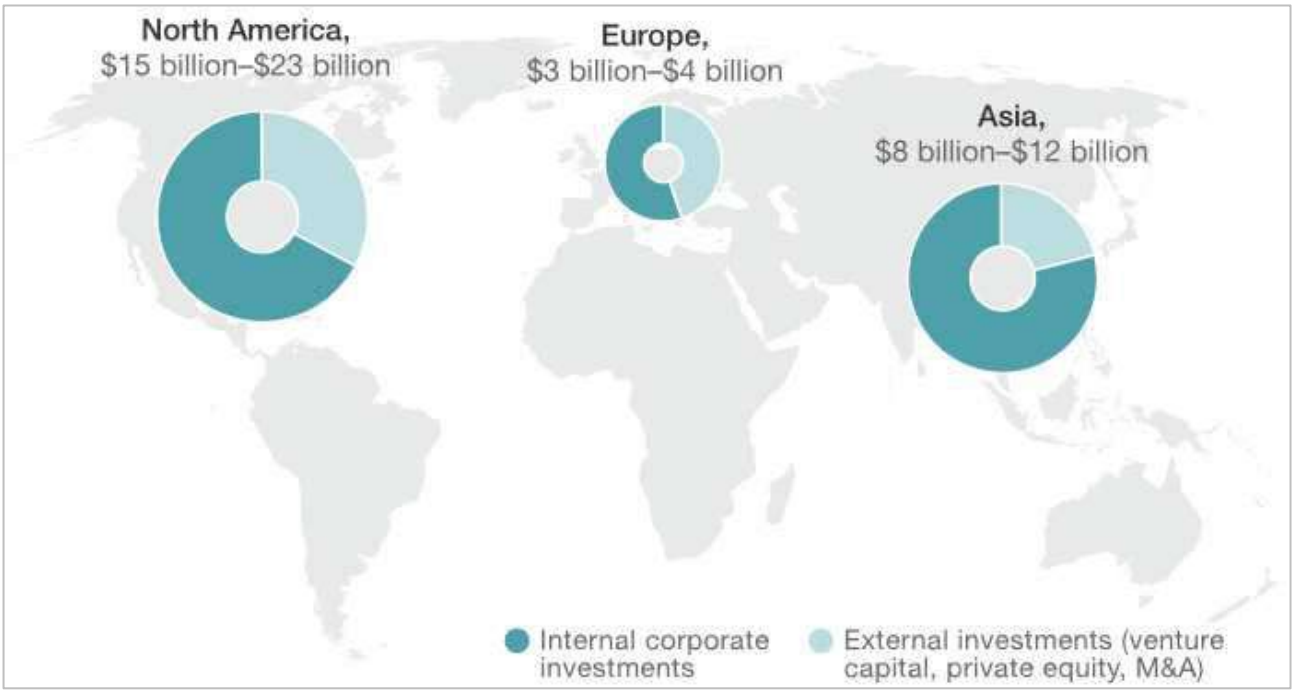
Historically, US is leading on innovation and technology. It sent the first rocket to the Moon, is the cradle of the internet and home to global companies such as Google, Facebook and Amazon. Also in the recent rise of **Artificial Intelligence and Cybersecurity**, the US is present on the world stage and recorded a six-fold increase of annual investments since 2000.[279]

[279] http://cdn.aiindex.org/2017-report.pdf; https://www.csoonline.com/article/3250850/security/artificial-intelligence-and-cybersecurity-the-real-deal.html

According to a recent study of PwC, North America and China together will be **home of 70% of the global economic impact of AI**. In this development, **North America** is expected to have the strongest boost in the next years, whereas **China** will likely uptake more slowly to see a large impact by 2030.[280]

Figure below uses 2016 data to show that investments in artificial intelligence in the US are significantly higher compared to AI investments in Europe, and that to a lesser extent the same goes for AI investments in Asia.

Figure 68: AI Investments in 2016



Source: McKinsey[281]

However, the global technology competition is fierce[282] and after the 2007 financial crisis, the US was facing **growing challenges to compete**, in particular against **competitors from Asia**.[283] In 2011, it only retained its historical position as economic world leader regarding the field of **Industrial Biotechnology**, however, regarding further KETs its market presence was as follows:

- In micro- and nano-electronics the US market share dropped from over 35% to 25% and was overtaken by China, which by 2011 held approximately 40% market share
- The historical market dominance in nanotechnology of 45% in 2000 was threatened onwards 2007 and decreased to 35%, while shares of Russia, China, Korea and Japan were on the rise

[280] PwC, 2017, "Sizing the prize, what's the real value of AI for your business and how can you capitalize?", Available at: www.pwc.com/gx/en/issues/analytics/assets/pwc-aianalysis-sizing-the-prize-report.pdf
[281] www.mckinsey.com/global-themes/europe/ten-imperativesfor-europe-in-the-age-of-ai-and-automation
[282] http://foreignpolicy.com/2017/11/03/the-next-space-race-is-artificial-intelligence-and-america-is-losing-to-china/
[283] http://www.aaas.org/news/releases/2012/0928sequester.shtml; http://www2.itif.org/2012-eroding-foundation.pdf; http://www.aip.org/fyi/2012/126.html

- Regarding EU and Asian dominated photonics, advanced materials & manufacturing technologies, the US decreased their presence even further, from 38% to 20%; 35% to 20%; and 27% to 24% in between 2000 and 2011284

Still, the US to date has highly ambitious and collaborative industries, educational and research institutions, which starkly contribute to the manufacturing sector.[285] In fact, by contributing **17% to the global manufacturing activities** with a **value of $5.5 trillion**, the US manufacturing sector alone has the size of the seventh-largest country in the world by GDP.[286]

To this global share, the **US high-tech and innovation sectors** are contributing significantly. In 2014, it accounted for 75% of private sector R&D and 86% of total goods exports by the US. [3] In addition, in 2015 the US invested 2.7% of its GDP in R&D, going towards a US share in the **worldwide ICT market of circa 28%**.[287]

However, the US faced multiple challenges and **struggles to preserve its world stage position**. It suffered from a lacking business environment and skilled workforce compared to competing nations[288]. Circa **3.1 million US manufacturing jobs were lost or outsourced** between 2001 and 2013[289], whereas competitors strongly invested in R&D and innovation systems. Thus, the US capacity to create and innovate was at risk and put the US leadership into question.

By facing these effects of 2007-2011, the US Government recognized the relevance of the SIS&DT to **compete in the global economy** and declared the **decline of its manufacturing** industry as it can be seen from below figure as a **matter of national security**.[290] It decided to further its competitive strategy and rolled out a series of policies and initiatives to bring the industry, the public and research institutions together to collaboratively engage in this field and to reclaim a position as economic world leader.

Figure 69: U.S Trade Balance for Advanced Technology Products

Source: https://energy.gov/sites/prod/files/2013/11/f4/nstc_feb2012.pdf

[284] https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/policy/country_report_us_final.pdf
[285] http://www3.weforum.org/docs/WEF_GCR_Report_2011-12.pdfy
[286] https://townhall.com/columnists/walterewilliams/2018/02/21/will-automation-kill-our-jobs-n2451190
[287] https://www.clustercollaboration.eu/sites/default/files/eccp_d3_2_preparatory_briefings_usa_1.pdf
[288] https://www.nist.gov/sites/default/files/documents/2017/04/28/Molnar_091211.pdf
[289] https://townhall.com/columnists/walterewilliams/2018/02/21/will-automation-kill-our-jobs-n2451190
[290] https://www.energy.gov/sites/prod/files/2013/11/f4/nstc_feb2012.pdf

6.2.2.2. Key Strategies

This section provides an outlook to the key strategies relevant for the development and uptake of KETs in the US. Specifically, we describe the **US Strategy for Innovation**, the role of the **National Science and Technology Council**, and the case of the **high-tech development framework** in Austin, Texas.

The US government does not use the term "KETs" as it is done in EU. As the European definition of KETs overlaps to a good extent with their "**Advanced Manufacturing**" concept as it can be seen from the following quote.

"*Advanced manufacturing is a family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b) make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences, for example nanotechnology, chemistry, and biology. It involves both new ways to manufacture existing products, and the manufacture of new products emerging from new advanced technologies*."[291]

US Innovation Strategy

In 2012, by announcing the **National Strategic Plan for Advanced Manufacturing** the Obama Administration incited a series of policies and initiatives to advance KETs and ICT.[292] In 2015, this strategy was complemented by the **US Innovation Strategy**, which promoted market-based innovations.[293]

Currently, the strategy highlights the US core principle of a **cohesive approach to research, development, and deployment for an effective national advanced manufacturing strategy**. It emphasises an effective commercialisation of federally-finance technologies, federal support for R&D of manufacturing processes, and trainings for manufacturing skills. Furthermore, for guiding all policies and initiatives under this strategy, the US government defined **five core objectives**:

- Accelerate investment in advanced manufacturing technology, especially by small and medium-sized manufacturing enterprises, by fostering more effective use of Federal capabilities and facilities, including early procurement by Federal agencies of cutting-edge products.
- Expand the number of workers who have skills needed by a growing advanced manufacturing sector and make the education and training system more responsive to the demand for skills.
- Create and support national and regional public-private, government-industry-academic partnerships to accelerate investment in and deployment of advanced manufacturing technologies.
- Optimize Federal investment in advanced manufacturing by taking a portfolio perspective across agencies and calibrating accordingly.
- Increase total U.S. public and private investments in advanced manufacturing R&D.[294]

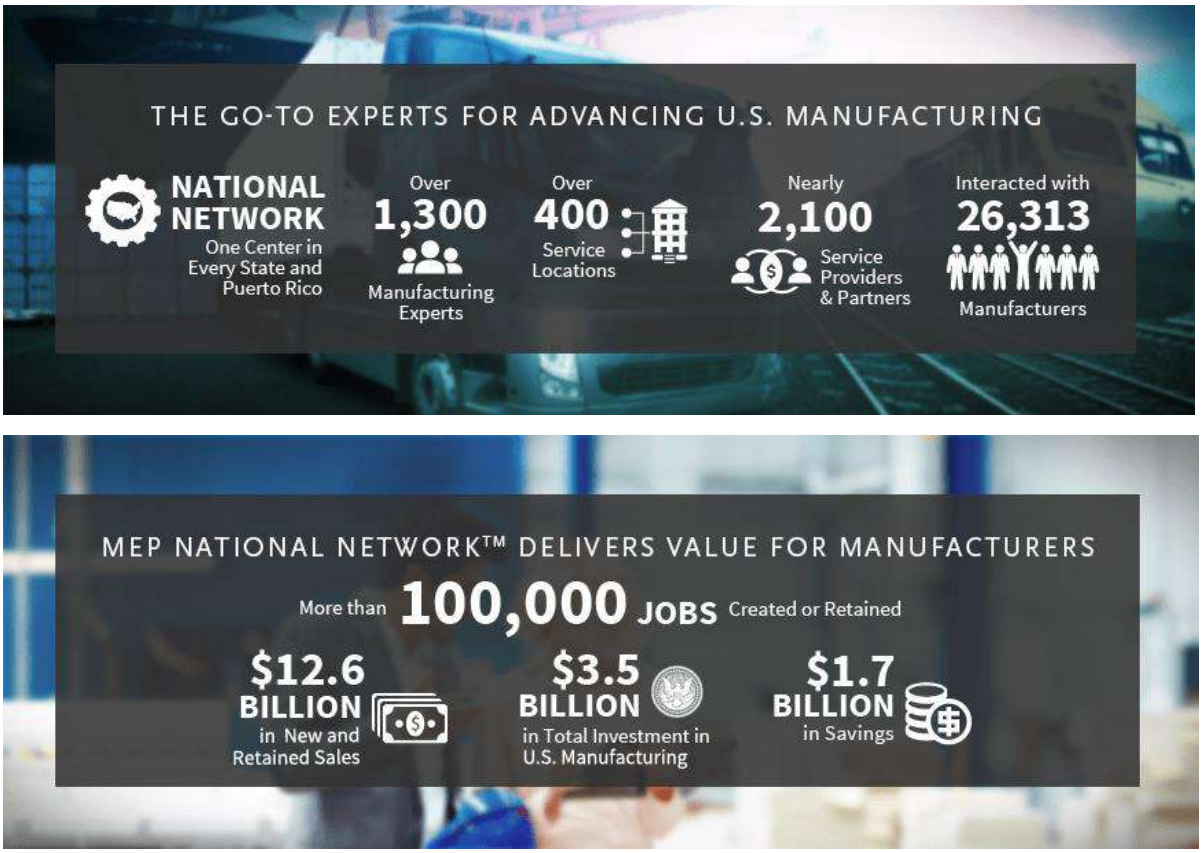
[291] President's Council of Advisors on Science and Technology, Report to the President on Ensuring American Leadership in Advanced Manufacturing, June 2011, p. ii.
[292] https://www.energy.gov/sites/prod/files/2013/11/f4/nstc_feb2012.pdf
[293] https://obamawhitehouse.archives.gov/sites/default/files/strategy_for_american_innovation_october_2015.pdf
[294] https://www.energy.gov/sites/prod/files/2013/11/f4/nstc_feb2012.pdf

National Science and Technology Council

The efforts of federal agencies are coordinated by the **National Science and Technology Council (NSTC)** as key player for the US Government to coordinate national services and technology policy. [295]

A key component of this strategy is the **Manufacturing Extension Partnership (MEP)**. Initially created in 1988, in 2011 the Obama administration expanded it to the **Advanced Manufacturing Partnership**, which **invested more than $500M** to promote strong public-private collaborations.[296] This partnership established centres across all 50 US states and Puerto Rico, dedicated to serving manufacturing SMEs. Federal appropriations pay half the costs, and the **remaining balance is covered by local governments, private entities and client fees**. In 2017, it demonstrated a **highly successful track record** in increasing sales, decreasing costs and creating jobs and business opportunities as illustrated in below Figure.[297]

Figure 70: MEP key figures



Source: https://www.nist.gov/mep/mep-national-network

High-tech development framework - the case of Austin, Texas

A highly influential report from the University of Texas in the early 1980s, suggesting **a need for a coordinated approach to high-technology company development**, led to the unveiling of

[295] https://www.whitehouse.gov/sites/whitehouse.gov/files/images/Blog/NSTC%20SAM%20technology%20areas%20snapshot.pdf
[296] https://www.manufacturing.gov/programs
[297] https://www.nist.gov/mep

a framework for the creation of a Technopolis in Austin, TX. The report's findings still apply 40 years later and are in line with latest US strategies on cohesive approaches to the research and development of advanced technologies. The framework stresses the importance of seven factors crucial in **pooling and developing resources, creating a fertile regulatory environment and providing overarching vision and leadership**. Among those the following factors:

- **Research universities play a vital role in the development** of high technology bedrocks by creating and developing new technologies while educating and training the workforce necessary for economic development. In the case of UT Austin, reports from 1984 show that the 6 home-grown companies created that year all had direct ties to the University;
- **Local, State and Federal governments** have a pivotal role to play in the creation and maintenance of necessary infrastructure, legal and regulatory environments and most importantly in terms of commitments to public funding. The overarching takeaway here is the need for continuity and alignment between all levels of government policy in order to have a positive impact on the growth of the technology sector;
- **Large and small technology companies are catalysts for the expansion** of a Technopolis thanks to their efforts in terms of job creation, the pooling and sourcing of talents, and the provision of opportunities for venture capital investment;
- Lastly, **influencers** are essential in maintaining momentum as they provide vision, communication and trust for the development of consensus for economic development through their roles as intermediaries between the above mentioned segments. Most importantly, they are catalysts for consensus between all parties.

6.2.2.3. Key US Policies, Initiatives and Players related to KETs

In this section, we describe the key policies in the US related to KETs. Specifically, we describe R&D Policy, recent developments in tax policy, and industrial policy in the US related to KETs.

Subsequent to the National Plan for Advanced Manufacturing in 2012, the US engaged in significant efforts to **strengthen the manufacturing competitiveness**. It has **created jobs and expanded at a historic rate since the recession**, of which **646,000** were manufacturing jobs only in between 2010 and 2014.[298] This was the result of comprehensive public investments and policies that incentivised for insourcing to make the US a **magnet for jobs and manufacturing**.[299] The key policies of these efforts are as follows.

US R&D Priorities related to KETs

As stated under the memorandum released by the Executive Office of the US President in August 2017[300], **R&D priority areas** underlined for the **FY 2019** and their relevance to KETs were as follows:

- **Military superiority**, in which trusted micro and nano-electronics, future computing capabilities, and dual-purpose KETs are underlined;
- **Physical and cyber security** obviously highlighting the importance of cybersecurity;

[298] Making in America: US manufacturing entrepreneurship and innovation. The Executive Office of the President. June 2014, 5, 1.
[299] State of the Union Speech of President Obama. U.S. Capital Washington D.C., 12th February 2013
[300] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/m-17-30.pdf

- **Prosperity** to be achieved through emerging technologies such as autonomous systems, biometrics, energy storage, gene editing and biotech that falls under Life Sciences, AI& machine learning, quantum computing and photonics;
- **Energy dominance** focusing on clean energies, energy efficiency, and long term low cost energy solutions;
- **Healthcare** solutions based on biological research.

The current administration urged federal agencies to focus on investments in **early stage STEM**[301] **based research**, since later-stage research projects are likely to be supported by private businesses.[302]

While the core principle of the US economic policy centres on the free market, the **majority of US global industry leaders** have been developed via **publicly funded R&D and public procurements**, especially under the guise of **defence** and **health**. Multiple US champions, including **IBM**, **Boeing**, **Caterpillar**, **Lockheed** and **Motorola**, appear to be rooted in government contracting and still largely depend on these contracts.[303]

The ***US National Artificial Intelligence R&D Strategic Plan***[304] issued by the end of 2016 establishes a set of objectives for **Federally-funded AI research**, both research occurring within the government as well as Federally-funded research occurring outside of government, such as in academia. The ultimate goal of this research is to produce new AI knowledge and technologies that provide a range of positive benefits to society, while minimizing the negative impacts. To achieve this goal, this AI R&D Strategic Plan identifies the following priorities for Federally-funded AI research:

- Make long-term investments in AI research;
- Prioritize investments in the next generation of AI that will drive discovery and insight and enable the United States to remain a world leader in AI;
- Develop effective methods for human-AI collaboration;
- Rather than replace humans, most AI systems will collaborate with humans to achieve optimal performance. Research is needed to create effective interactions between humans and AI systems;
- Understand and address the ethical, legal, and societal implications of AI;
- Expect AI technologies to behave according to the formal and informal norms to which we hold our fellow humans. Research is needed to understand the ethical, legal, and social implications of AI, and to develop methods for designing AI systems that align with ethical, legal, and societal goals;
- Ensure the safety and security of AI systems;
- Before AI systems are in widespread use, assurance is needed that the systems will operate safely and securely, in a controlled, well-defined, and well-understood manner. Further progress in research is needed to address this challenge of creating AI systems that are reliable, dependable, and trustworthy;
- Develop shared public datasets and environments for AI training and testing;

[301] Note: Science, technology, engineering, math
[302] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/m-17-30.pdf
[303] Government Office for Science, International industrial policy experiences and the lessons for the UK, 2013, pp. 27-29, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/277162/ep4-international-industrial-policy-experiences.pdf#page=27 , (accessed 23 July 2016)
[304] https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf

- The depth, quality, and accuracy of training datasets and resources significantly affect AI performance. Researchers need to develop high quality datasets and environments and enable responsible access to high-quality datasets as well as to testing and training resources;
- Measure and evaluate AI technologies through standards and benchmarks;
- Essential to advancements in AI are standards, benchmarks, testbeds, and community engagement that guide and evaluate progress in AI. Additional research is needed to develop a broad spectrum of evaluative techniques;
- Better understand the national AI R&D workforce needs;
- Advances in AI will require a strong community of AI researchers. An improved understanding of current and future R&D workforce demands in AI is needed to help ensure that sufficient AI experts are available to address the strategic R&D areas outlined in this plan.

The AI R&D Strategic Plan closes with two recommendations:

- First Recommendation: Develop an AI R&D implementation framework to identify S&T opportunities and support effective coordination of AI R&D investments, consistent with Strategies 1-6 of this plan;
- Second Recommendation: Study the national landscape for creating and sustaining a healthy AI R&D workforce, consistent with Strategy 7 of this plan.

The US R&D projects for national security challenges of the Defence Advanced Research Projects Agency (DARPA) focuses on the following fields[305]

- **Strengthening cybersecurity** and enhancing the survivability of manned and unmanned information systems under attack. In particular, the Plan X program aims to facilitate situational awareness in the cyber domain. Other projects pursue technologies to enable computer systems to work through attacks, to permit trustworthy internet communications, and to automate the discovery, identification and characterization of new malware;
- Plumbing the **web's deepest resources** to illicit activities relevant to military, law enforcement and intelligence interests, with a focus on human trafficking. Projects such as DARPA Memex, aim to **uncover information that conventional web searches cannot uncover**, such as potentially significant links among pages;
- **Advancing breakthrough neurotechnologies** to accelerate the recovery for injured brains and bodies. In particular, a focus lies on providing **high resolution insights into neural circuits** to lower the need for and impacts of invasive surgeries and to improve neurocognitive and medical outcomes for wounded warriors and others;
- **Owning the "electromagnetic spectrum"**, which is as important a battlespace as air, land, sea and space, since it is crucial for (invisible) communications, precision timing and navigation. Of not owned, it can provide a window of otherwise invisible activities by adversaries;
- Exploring **"systems-of-systems" networks** for operations in the **contested air battle space** to support interaction and communication between manned and unmanned platforms, in particular in operations where critical communication is degraded or denied;
- **Revolutionizing the satellite launch and service** to improve the price-efficiency, involved risks and organisational complexity. For instance, DARPA aims to enable 100-pound payloads for less than $1 million and to launch these within just 24 hours' notice.

[305]DARPA: https://www.darpa.mil/attachments/DARPATodayAnticipatingandMeetingNewChallenges.pdf

Furthermore, DARPA's Phoenix program strives to develop advanced technologies to **robotically service and maintain satellites** in harsh environments of geosynchronous orbits;

- **Enabling a rapid biological threat assessment and response** for cases such as natural outbreaks or bioterrorist attacks. Since current technologies remain slower then potential spreading of biological threats, DARPA advances a rapid development of medical countermeasures, also to shift the **cost-benefit calculus of adversaries** for using biological weapons;
- **Finding synergies of engineering and biology**, which can be applied to bio-based materials with unconventional mechanical optical and electrical properties;
- Achieving **"extreme hypersonic flight"**, which refers to a **speed of five times as fast as sound**. For this research, especially the Hypersonic Air-breathing Weapon Concept (HAWC) and the Tactical Boost Glide (TBG) are developing technologies to enable air-launched hypersonic boostglide systems.

Tax policy developments

The 2017 recent tax reforms of the Trump administration put a strong emphasis on US-based business operations. US companies have stakes overseas of approximately **$2 trillion** to avoid the former US tax rates of 35%. Thus, these were **decreased to a rate of 21%** in the U.S. and even lower for foreign profits, based on tangible depreciable assets.[306]

Furthermore, the US use tax incentives to attract or hold individual companies to **specific regions**. A prominent example is the technology company **Tesla Motors**, which received subsidies of the value of approximately $1.3 billion from Nevada. These include **100% abatement** of sales taxes, property taxes, and modified business taxes. In the same period, Tesla built its Gigafactory at the Tahoe Reno Industrial Centre in Nevada and created circa **6500 direct jobs**.[307]

Industrial policy in the US relevant for KETs

Primarily, the aim of the recent industry policy of the Trump administration was to promote US manufacturing by creating incentives for **national industry employment opportunities**. It **renegotiated trade deals** such as NAFTA and threatened tariffs on imports of steel to protect US production companies, while **reducing corporate taxes** and rolling back existing regulations at the same time. [308]

However, in terms of advanced manufacturing the industry policy **cut several budgets** for workforce education and partnership networks to pressure companies towards private actions.[309] For instance, the budget for the **ARPA-E** programme by the Department of Energy which aimed to contribute to cutting edge research programmes. As well, the manufacturing initiative "**Manufacturing USA**" of the Obama initiative experienced significant **budget constraints**.[310]

---

[306] https://www.cnbc.com/2017/12/19/tax-bill-includes-an-incentive-for-u-s-companies-to-invest-in-foreign-manufacturing.html
[307] http://www.civitas.org.uk/content/files/IndustrialpolicyintheUnitedStates.pdf
[308] https://www.brookings.edu/blog/techtank/2017/07/14/trump-administration-brings-a-different-approach-to-manufacturing/
[309] https://www.brookings.edu/blog/techtank/2017/07/14/trump-administration-brings-a-different-approach-to-manufacturing/
[310] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/budget.pdf ; https://www.manufacturingusa.com/about

On the other hand, in regard to the guise of **security**, the Trump administration adopted significant funding for the **R&D of cybersecurity**. Primarily, this budget was assigned towards increasing the personnel and efforts of the **Department of Homeland Security** (DHS), the **Department of Defence** (DOD), and the **Federal Bureau of Investigation**. Furthermore, also the National Cybersecurity and Communications Integration Centre was strengthened, also to enable the DHS to respond effectively to critical infrastructure and cyber-attacks.[311]

Venture Capital for SMEs and Start-Ups

Inspired by success stories of Silicon Valley venture capitalists, multiple US federal agencies set up **public Venture Capital initiatives**. Similar to private funds, they make equity investments, of which most are **technology SMEs**. Yet, unlike private investments, the government agencies seek to develop, adapt and shape commercially viable innovations for their own needs. In this role, the agencies often times have **membership** in the SME's management board, or supports with **organisational or technical collaborations**.

Furthermore, these public VC investments also allow the US government to **create innovation networks around high potential and dynamic SMEs**. The first federal-level VC fund was initiated by the CIA in 1999; in 2013, there were **36 state-level VC programmes** in 30 states to participate in the State Small Business Credit Initiative (SSBCI), introduced under the Obama Administration.[312]

Key Initiatives in the US relevant for KETs

In this section we describe key initiatives in the US relevant for KETs. Specifically, we describe the Innovation Corps Programme, the XSEDE initiative, the National Nanotechnology Initiative, the Advanced Wireless Research Initiative, the Smart Cities and Internet of Things Initiative, the Big Data Research and Development Initiative, and the Technology Innovation Program (TIP).

In order to set the foundation for research, development and usage of KETs, the US required to set the stage with a range of initiatives to provide required services such as mobile internet or (super-) computing facilities. These key initiatives comprise the following.

- **Innovation Corps Program (I-Corps)**

The Innovation Corps Program is a programme governed by the National Science Foundation (NSF) to **jumpstart the national innovation ecosystem for all KETs**. It supports the commercialisation of NSF-funded research by connecting it to technological, entrepreneurial and business communities. Therefore, it proceeds by **selecting projects** based on the product and services viability, defines a **transition plan from research to busines**s, and conducts technology **presentations for potential partners**. It is evaluated by principal investigators, which are required to submit a final report for the general public to the program officer within 90 days after expiration of the grant. The programme was implemented in 2011 and comprises an overall **annual budget of $30 million**.[313]

[311] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/budget.pdf
[312] www.whitehouse.gov/the-press-office/2011/05/16/white-house-releases-small-business-agenda-growingamericas-small-busine; http://www.civitas.org.uk/content/files/IndustrialpolicyintheUnitedStates.pdf
[313] https://www.nsf.gov/about/budget/fy2017/pdf/38_fy2017.pdf

- **XSEDE**

XSEDE is a virtual organisation of the US to support the research and development of **High-Performance-Computers**. Initially funded in 2011 by the National Science Foundation under the National Strategic Computer Initiative (NSCI), it became the **cornerstone of the national cyberinfrastructure ecosystem**. It provides resources such as **supercomputers, network and expertise**; thus, it lowers barriers for researchers, engineers and scholars to participate in advanced computing. [314]

In 2015, XSEDE provided computational and data services to more than **6,000 scientists, engineers and students** and supported more than **20,000 users** through the web portal. This engagement led to a series of significant breakthroughs such as the discovery of **gravitational waves**, high-resolution **maps of the Arctic**, and uncovering the **structure of HIV**.

In 2016, a subsequent **funding of $110 million** was granted with the announcement of **XSEDE 2.0** to continue and expand the initiative efforts.[315]

- **National Nanotechnology Initiative**

The National Nanotechnology Initiative (NNI) focuses mainly to **promote nanotechnology and is implemented by 25 different bodies**, ranging from the Department of Agriculture to the US Geological Survey. It was **first implemented in 2000**[316], **expanded by the Obama administration**, and currently has an **overall budget of EUR 1.2 billion**.

On the one hand, its activities are manifold and designed to **provide comprehensive support** government organisations, academia, the industry, professional societies and foreign organisations to foster R&D, education and partnerships in the field of nanotechnology.[317] On the other hand, a few **Nanotechnology Signature Initiatives (NSIs)** provide spotlight on critical areas, for instance, on **solar power and nano-electronics**.[318]

The **National Nanotechnology Coordination Office (NNCO)** is the coordination office of the NNI. It acts as a primary point of contact, participates in committee meetings, and promotes access to technologies and expertise in the field of nanotechnology.[319] The annual **impact evaluation is run by the Office of Management and Budget (OMB)** by using the Program Assessment Rating Tool (PART). In individual cases, agencies may also conduct evaluations of specific funding activities.[320]

- **Advanced Wireless Research Initiative**

In 2015, the Obama Administration announced the launch of a **$400 million** Advanced Wireless Research Initiative to promote the deployment and use of 5G mobile networks. These wireless networks are up to **100 times faster** than today and will enable breakthrough applications for

[314] https://obamawhitehouse.archives.gov/the-press-office/2015/07/29/executive-order-creating-national-strategic-computing-initiative; https://www.whitehouse.gov/sites/whitehouse.gov/files/images/NSCI%20Strategic%20Plan.pdf
[315] https://www.nsf.gov/news/news_summ.jsp?cntn_id=189573
[316] https://www.nano.gov/sites/default/files/pub_resource/nsi_status_report_executive_summary.pdf
[317] https://www.nano.gov/2018budgetsupplement
[318] https://www.nano.gov/sites/default/files/pub_resource/nsi_status_report_executive_summary.pdf
[319] https://www.nano.gov/about-nni/nnco
[320] https://www.nano.gov/node/1536

consumers, smart cities and the Internet of Things. A full length HD movie, for instance, will be downloaded in less than 5 seconds, whereas it currently takes 6 minutes on 4G.[321]

- **Smart Cities and Internet of Things**

The Internet of Things (IoT) in the US is mainly supported under the **2015 "Smart Cities" Initiative** to counter present and future local city challenges such as traffic congestion or crime prevention. By implementing a **Cyber-Physical Systems reward programme**, it aims to incite collaborative IoT research that shall promote **smart and connected communities**. This IoT research programme has a dedicated **budget of $35+$10 million**.[322]

- **Big Data Research and Development Initiative**

The **Big Data Research and Development Initiative** from 2012 was established to further the implementation and usage of **Big Data and Cloud Computing**. It challenges the industry, research universities and non-profits to advance the state-of-the-art technologies and to **expand the workforce** needed to develop and use Big Data technologies. The initiative was launched in six federal departments and agencies with different foci, such as the US Geological Survey, the National Institute of Health, and the Department of Defence. The overall budget of the initiative is **$200 million**.[323]

- **Technology Innovation Program (TIP)**

Technology Innovation Program focuses on KETs such as **biotechnology, advanced materials and advanced manufacturing technologies**. It aims to assist businesses, higher education and other research institutions in **supporting high-risk/high-reward research** in areas of critical importance. Single company projects can receive up to a **$3M funding** over a maximum of three years and joint Venture projects up to **$9M over maximum five years**. Proposers must cover at least **50% of the total project costs**.

The TIP is a revised version of the former ATP programme and was established by the **National Institute of Standards and Technology**. Currently, TIP is in the process of shut down[324]; however, in 2010-2012 the budget was **EUR 135.5 million.** By cooperating with the National Bureau of Economic Research, it runs **evaluations with rigorous progress reviews and centralised assessment mechanisms** with the Program Assessment Rating Tool (PART). Most common reason for not submitting a proposal was that required **cost share was too high**.

Key Players in the US relevant for KETs

In the fast-paced KETs research and development, multiple **stakeholders** engage in specific technologies, of which dominant companies as **Google**, **IBM**, **Facebook** and **Amazon** have contributed to multiple opportunities and **private-public-partnerships**. In addition, several US institutions became well-known players of the ecosystem, of which especially the following gained significant influence and visibility.

---

[321] https://obamawhitehouse.archives.gov/the-press-office/2016/07/15/fact-sheet-administration-announces-advanced-wireless-research

[322] https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help; https://thestack.com/iot/2015/09/15/u-s-government-to-invest-over-160mn-in-iot-smart-cities-initiative/

[323] https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/big_data_press_release_final_2.pdf;

[324] www.nist.gov/tip; http://www.nist.gov/tip/factsheets/upload/tip_performance_measures__fact_sheet_11jan2011.pdf ; http://www.nist.gov/tip/factsheets/upload/tip_at_a_glance_2011.pdf

- ***The National Science and Technology Council*** (NSTC) is the primary key player for the US government to coordinate services and technology policy. One of its main objectives is to establish clear national goals for investments and to prepare strategies, which are coordinated by agencies across the US.[325]
- ***The Office of Science and Technology Policy*** (OSTP) is the highest governmental body that advises the US government in terms of innovation. Having its origin in the 20st century "Space Race", the OSTP leads the inter-agency efforts to develop and implement science and technology policies by liaising with the private sector, state and local governments, as well as science and higher education communities.[326]
- ***The National Science Foundation*** (NSF) is a key player for industrial pilot production activities with a focus on commercialising and scaling innovations. Furthermore, NSF-funding also provides assistance to researchers and entrepreneurs[327]
- ***The Department of Defence*** is the most important public player in terms of budget. Amounting to $132 billion, it has about 50% of all R&D and innovation budget as its disposal.[328]

Furthermore, regarding individual KETs activities a number of specialised agencies gained an established position in the respective field. For instance, these are agencies such as Advanced Research Projects Agency-Energy (ARPA-E); National Institutes of Health (NIHs); National Institute of Food and Agriculture (NIFA).

6.3. Overview of the latest strategies, policies and initiatives on SIS & DT

In this section, we provide an overview of the latest strategies, policies and initiatives on SIS&DT. We provide an overview of strategies at the EU level in section 13.1, at Member State level in section 13.2, and at regional level in section 13.3. In section 13.4, we analyse what is happening at city level, and describe local conditions and developments for the most promising and active cities in Europe.

3.3.1 Overview of the latest strategies, policies and initiatives on SIS & DT at EU level

In this section we provide an overview of the latest strategies, policies and initiatives on SIS & DT at EU level. This section contains detailed tables describing strategies, policies and initiatives for different thematic areas.

With the transition towards the Fourth Industrial Revolution in full swing, driven by digital and Key Enabling Technologies, structural changes offer opportunities for Europe and at the same time can pose major challenges.

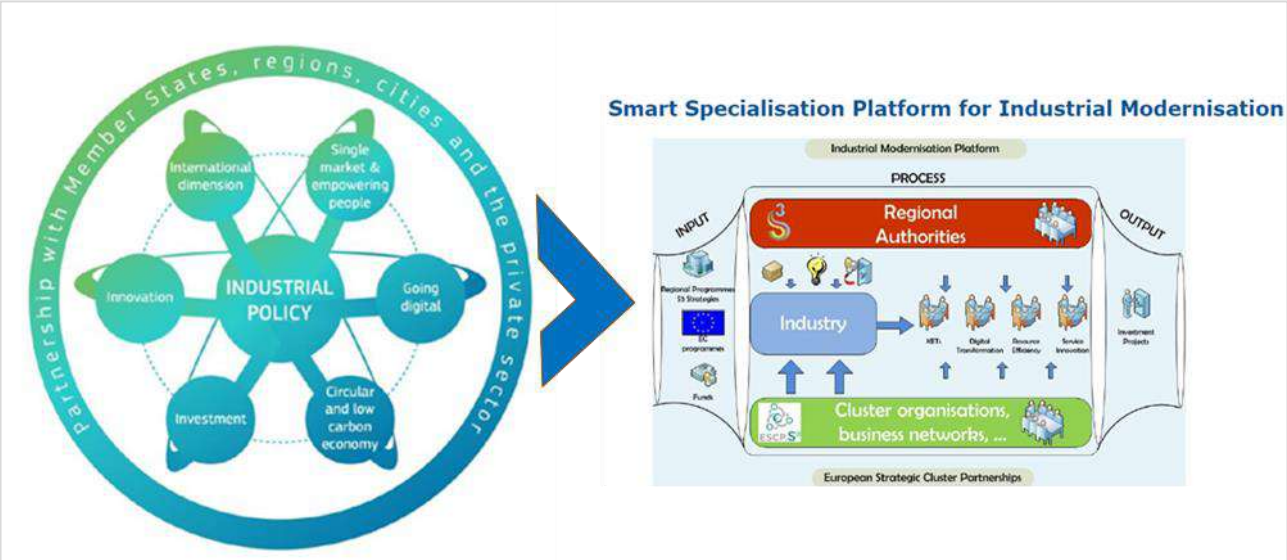
These structural changes require **modernisation** efforts to ensure that industry is well equipped to overcome the challenges and to stay competitive in global markets. These challenges include the need to develop a truly digital entrepreneurial culture, to stimulate investments in new technologies, and to improve the market base for the commercialisation of KETs developed in Europe.

[325] https://www.whitehouse.gov/sites/whitehouse.gov/files/images/Blog/NSTC%20SAM%20technology%20areas%20snapshot.pdf
[326] https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/policy/country_report_us_final.pdf
[327] https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/policy/country_report_us_final.pdf
[328] https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/policy/country_report_us_final.pdf

Thanks to its enabling power to for the development of new goods and services and the restructuring of industrial processes needed to modernise EU industry and make the transition to a knowledge-based and low carbon resource-efficient economy, KETs have been instrumental under different EU level policies on **Research&Innovation**[329], **Industrial Modernisation**[330] and **Digital Growth**[331] under smart and sustainable growth pillars of the **EU2020 Strategy.**

To help European industry meet these challenges, the **European Commission** has implemented a range of policy initiatives aimed at supporting **industrial modernisation** and the **technological transformation** that companies must undergo. As seen in below figure, partnerships among MSs, Regions, Cities and the private sector are key to achieving all of the action pillars of the industrial policy. In order to bring these different stakeholders (e.g. industry, clusters, regional authorities etc.) together to achieve SIS collectively, the **S3 Industrial Modernisation Platform** as well as the **Vanguard Initiative** have been established for achieving smart and sustainable growth through SIS & DT.

Figure 71: Smart Specialisation Platform for Industrial Modernisation



Source: PwC depiction by using EC input

With an overall budget of €9.2 billion, the new **'Digital Europe Program'** proposed under the **'European Multiannual Financial Framework for 2021-2027'** aims to shape and support **Europe's digital transformation** since it holds the key for unlocking future growth in Europe[332]. The EU support is expected to concentrate around the following **thematic focus areas** that are **directly related to the deployment of KETs, ICT and other digital technologies.**

[329] http://ec.europa.eu/research/industrial_technologies/index_en.cfm
[330] http://ec.europa.eu/growth/industry/policy/key-enabling-technologies_en
[331] http://s3platform.jrc.ec.europa.eu/kets-and-manufacturing
[332] https://ec.europa.eu/commission/sites/beta-political/files/budget-june2018-digital-transformation_en.pdf

Through dedicated programs and targeted financial support, EC aims to bridge the EU's digital investment gap, tackle digital challenges, from artificial intelligence to the promotion of digital skills, from supercomputing to the capacity to equip the EU against cyberattacks and cybercrime. **Investing in digital skills** development is one of the key priorities by offering the opportunity to pursue training in **advanced digital technologies**, such as data analytics, robotics, artificial intelligence, blockchain technology, cybersecurity and high-performance computing.

Table 1 below presents, key EU strategy, policy and initiatives put in-place by the EC in support of SIS and DT under different streams.

Table 2: Key EU Strategy, Policy, Initiative and Instruments in support of SIS&DT

	Brief Description
Smart Industrial Specialisation	
EU Industrial Policy[333]	European Union's industrial policy seeks to strengthen the competitiveness of European industry, mostly by taking measures that cut across various sectors. It is a crosscutting policy area affecting numerous other policies such as trade, the internal market, research and innovation, employment, and environmental protection. This strategy looks to help EU industry face global challenges and seize the opportunities offered by new technologies and the single market. Main goals include the transformation and modernisation of European industry.
(Renewed) EU industrial policy strategy[334]	The renewed EU industrial policy strategy declared in Sept 2017 aims to turn the EU into a world leader in innovation, digitisation and decarbonisation by investing in a smart, innovative and sustainable industry. The strategy announces new initiatives in the areas of circular economy, mobility, intellectual property, public procurement, skills and sustainable finance, in addition to proposals on trade, investment screening, cybersecurity and data. It underlines the importance of modernisation efforts to be taken in order to maintain and reinforce its competitive advantage. Since the Digital transformation is at the core of the ongoing industrial revolution, boosting the uptake of smart technologies (i.e. big data, artificial intelligence and robotics, the Internet of Things and high-performance computing) along and across industrial value chains is seen crucial. While doing this, the transformation of the companies towards more sustainable and resource-efficient business models is aimed not only for the environment protection and climate change, but also to get competitive advantage by cost savings. The strategy also aims to stimulate more capital investment, facilitate the uptake of promising innovation and provide a favourable environment for the scale-up of dynamic SMEs.

[333] http://www.consilium.europa.eu/en/policies/eu-industrial-policy/
[334] http://eur-lex.europa.eu/resource.html?uri=cellar:c8b9aac5-9861-11e7-b92d-01aa75ed71a1.0001.02/DOC_1&format=PDF

	The main **new elements of the EU Industrial Policy Strategy** include: • A comprehensive package to reinforce our industry's cybersecurity • A proposal for a Regulation on the free flow of non-personal data that will enable data to circulate freely across borders, helping to modernise industry and create a truly common European data space • A new series of actions on Circular Economy, including a strategy on plastics and measures to improve the production of renewable biological resources and their conversion into bio-based products and bio-energy • A set of initiatives to modernise the Intellectual Property Framework • An initiative to improve the functioning of public procurement in the EU • Extension of the Skills Agenda to new key industry sectors, such as construction, steel, paper, green technologies and renewable energies, manufacturing and maritime shipping • A strategy on sustainable finance to better orient private capital flows to more sustainable investments • Initiatives for a balanced and progressive trade policy and a European framework for the screening of foreign direct investments that may pose a threat to security or public order • A revised list of critical raw materials where the Commission will continue to help ensure the secure, sustainable and affordable supply for the EU manufacturing industry • New proposals for clean, competitive and connected mobility, including tightened CO_2 emissions standards

ICT Innovation for Manufacturing SMEs (**I4MS**) Initiative[335]	The I4MS initiative of the European Commission launched in July 2013 with a budget of 77M€ funding targets to help SMEs and mid-caps in the manufacturing sector along three dimensions: • Provide access to competences that can help in assessing, planning and mastering the digital transformation. • Provide access to innovation networks of a broad spectrum of competences and best practice examples. • Provide financial support to SMEs and mid-caps on the demand and the supply side to master the digital transformation.
The European strategy for KETs[336]	**Key Enabling Technologies (KETs)** are recognised as instrumental in modernising Europe's industrial base and in driving the development of entirely new industries and so considered as a priority for European industrial policy. The European Strategy for KETs aims to increase the exploitation of KETs in the EU and to reverse the decline in manufacturing to stimulate growth and jobs. KETs are under the scope of EU policy agenda since 2009 with increasing pace as a means to strengthen EU's industrial and innovation capacity to address societal challenges. In order to support the KETs deployment and monitor the progress, **KETs Observatory**[337] has been established as an online monitoring tool that provides the EU, national and regional policy makers and business stakeholders with quantitative and qualitative information on the deployment of KETs both within the EU-28 and in comparison with other world regions (e.g. North America, East Asia). The Observatory maintains an extensive set of indicators at regional, national and international level to monitor the generation and commercialisation of new knowledge around these technologies. It provides a thorough analysis of how countries cover KETs deployment value chain from technology development to commercialization. It also regularly analyses emerging or fast-growing KETs-based products and their value chains, key players and constraints, and recommends specific policy actions to help the EU industry stay ahead of global competition.

[335] https://ec.europa.eu/digital-single-market/en/news/i4ms-initiative-ict-innovation-manufacturing-smes-enhancing-digital-transformation-european
[336] https://ec.europa.eu/growth/industry/policy/key-enabling-technologies/european-strategy_en
[337] https://ec.europa.eu/growth/tools-databases/kets-tools/kets-observatory/kets-observatory/methodology

EU Regional Policy: Smart **Specialisation Strategy (RIS3) and Smart Specialisation Platform for Industrial Modernisation**	**Smart Specialisation Strategy (S3)** is an innovative approach that aims to boost growth and jobs in Europe, by enabling each region to identify and develop its own competitive advantages. Through its partnership and bottom-up approach, smart specialisation brings together local authorities, academia, business spheres and the civil society, working for the implementation of long-term growth strategies defined under their **Research and Innovation Strategies for Smart Specialisation (RIS3)**[338] supported by EU funds. **Smart Specialisation (S3) Platform**[339] has been launched in 2011 by the European Commission for providing advice to regional and national authorities on how to develop and implement their RIS3. This Platform facilitates mutual learning, data gathering, analysis, and networking opportunities for around 170 EU regions and 18 national governments. Thematic S3 platforms have also been created for the Regions join forces and pool resources on the basis of matching S3 priorities in high value-added sectors. The **Smart Specialisation Platform for Industrial Modernisation (S3P-Industry)**[340] have been launched to support EU regions committed to generate a pipeline of industrial investment projects following a bottom-up approach - implemented through interregional cooperation, cluster participation and industry involvement that will be done via **Reconfirm Initiative**-Regional cooperation networks for industrial modernisation. In parallel, **Vanguard Initiative**[341] has also been set up by the Regions for achieving new growth through smart specialisation.
Digital Transformation	

[338] http://s3platform.jrc.ec.europa.eu/s3-guide
[339] http://s3platform.jrc.ec.europa.eu/
[340] http://s3platform.jrc.ec.europa.eu/industrial-modernisation
[341] https://www.s3vanguardinitiative.eu/

EU Digital Single Market Strategy[342]	EU DSM Strategy aims to maximise the growth potential of the European Digital Economy and of its society mainly by creating the right environment and conditions for digital networks and services to flourish by providing high-speed, secure and trustworthy infrastructures and services supported by the right regulatory conditions as an enabler for the deployment of innovative digital services: defining priorities for standards and interoperability; ensuring better access to consumers and businesses to online goods and most relevantly.
Digitising Europe Strategy[343]	Under DSM Strategy, the measures to Digitise European Industry aims to help all companies large and small, researchers and public authorities to make the most of new technologies by linking up national & regional initiatives and boost investment through strategic partnerships and networks.
Digitising Europe Initiative (DEI)[344]	The EC launched the DEI in April 2016 as part of the Digital Single Market strategy with the aim of reinforcing the EU's competitiveness in digital technologies and ensure that every business in Europe - whichever the sector, wherever the location, whatever the size - can draw the full benefits from digital innovation. Building on and complementing the various national initiatives for digitising industry, the DEI actions are structured around five main pillars: • European platform of national initiatives on digitising industry • Digital innovations for all: **Digital Innovation Hubs (DIHs)** • Strengthening leadership through partnerships and industrial platforms • A regulatory framework fit for the digital age in key fields for industry such as cybersecurity and free flow of data Preparing Europeans for the digital future by adapting the workforce and education and learning systems, together with major investments in reskilling citizens. European initiatives such as the digital skill and jobs coalition and the digital opportunity scheme are launched for this purpose.

[342] https://ec.europa.eu/commission/priorities/digital-single-market_en
[343] https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry
[344] https://ec.europa.eu/digital-single-market/en/pillars-digitising-european-industry-initiative

Digital Transformation[345]	The **digital transformation** through the deployment of technologies such as the **Internet of Things, big data, advanced manufacturing, robotics, 3D printing, blockchain technologies and artificial intelligence** can bring enormous growth potential to the industry. Digital transformation is characterised by a fusion of advanced technologies and the integration of physical and digital systems, the predominance of innovative business models and new processes, and the creation of smart products and services.EC put in-place different policies in order to support this transformation under the following domains: • Big data and digital platforms • Digital skills • Cities and regions • ICT standardisation and interoperability
Digital Innovation Hubs (DIHs)[346]	**DIHs** are ecosystems that consist of SMEs, large industries, startups, researchers, accelerators, and investors formed for creating the best conditions for long-term business success for all involved. DIHs aim to support all companies regardless of their size and focus for grasping the digital opportunities. DIHs where technical universities or research organisations at the core, act as one-stop-shops to companies –especially SMEs, startups and mid-caps– to get access to technology-testing, financing advice, market intelligence and networking opportunities as well as training and skills development. To help DIHs to effectively collaborate and network, the European Commission launched the **European network of Digital Innovation Hubs**[347], a repository that includes more than 450 existing hubs across Europe and that will keep growing with new additions in the future. Among those, a particular one- **Manufacturing Industry Digital Innovation Hubs (MIDIH)**[348]**,** has been formed as a "one stop shop" for the provision of services, access to the most advanced digital solutions, the most advanced industrial experiments, pools of human and industrial competencies and access to "ICT for Manufacturing" market and financial opportunities under **EIT-Digital**[349]. MIDIHs aim to leverage

[345] https://ec.europa.eu/growth/industry/policy/digital-transformation_en
[346] https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs
[347] http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool
[348] http://midih.eu/project.php
[349] https://www.eitdigital.eu/

	networks of local Competence Centres, each specialised in peculiar aspects of the **CPPS/IIOT** (**Cyber Physical Production System / Industrial Internet of Things**) technologies and able to attract, mentor and nurture local **Manufacturing SMEs towards Industry 4.0** projects, experiments and business. A common platform of knowledge, methods and collaboration tools will be shared among the MIDIHs network and allow cross-border fertilisation, continuous improvement, open innovation.
Digital Agenda Toolbox[350]	The Digital Agenda Toolbox provides support to regional and national authorities to develop a thorough understanding of the digital growth potential stemming from the **Digital Agenda for Europe (DAE)**. It highlights the opportunities Information and Communication Technology (ICT) entails as a key element in their national or regional research and innovation strategies for **smart specialisation (RIS3)** and related **Operational Programmes (OPs)**. At the same time, this Toolbox provides guidance for the fulfilment of the DAE-related ex-ante conditionalities that will form the basis for using **European Regional Development Funds (ERDF)** for ICT investments. It thus complements the **RIS3 Guide** and other related policy documents such as the Guide on Broadband Investment. The Toolbox furthermore provides hands-on assistance for developing a strategic policy framework for digital growth by discussing the do's and don'ts of the process and giving examples of good practices.
Clusters	
EU Cluster Policy[351] in support of SIS&DT	EU Cluster policy places clusters as a catalyser to facilitate value chain innovation and industrial transformation as well as supporting SME internationalisation. Thus, **EU Cluster Observatory**[352], **EU Cluster Excellence Platform** and **EU Cluster Collaboration Platforms** have been established by the EC. Most recently, **European Observatory for Clusters and Industrial Change**[353] as well as **European Strategic Cluster Partnerships for smart specialisation** (ESCP-S3)[354] investments have been put in-place.

[350] EU Digital Agenda Toolbox: http://s3platform.jrc.ec.europa.eu/dae-toolbox
[351] https://ec.europa.eu/growth/industry/policy/cluster/observatory/cluster-policy_en
[352] https://www.clustercollaboration.eu/eu-initiatives/european-cluster-observatory
[353] https://www.merit.unu.edu/new-european-observatory-for-clusters-and-industrial-change/
[354] https://www.clustercollaboration.eu/news/call-european-strategic-cluster-partneships-smart-specialisation

Horizon 2020 **INNOSUP-1** cluster facilitated projects for new industrial value chains	The INNOSUP-1 programme aims to develop new industrial value chains and fosters emerging industries across the EU by supporting cross-sectorial and cross-regional innovation in SMEs through clusters. Currently there are 9 ongoing projects reaching out to >3,000 SMEs and supporting nearly 500 SMEs directly through innovation vouchers of up to EUR 60,000.[355] Proposals under the project focus on the integration and support of groups of SMEs acting in concert with other innovation actors to address specific problems and challenges, and should demonstrate capacity to validate ideas for structured innovation projects driven by SMEs from different sectors and countries.
SILICON EUROPE[356] - The European cluster alliance for innovative electronics & software technologies	Silicon Europe unites the twelve renowned European clusters in an alliance with access to the most advanced technologies and expertise in all fields of the electronics and software value chain in order to support Europe's goal to be the world's leading centre for innovative electronics & software technologies. It is the brand under which the leading European electronics and digitization clusters collaborate to represent, support and promote the companies and organizations of their regional business networks at European and global levels. Silicon Europe acts as an intermediary between all the relevant partners from research and academia, public authorities and industry.
Cities	
The Digital Cities Challenge Initiative	Since the key role of cities and regions in the digital transformation process well perceived, The Commission's 'Digital Cities Challenge' initiative invites city leaders and key stakeholders to make their cities more productive, innovative, better places to live, by putting advanced technologies at the service of their citizens.
Urban Agenda for EU- Digital Transition Action Plan[357]	The objective of the Digital Transition Action Plan is to provide improved public services to citizens, to support European cities in exploiting the possibilities of digitalisation, and assist European businesses to develop new innovations and create new business opportunities for global markets. The action plan is part of the implementation of **Urban Agenda for EU**, adopted by the Pact of Amsterdam in May 2016. This plan is linked to several EU level strategies, such as the Digital Single Market Strategy for

[355] http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/innosup-01-2018-2020.html
[356] https://www.silicon-europe.eu/home/
[357] https://ec.europa.eu/futurium/en/system/files/ged/full_draft_action_plan_05feb18.pdf

	Europe, European Commission's Digital Agenda under EU 2020 Strategy. Cities are included under EU Urban Agenda[358] and **Smart Cities** are one of the initiatives launched under Cities. Within the **partnership of the Urban Agenda for the EU on the digital transition,** Cities, EU countries and the EC work together to provide more efficient public services and a better knowledge exchange around thematic focus areas including **future learning and skills development.**
URBIS[359]	URBIS is a new dedicated **urban investment advisory platform** within the **European Investment Advisory Hub (EIAH)** set up to provide advisory support to urban authorities to facilitate, accelerate and unlock urban investment projects, programs and platforms. URBIS has been developed in partnership by the EC (**DG REGIO**) and the **EIB** in the context of the **EU One Stop Shop for Cities** and in support of the ambitions defined in the **EU Urban Agenda**.
European Innovation Partnership on Smart Cities and Communities (EIP-SCC)[360]	EIP-SCC is an EU funding instrument that brings together cities, industry and citizens to improve urban life through more sustainable integrated solutions. It addresses city-specific challenges from different policy fields such as energy, mobility and transport, and ICT. It strongly builds on the engagement of citizens, industry and other important stakeholders to develop innovative solutions and participate in city governance. The mapping tool Smart Cities Info System[361] allows partnerships under thematic topics.

In below figure, we depict main EU Initiatives (non-exhaustive) put in-place by the European Commission under its EU 2020 Strategy in support of DT and SIS. These efforts are mainly rolled-out at National and Regional Levels across EU. We looked at some of these initiatives closely for the identification of thematic focus areas around certain technologies across EU as well as the identification of most active Regions and MSs at particular technology domains.

In sections **3.3.2., 3.3.3.** and **3.3.4.,** particular S/P/Is being launched at National, Regional and City levels, respectively, while in section **3.3.5.** Industry-lead initiatives at all levels and under **3.3.6.** Mobility Sector specific ones are being presented.

[358] https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development_en
[359] http://eiah.eib.org/about/initiative-urbis.htm
[360] http://ec.europa.eu/eip/smartcities/index_en.htm
[361] https://smartcities-infosystem.eu/

Table 3: EU 2020 Strategy and corresponding EU Initiatives on Skills, SIS&DT

	EU-2020 Strategy		
	Smart Growth	Sustainable Growth	Inclusive Growth
Relevant Flagship Initiatives	Digital Agenda Innovation Union	Resource Eff. EU Industrial Policy	Agenda for new skills and jobs
Relevant EU Policy & Strategies	• **EU Strategy for KETs** • **Digitising European industry** • **Digital Single Market Strategy**	• **Industrial Modernisation St.** • **Smart Specialisation Strategy** • **EU Cluster Policy**	**New Skills Agenda for EU[3]** • **Digital Skills and Job Coalition-> Digital Opportunity Scheme under Erasmus+** • **Blueprint for Sectoral Cooperation on Skills** • **Vocational Education and Training (VET)** • **European Qualifications framework** • **Upskilling pathways** • **Key Competences for Lifelong Learning** **Digital Education Action Plan** • **Making better use of digital technology for teaching and learning** • **Developing relevant digital competences and skills** • **Improving education through better data analysis and foresight** **EU Strategic Framework on Education and Training: ET 2020[4]** • **Rethinking Education initiative** • **Grand Coalition for Digital Jobs** • **Entrepreneurship 2020 Action plan**
Relevant EU Programmes	H2020 Prg[1]: RD&I Policy • Excellent Science o Future & Emerging Technologies • Leadership in Enabling and Industrial Technologies (LEIT) o KETs o ICT Technologies • Societal Challenges o Secure, clean & efficient energy o Smart, green and integrated transport o Climate, environment, resource efficiency	COSME Prg[2]: Support for SMEs • Entrepreneurship 2020 AP o Digital Entrepreneurship o Erasmus for entrepreneurs • Access to finance • World-class Clusters • Competitive Industries • Improving framework conditions	
Relevant EU Initiatives	o Pan-EU Digital Innovation Hubs **(DIHs)** o Innov for manufacturing SMEs (I4MS) o Smart Anything Everywhere (SAE) o Open Data Incubator Europe (ODINE), o European Coordination Hub for Open Robotics Development (ECHORD++), o Access Center for Photonics Innovation Solutions and Technology Support (ACTPHAST) o Supercomputing Exercise for SMEs (SESAME NET) • **cPPPs (under H2020)** o Factories of the Future (FoF) o Sustainable Process Industries (SPIRE) ↓ o Robotics I4MS o Photonics & o 5G o HPC SAE o Big Data o Cybersecurity • **ETPs** o ARTEMIS (embedded intelligent systems) o Manufuture o Nanofutures o EPoSS o ETP4HPC o euRobotics [AISBL] o Photonics 21 o NESSI o EuMaT • **EIT-KICs** o EIT Digital & Manufacturing Industry Digital Innovation Hub (MIDIH) underneath o KIC-Added Value Manufacturing	• **S3-Industrial Modernisation Platform** o ADMA Energy o Bio-economy o Efficient and Sustainable Manufacturing o High Performance Production through 3D-Printing o New nano-enabled Products o Photonics o SME integration to Industry 4.0 o Artificial Intelligence and Human Machine Interface o Cybersecurity o Medical Tech & Personalised Medicine o Safe and sustainable mobility • Strategic Cluster Partnerships for S3 investment • **Vanguard Initiative** o Bio-Economy – Interregional cooperation on innovative use of non-food Biomass o Efficient and Sustainable Manufacturing (ESM) o High Performance Production through 3D-Printing o Making EU the global leader in components for marine renewables and offshore energy applications o Vanguard Initiative pilot project on New nano-enabled Products • **EU-JTIs** o Nanoelectronics Technologies 2020 (ENIAC) o Electronic Components and Systems for European Leadership (ECSEL)	1 https://ec.europa.eu/programmes/horizon2020/h2020-sections 2 http://ec.europa.eu/DocsRoom/documents/9783 3 http://ec.europa.eu/social/main.jsp?catId=1223&langId=en 4 **http://ec.europa.eu/education/policy/strategic-framework_en** 5 http://skillspanorama.cedefop.europa.eu/en 6 **https://www.eurofound.europa.eu/topic**
Relevant National& Regional Initiatives	National & Regional Participants & Initiatives connected to above listed EU Initiatives such as: • National & Regional Technology Platforms on ADMA, KETs, Nanotech, etc. • National Initiatives for Digitisation of Industry and DIHs		
Relevant EU Tools	• Digital Transformation Monitor&Scoreboard • KETs Observatory • Innovation Union Scoreboard • Digital Agenda Scoreboard-DESI Index • EU Digital Agenda Toolbox • EU Observatory for Nanomaterials (EUON)	• RIM+ Monitor • Innobarometer Survey • Advanced Manufacturing Survey • Etc.	• Cedefop Skills Panaroma[5] • Eurofound[6] studies on: o Labour market change o The digital age: opportunities and challenges for work and employment

3.3.2 Overview of the latest strategies, policies and initiatives on SIS & DT at MS level

In this section we provide an overview of the latest strategies, policies and initiatives on smart industrial specialisation and digital transformation at **Member State level**. The table below provides a listing per country.

Table 4: National level strategy, policy and initiatives on SIS & DT

MS	Relevant Strategy, Policy and Initiatives
Austria	*National Strategy:* **Industry 4.0 Austria** *National Initiatives:* **Industrie 4.0 Österreich**[362]: aims to foster collaboration among all stakeholders facilitate new technological developments and innovations in the context of digitization. **Digital Roadmap**[363] is the Austrian strategy for efficient coordination of eGovernment agendas in Austria. **Produktion der Zukunft**[364] The Austrian Research Promotion Agency (FFG) is the national funding agency for industrial research and development in Austria. As a "one-stop shop" offering a diversified and targeted programme portfolio, the FFG gives Austrian businesses and research facilities quick and uncomplicated access to research funding.
Belgium	*National Strategy:* **Digital Belgium**: at federal level. Among different measures related to the federal competences several types of investments for digital transformation can benefit from tax reductions.[365] *National Initiatives:* **MADE DIFFERENT – Factories of the future**: increase overall competitiveness of the manufacturing industry through 7 crucial transformations: World-class production technologies; End-to-end engineering; Simultaneous product and production development; Human-centred production; Networked factory; Eco-production and Smart production process innovation.[366]

[362] http://plattformindustrie40.at/was-ist-industrie-4-0/?lang=en
[363] https://www.digitalroadmap.gv.at/
[364] https://www.ffg.at/en
[365] http://digitalbelgium.be/en/
[366] http://www.madedifferent.be/en

Bulgaria	National policy initiative on digitising industry under preparation: The initiative brings together industrial, academic and public stakeholders for implementation of Industry 4.0 in Bulgaria.
Croatia	*National Initiatives*: **Digitizing impulse 2020**: Creation of smart companies and digitisation of business and production processes in order to increase the overall quality, reduce production costs and to increase the flexibility and efficiency of production.
Cyprus	*National Strategy*: **National Integrated Industrial Strategy 2017-2030**: the private sector and the state, integrate them under a national strategy for industry, and an action plan incorporating concrete policies, measures and actions with an aim to modernize and digitize industry.367
Czech Republic	*National Initiatives*: **Průmysl 4.0**: addresses a revision of organisational structure of National Application Oriented Research Centres for Industry 4.0. The goal of the Initiative Industry 4.0 is to show possible trends and outline measures that would not only boost the economy and industrial base in the Czech Republic, but also to help prepare the entire society to absorb this technological change.368
Denmark	*National Initiatives*: **Approved Technological Institutes (GTS):** 8 institutes that develop and sell technological services to Danish companies. **Manufacturing Academy of Denmark (MADE):** support and strengthen the manufacturing industry in Denmark through applied industrial research, innovation and education, enabling increase productivity and growth.
Estonia	
Finland	*National Strategy*: **Digitising Finnish Industry program** will bring together existing initiatives from the public and private sector. National Initiatives: **DIGILE**369 is a programme focused on promoting the development of digital service know-how for business needs. Ever smarter services are also a means of increasing the productivity of work.

[367] http://www.mcit.gov.cy/mcit/sit/sit.nsf/All/FBC207AE9BC8BE69C225819C0040030F?OpenDocument
[368] https://ec.europa.eu/growth/tools-databases/dem/monitor/content/czech-republic-%E2%80%9Cpr%C5%AFmysl-40%E2%80%9D
[369] http://www.internetofthings.fi/

France	*National Initiatives*: **Alliance Industrie du Futur**370 organizes and coordinates, at the national level, initiatives, projects and works aimed at modernizing and transforming the industry in France. **Programme des Investissements d'Avenir**371 The "Investments for the Future" program supports innovative projects on an industrial level, and in particular collaborative projects, in themes as Cloud computing, Big Data, smart grids, biotechnologies, green chemistry, marine energies etc. **Transition Numerique**372 helps small businesses and SMEs to take ownership of new digital uses and to integrate these technologies to improve their competitiveness. **Nouvelle France Industrielle**373 intends to succeed the French reindustrialisation. The main objective is to bring each company to take a step on the way of the modernization of its industrial tool and the transformation of its economic model by the digital one.

370 http://www.industrie-dufutur.org/aif/
371 https://www.entreprises.gouv.fr/politique-et-enjeux/programme-des-investissements-d-avenir
372 http://transition-numerique.fr/
373 https://www.economie.gouv.fr/entreprises/nouvelle-france-industrielle

Germany	*National Strategy*: High-Tech Strategy 2020 *Relevant National Policies* (Industrial, Digital, RD&I, Finance on SIS&DT):German Industrial Policy; ICT 2020: Research for Innovations-IT Systems for Industry 4.0; *National Initiatives*: **Mittelstand 4.0** – Digital Production and Work Processes: competence Centres raise awareness, provide information and training for business leaders and staff members across the country and offer a hands-on approach for testing out the digital transformation in allocated demonstration factories **InnoKom**: aims at compensating the lack of industrial research in structural weak regions **Industrie 4.0:** combines production methods with state-of-the-art information and communication technology **Autonomik for Industrie 4.0**: pick up on key trends at an early stage and to accelerate the process of transferring scientific findings into the development of marketable high-tech technologies with high-level potential for practical applications **Plattform Industrie 4.0**374 aims to develop joint recommendations for all stakeholders, that serve as the basis for a consistent and reliable framework. The platform will initiate alliances and networks at the precompetitive stage, which support the evolution of the entrepreneurial skills and energy present in Germany. The platform aims to identify all relevant trends and developments in the manufacturing sector and to combine them to produce a common overall understanding of Industrie 4.0. **Smart Service World**375 is a strategic initiative of the German government. The traditional provider-customer relationship is replaced by an ecosystem of specialized partners. The new smart service architecture of cyber-physical systems, data services and service platforms creates new business relationships and models that transform existing value chains beyond recognition.
Greece	*Relevant National Policies*: Escrow Account this policy aims at enhancing market liquidity and stimulating business activity.

[374] http://www.plattform-i40.de/I40/Navigation/EN/Home/home.html
[375] https://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Industrie-4-0/Smart-service-world/industrie-4-0-smart-service-world-content.html

Hungary	National Strategy: **National initiative IPAR4.0 Technology Platform**376: primary focus is on the automotive sector. Additional objectives are to act as a lobbying forum and an advisory body to the Government in shaping the digitalisation policy. National Initiatives: **Dobbantó képzések**377: the "Women Entrepreneur Competence Development Programme" provides intense courses for women intending to start a business or already running one.
Ireland	*National Strategy*: **National Digital Strategy** (NDS)378: foundation step in helping Ireland to reap the full rewards of a digitally enabled society. *National Initiatives*: **Irish Digital Skills and Jobs Coalition**379 is a multi-stakeholder partnership between representatives of academia, industry, the public service and the non-profit sector. Its main goal is to tackle the digital skills shortage and improve the digital skills to allow Irish citizens to benefit from the digital economy. **The Entrepreneurship Summer Camps**380 programme is intended to provide students with environments that stimulate their creativity, innovation and invention. In the same line, activities aiming at stimulating entrepreneurial thinking and design skills among students will be developed.
Italy	*National Strategy:* **Piano Nazionale "Industria 4.0"**381: has committed investments for the establishment of selected I4.0 competence centres and for the strengthening of technological clusters "Fabbrica Intelligente" and "Agrifood".

[376] https://www.i40platform.hu/en/about_us
[377] https://dobbanto.seed.hu/en
[378] https://www.dccae.gov.ie/en-ie/communications/topics/Digital-Strategy/Pages/default.aspx
[379] https://www.digitalcoalition.ie/about/
[380] https://www.education.ie/en/Press-Events/Press-Releases/2017-Press-Releases/PR2017-03-02.html
[381] http://www.mise.gov.it/index.php/en/202-news-english/2036690-national-industry-4-0-plan

Lavtia	*National Strategy*: **National Industrial Policy Guidelines 2014 -2020:** objective is the transformation of economy towards innovation and creation of higher value added products and knowledge. *National Initiatives*: **The Innovation Motivation Program**382 is a support program which main goal is to raise awareness among the community about innovative entrepreneurship. It also targets to support those who wish to develop a new innovative business idea. **Demola (Riga IT TechHub)**383 is an international organization that facilitates co-creation projects between university students and companies, either locally or internationally, with the aim to find innovative solutions to the needs of companies, institutions and organizations that are seeking for the spark of creativity, design thinking and new products.
Lithuania	*National Strategy*: **Lithuanian Innovation Development Programme 2014-2020**384 has the aim to gather and mobilise resources at the state level for the enhancement of the innovativeness in the country. Through the programme, the Lithuanian government seeks to foster a more competitive economy based on a digitally and technically qualified labour force in line with its smart specialisation strategy. *National Initiatives* **Cluster and "valleys" policy**: selected pilot factories and several innovation hubs based on the clusters **Pramone 4.0**: support industry in the integration of digital solutions and new technologies.

[382] http://www.labsoflatvia.com/news/5-65-million-innovation-motivation-programme-project-developed
[383] https://latvia.demola.net/about
[384] https://mita.lrv.lt/en/national-r-d-programmes/innovation-policy-in-lithuania

Luxembourg	*National Initiatives*: **The development of a powerful High-Performance Computer (HPC)**385 facility at the University of Luxembourg: strategic asset of the university and an important comparative advantage for the scientific and economic competitiveness of Luxembourg **Digital4Industry**386: targets the local manufacturing industry, SME's as well as large enterprises. It has three main objectives: 1. Creating awareness and informing about the risks and opportunities related to the implementation as well as the non-implementation of industry 4.0; 2. Identifying specific concerns and challenges by the local industry and working on solutions to enable early adoption of Industry 4.0 concepts; 3. Initiating collaborative pilot projects to showcase value creation by the implementation of practical Industry 4.0 solutions. **Haut Comité pour le soutien, le développement et la promotion de l'Industrie au Luxembourg** (2013) has been launched by the government to support the industrial renewal. **Digital Lëtzebuerg**387 (2014) was launched by the government as an incentive to stimulate cooperation between Government and private sector and a tool that identifies areas for further action Hello Future388 is a campaign that aims at bringing together education, students and industrial sector in an online platform.
Malta	*National Initiatives*: **Mobile Government Strategy 2017-2018**389 aims at empowering citizens, enabling mobility within public administration, achieving increased take-up of electronic public services, and facilitating the availability of public sector information.

385 https://hpc.uni.lu/
386 http://digital4industry.lu/
387 https://digital-luxembourg.public.lu/
388 http://www.hellofuture.lu/
389 https://www.mita.gov.mt/en/News/Pages/2016/Launch-of-the-Mobile-Government-Strategy.aspx

Netherlands	*National Initiatives:* **Fieldlabs**: open environments for testing and demonstrating in specific areas of industrial transformation Smart Industry/Dutch Industry fit for the Future390: is PPP action program with 4 action lines: awareness, fieldlab, skills/knowledge and ICT. **Digitaal 2017** is the initiative of the Dutch government that aims to offer all governmental services online by 2017. The goal is to develop an integral service and to operate from one central website regardless of the particular service being offered. With this new programme, the Dutch government aims at improving, simplifying and accelerating public services.
Poland	*National Strategy*: **Smart Growth 2014-2020 (PO IR)**[391]: key national Work Program focusing on R&D *National Initiatives*: **Program Inteligentny Rozwój 2014-2020** aims to stimulate the transition to an innovation-based economy and to improve competitiveness in Poland by increasing the expenditures of research and development activities of enterprises. An additional goal is to foster knowledge transfer and strengthen the cooperation between businesses and research centres at the national and regional level. **Platforma Przemysłu Przyszłości – PPP (Future Industry Platform)**[392]: PPP main tasks will be to integrate private and public stakeholders in the field of industrial transformation and to build awareness among Polish enterprises about the technological and business opportunities carried by the Industry 4.0. **CuBR**[393] a joint initiative of the National Centre for Research and Development (NCBR) and KGHM Polska Miedź SA on the development and implementation of innovative equipment, materials, products and technologies in order to increase the competitiveness of Polish non-ferrous metals industry. **BIOSTRATEG**[394] transfer innovative solutions for agriculture, environment, forestry and biodiversity conservation. It also seeks to enable Polish companies gaining a competitive edge on international markets.

[390] http://smartindustry.nl/wp-content/uploads/2017/08/opmaak-smart-industry.pdf
[391] https://www.poir.gov.pl/media/10296/POIR_broszura_ang_082015.pdf
[392] https://ec.europa.eu/futurium/en/system/files/ged/poland_211117.pdf
[393] http://www.ncbr.gov.pl/en/news/art,3875,more-than-pln-100-million-in-3rd-competition-for-innovators-in-non-ferrous-metals-industry.html
[394] http://www.ncbr.gov.pl/en/news/art,4300,pln-150-million-up-for-grabs-in-the-final-competition-under-biostrateg.html

Portugal	*National Strategy*: **Industria 4.0**[395]: initiative was built according to bottom-up approaches that lead to the definition of 60 measures organized in 6 strategic vectors: Human capital qualification, Technological cooperation, Startup i4.0, Financing and investment incentive, Internationalization, Standards and regulation *National Initiatives*: **Programa QUALIFICA**[396] is Portugal's adult qualification programme. The objective is to improve the levels of qualification of the population and thus improve their employability. It ensures the continuity of lifelong learning policies and the permanent improvement of the quality learning processes. **PRODUTECH** – Production Technologies Cluster[397] is an initiative promoted by the Portuguese Industry of Manufacturing Technologies. This Cluster comprises companies that are capable of addressing competitiveness and sustainability challenges by delivering innovative, flexible, integrated and competitive production technology solutions. **Footure 4.0 Project**[398]. Implementation of the Shoe Industry Cluster for the Digital Economy based on multiple initiatives that aim to serve four strategic pillars: (1) Innovation of the customer experience, (2) Intelligent manufacturing, (3) Qualification and (4) Sector leadership and dissemination. **Creation of an Open Days i4.0 program**. Creation of an open days program in factories in Portugal with i4.0 technology that aims to share and disseminate the "modus operandi" of technologically advanced factories that operate in several relevant segments in Portugal. **Creation of maturity evaluation matrix i4.0.** Creation and dissemination of a self-diagnostic tool for technological maturity assessment of i4.0 at the corporate level, based on the definition of a set of evaluation criteria and good practices. **Open Science and Open Innovation**. Encouraging joint activities on Open Science and Open Innovation, focusing first and foremost on actors in the industrial ranks i4.0 mapped in the national Industry 4.0 program, involving companies, researchers, students, decision makers, funding agencies and other relevant entities.

[395] https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Ind%C3%BAstria%204.pdf
[396] https://ec.europa.eu/epale/en/content/qualifica-program-publicly-presented
[397] http://www.produtech.org/about-us
[398] https://ec.europa.eu/futurium/en/system/files/ged/pt_country_analysis.pdf

	Knowledge desk. Promote the set-up of Knowledge Branches with the purpose of bringing people, companies and institutions together in the creation and sharing of knowledge, creating bridges between the identification and analysis of social, economic and cultural needs and challenges and knowledge production institutions that can contribute to respond to them. **Born from Knowledge**. Program dedicated to stimulating innovation and the capacity to undertake on the basis of training, scientific research and knowledge. **Promoting and enhancing the role of local authorities in initiatives i4.0**. The intention is to promote with the local authorities the implementation of initiatives with an impact on the local business fabric aimed at building and accelerating business ideas that fall within Industry 4.0 or processes of digital transformation of existing business models. **Promotion of the sharing of experiences and knowledge in the scope of i4.0.** Promotion and dissemination of events of public or private initiative for the sharing of experiences and knowledge, training of human resources, development of partnerships and attraction of experience, on the topics of technological innovation, digitization and automation, within the scope of i4.0. **Creation of National Digital Network.** Creation of a network of volunteers in the business, academic and scientific ecosystem, to raise awareness, monitor and promote the digital transformation of Portuguese companies and their public measures to support this transformation, with a view to accelerating in proximity the digitalization of the economy. **Exhibition 560**. Sustained development of Exhibition 560 - itinerant exhibition, within the Ministry of Economy, of the most sophisticated and technological products of Portuguese industry. **Development of a study on cybersecurity in context i4.0.** Information security is a key issue to ensure the competitive advantage in an environment whose evolution is increasingly dependent on technological innovation. **Digital Single Balcony -Tourism.** Creation of a Single Digital Counter to manage the interaction between the various entities in the Tourism and the State sector, allowing to reduce the dispersion of information by concentrating on a single channel of information services, licensing and finance. **Digital Tourism Forum**. Creation of a forum for debate and sharing of experiences on the digitization of the tourism sector, which will ensure the continuity of the "Industry 4.0 | The future of Portuguese industry "in the sector through

	periodic sessions of presentation and discussion of solutions, analysis of success stories and best practices of technological scope, nationally and internationally, transversal and specific to the different segments.
Romania	*National Strategy:* **Government Strategy for development of SMEs and improving the business environment in Romania** – Horizon 2020 The strategy updates the Romanian policy priorities in the field of SMEs to new developments in Europe. The Strategy sets out a series of priorities, as: smart growth, by developing an economy based on knowledge and innovation; as well as sustainable growth, by promoting a more efficient, greener and competitive economy in terms of resources use. *National Initiatives:* **Business Incubators Law** (Law 102/2016 Legea incubatoarelor de afaceri) regulates the legal establishment and functioning of such places, by providing incentives for stimulating the establishment of business incubators, creating jobs, diversifying economies and supporting entrepreneurship in local communities. **Manifesto for Digital Romania**[399]: objective is to adopt a coordinated, integrated, efficient and transparent strategy for technological development, focusing on efficient use of public money, administrative simplification, wide access to participation in public tenders - in close consultation with industry, civil society and citizens.

[399] https://www.uradmonitor.com/digital-romania-forum-industry-4-0/

Slovakia	*National Strategy*: Koncepcia inteligentného priemyslu pre Slovensko (Conception of Smart Industry for Slovakia)400: 5 targeted areas: 1. R&D and innovation 2. Reference architecture, standardization and legal framework conditions 3. Security of networked systems 4. Labour market and education 5. Information and publicity, financial *National Initiatives:* **Národné podnikateľské centrum, "National Business Centre"**401. The model of the Centre is based on good practices observed in other European and international countries. The main objective of the Centre is to serve as a one-stop-shop to provide exhaustive and comprehensive support for challenges that new and existing entrepreneurs may encounter in their establishment and development. In addition, it provides a number of programmes including an acceleration, an incubation and a growth programme.
Slovenia	*National Initiatives*: **Slovenian Digital Coalition – digitalna.si**[402]: objective of the coalition is to support national digital transformation with the aim of placement of Slovenia as a reference environment for introducing innovative approaches in the use of digital technologies. **Public call for support of "RDI in the value chains and networks"** is one of the key instruments in the field of research, development and innovation investment that, for the first time, combines support for all phases from industrial research and experimental development to commercialisation on the market. It is structured in two parts, the first supporting the implementation of R&D programmes and the second supporting R&D projects.

[400] https://ec.europa.eu/futurium/en/system/files/ged/slovakia_211117.pdf
[401] http://www.sbagency.sk/en/national-business-center
[402] http://www.digitalna.si/digital-coalition-.html

Spain	*National Strategy*: **Industria Conectada 4.0**[403]: framed in the context of the Clustering national strategy, support the development of Innovation Enterprise Association. 4 main lines: Awareness and training; Collaborative Environments and platforms; Boost digital enablers; Support to the digital transformation of the industrial companies. National Initiatives: **TECNALIA**[404] is the first privately funded applied research and technological development centre in Spain and one of the leading such centres in Europe. **The programme Red.es**[405] launched in 2016 aims to stimulate the digital economy, innovation and entrepreneurship of the country by encouraging efficient and intensive use of ICTs. The programme consists in helping mainly SMEs and public administrations to adopt business solutions based on cloud computing.
Sweden	*National Strategy*: **Smart Industry**[406]: The Government's strategy for new industrialisation is to strengthen companies' capacity for change and competitiveness **För ett hållbart digitaliserat Sverige - en digitaliseringsstrategi**. The Swedish Government presented the Digital Strategy for a sustainable digital transformation in May 2017. Sweden aims at becoming the world leader in harnessing the opportunities of digital transformation. **National research and innovation program for smart manufacturing** "Produktion2030"407: is a Swedish PPP, bringing together industry, academia and Research institutes. *National Initiatives*: **Sverige helt uppkopplat 2025 – en bredbandsstrategi.** The main objective in the short term focuses on achieving broadband access for 95% of Swedish homes and workplaces at a minimum capacity of 100 mbit/s by 2020. Access to high-speed broadband and to reliable and high-quality mobile services in all of Sweden are the main goals in the long term – 2025 and 2023, respectively.

[403] http://www.industriaconectada40.gob.es/Paginas/index.aspx
[404] https://www.tecnalia.com/en/tecnalia/tecnalia.htm
[405] http://www.red.es/redes/en/quienes-somos/redes
[406] http://www.government.se/information-material/2016/04/smart-industry---a-strategy-for-new-industrialisation-for-sweden/
[407] http://produktion2030.se/en/

UK	*National Strategy:* **Digital Strategy**[408] aims to boost digital sectors and overcome barriers to growth and innovation, creating more of the high-skilled, high-paid jobs of the future. *National Initiatives*: **Green paper on Industrial Strategy**[409]: objective of the modern industrial strategy is to improve living standards and economic growth by increasing productivity and driving growth across the whole country. The pillars are: investing in science, R&I; developing skills, upgrading infrastructure; supporting businesses to stand and grow; improving procurement; encouraging trade and inward investment; delivering affordable energy and clean growth; cultivating world-leading sectors; driving growth across the whole country; creating the right institutions to bring together sectors and places. **Manufacturing Catapult**[410]: High Value Manufacturing (HVM) Catapult is the catalyst for the future growth and success of advanced manufacturing in the UK. **Innovate UK**: UK's innovation agency that drives productivity and growth by supporting businesses to realise the potential of new technologies, develop ideas and make them a commercial success. **EPSRC Manufacturing the Future**[411] : EPSRC is pioneering a prosperous future for the UK by creating new industries and jobs through innovative manufacturing businesses.

[408] https://www.gov.uk/government/publications/uk-digital-strategy
[409] https://beisgovuk.citizenspace.com/strategy/industrial-strategy/supporting_documents/buildingourindustrialstrategygreenpaper.pdf
[410] https://hvm.catapult.org.uk/
[411] https://www.epsrc.ac.uk/research/ourportfolio/themes/manufacturingthefuture/

3.3.3 Overview of the latest strategies, policies and initiatives on SIS & DT at Regional level

In this section we provide an overview of the latest strategies, policies and initiatives on smart industrial specialisation and digital transformation in Europe at regional level. Specifically, in **section 3.3.3.1** the main **technology focus areas** of the Member States and Regions relevant to SIS&DT and in **section 3.3.3.2** their performance by looking at their participation to key EU Initiatives on SIS&DT have been provided.

The following table presents particular policy, strategy and/or initiatives identified in some regions related to SIS&DT.

Table 5: Non-exhaustive list of Regional initiatives on SIS & DT

Regions	Relevant Initiatives
Flanders (BE)	*Regional Strategy:* **Industrie 4.0[412]:** Vision 2050 sets out a vision for an inclusive, open, resilient and internationally connected region that creates prosperity and well-being for its citizens in a smart, innovative and sustainable manner. This long-term strategy provides a strategic response to the new opportunities and challenges Flanders is facing. *Regional Initiatives:* **Flanders Make/Minds[413]:** Flanders Make is the strategic research centre for the manufacturing industry. The purpose is to realise a top-level research network in Flanders that delivers full support to the innovation projects of manufacturing companies.
Wallonia (BE)	*Regional Strategy:* **Industrial Transformation Strategy (Marshal Plan)** *Regional Initiatives:* **Plan Marshall 4.0[414]:** This initiative is structured around four key guidelines: research and innovation, upskilling of the workforce as well as local development and green economy. The initiative will last four years in total (2015-2019). **Digital Wallonia:** The actions for digitising industry are connected to the overall transformation strategy (Marshal Plan) and coordinated through a Digital Agency
Scotland (GB)	*Regional Initiatives:* **Action Plan for Manufacturing**[415] The Action Plan is based on a commitment to raising productivity through increased investment and innovation and a long-term partnership between Scottish Government, industry, our enterprise agencies and other key stakeholders.

[412] https://www.industrie40.vlaanderen/
[413] http://www.flandersmake.be/en
[414] http://planmarshall.wallonie.be/
[415] https://www.skillsdevelopmentscotland.co.uk/media/41516/a-manufacturing-future-for-scotland-1.pdf

Basque Country (ES)	**Basque Industry 4.0**[416] is an event focused on the smart tools as a support to the design, development, production, logistics and integrated management of manufacturing. In this initiative, especially the **Basque Digital Innovation Hub**[191] aims to strengthen the position of the Basque country as an economy with an industrial base through the promotion of knowledge intensive manufacturing. It wishes to promote KETs, support education and job training in relevant fields and scale up RD&I in advanced manufacturing.
Ile-de-France (FR)	**Plan Industries Ile-de-France**[192] supports companies operating in the Paris region in the aerospace, automotive and mechanics sectors The aim is to optimize the organizational, productive and commercial performance.
OstWestfalenLippe (DE)	The technology network **"it's OWL" (short for Intelligent Technical Systems OstWestfalenLippe)**[417] is an alliance of 180 businesses, universities, research institutes and organizations working together to make the innovative leap from mechatronics to intelligent technical systems.

[416] http://www.spri.eus/eventos_ext/basqueindustry4/index.html#intro
[417] http://www.its-owl.com/technology-network/

Baden-Wurttemberg (DE)	**Allianz Industrie 4.0**[418], a network launched by the State of Baden-Württemberg with the aim of sharing the resources and know-how of production, information and communication technologies to help businesses in their digital transformation process. Allianz offers a platform to promote partnerships. The objectives of this platform are to provide advice and support to small and medium-sized businesses to find their own way into the industrial future, strengthen innovation processes and strengthen collaboration between industries and technological sectors. Within the Allianz Industrie 4.0, the **Learning Factories 4.0** are one of the most prominent and effective policies. The Learning Factories are a government backed initiative to create learning factories to demonstrate the principles of digitally controlled production modules and teach students by providing real-life practice. Modular learning systems are used to provide a simple and safe introduction to components of industrial automation, and an interlinked machine system is used to provide training in intelligent production processes on the basis of real industrial standards. The Learning Factories are cost efficient[419] and have been established in 16 training centre projects in vocational schools across Baden-Wurttemberg, involving 30 vocational schools and 250 companies and industrial organisations. They serve the additional purpose of acting as 'showrooms' or research facilities, allowing information and demonstrations about Industrie 4.0 manufacturing technologies to be provided to SMEs.
Region Western Greece	**Operational Programme**[420] is a policy that aims to boost economic development and create job opportunities in Western Greece. It contributes to achieving the Europe 2020 targets for smart, sustainable and inclusive growth, also in line with the smart specialisation strategy. It should create jobs and help SMEs to become more competitive and innovation-driven.
Lombardia (IT)	**Associazione Fabbrica Intelligente Lombardia**[421] fosters research and innovation in the advanced manufacturing sector, promoting best practices and enabling technologies, in order to support and develop the leadership and competitiveness of the Lombard productive system.

[418] http://www.i40-bw.de/en/
[419] http://www.ptw-darmstadt.de/Webseiten/CLF_7th_2017/images/Downloads/Keynotes/Dr.%20Pittschellis.pdf
[420] http://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/greece/2014gr16m2op005
[421] http://www.afil.it/chi-siamo/mission/

Wales (UK)	Established in 2011, the **ESTnet**[422] is a network of technology organisations, whose members design, develop, manufacture or integrate electronic and software technologies. The mission of ESTnet is for its business members to encourage commercial collaboration, supply chain development and knowledge transfer and management. Skills development is a key issue for the sector and therefore ESTnet assists its members to identify and meet current and future skills requirements particularly to allow them to keep pace with technology developments.
Suomi (FI)	**Kampusareena**[423] is a shared innovation platform of companies, researchers and students in the middle of the campus area of Tampere University of Technology. Kampusareena is also architecturally and technologically of high-quality, but its strongest novelty value lies in its concepts: it combines the world's best benchmarked platform concepts supporting the shared use of company collaboration and research equipment, which is based on co-creation and agile cooperation. The aim has been to develop a completely new, expandable innovation campus concept, which also serves as a visiting card for the TUT campus area
Catalonia (ES)	**Catalonia Clusters' Programme**[424] is a service-based programme that is customised to the needs of the Catalan clusters. An action plan is developed every year covering the following areas: strategic coaching, support to internationalisation, capacity building, strategic update, networking activities, Espai Catalonia Clusters, co-working space.
Asturias (ES)	**Asturias clusters network**[425] is the meeting point for the 10 existing cluster organizations in the region. They work in different fields such as energy, food industry, advanced manufacturing, materials, chemistry, steel, construction, ICT, creative sector and rural tourism. The aim is both the improvement of competitiveness of Asturian companies and also the recruitment of new investments to revitalize, create wealth and introduce new activities in the regional business environment.

[422] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/regional-good-practice/estnet
[423] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/regional-good-practice/kampusareena-university-technology%E2%80%99s-open-innovation-platform
[424] https://www.clustercollaboration.eu/cluster-networks/catalonias-cluster-network
[425] https://www.clustercollaboration.eu/cluster-networks/asturias-clusters-network

Basque (ES)	**Basque Clusters**[426] provide assistance for: capacity building seminars & meetings for all Cluster Organisations' management, on issues such as Evaluation or Technology Watch; strong focus on all participant clusters sharing their own experiences together, exchanging ideas with managing authorities & with academics; interaction with International Cluster Organisations and Cluster Managing Authorities; networking Support and business visits to and from international customers and partners.
Auvergne-Rhône-Alpes Region (FR)	The cluster association "**Factory of the Future**"[427] aims to encourage and promote the collaborative actions for innovation undertaken in the Auvergne-Rhône-Alpes Region on the topic of the Factory of the Future. The 7 key topics developed within the association are: advanced manufacturing processes, agile and smart manufacturing systems, digital virtual factories, resource-efficient factories, collaborative and mobile enterprises, role of Human in the factories, customer-focused manufacturing.
Emilia-Romagna (IT)	**ASTER**[428] is the consortium for innovation and technology transfer in Emilia-Romagna. Its objective is to strengthen the Regional Innovation System by launching and coordinating the implementation of actions, projects and new initiatives for enhancing innovation factors of the regional ecosystem.
Eindhoven (NL)	**Brainport Development**[429] is a regional economic development organisation, working with representatives from industry, knowledge institutions and public authorities to strengthen the Brainport Eindhoven top technology region.

[426] https://www.clustercollaboration.eu/cluster-networks/basque-clusters
[427] https://www.clustercollaboration.eu/cluster-networks/cluster-association-factory-future-auvergne-rhone-alpes-region
[428] https://www.clustercollaboration.eu/cluster-networks/aster-emilia-romagna-cluster-network
[429] https://www.clustercollaboration.eu/cluster-networks/brainport-development

Grand Est Industry 4.0 (FR)	The **Great East Region** is the **2nd largest industrial region in France** and has recently launched the plan **"Industry of the Future"** to support the local industrial ecosystem. It will provide solutions to companies in order to: 1) Push them **forward on the value chain** 2) Help them to **reach international markets** 3) Foster the development of **short term technological solutions** The plan consists of an **industrial performance diagnostics** followed by an **adapted support** to the companies. This analysis focuses on the **industrial organisation**, the **KETs**, the **environmental impact** and the **human factor**. The region will then propose a concrete **strategic plan**, **relationships with economic institutions or providers**, **financing solutions** and **support** and **promotion** on **international markets** to the companies so that they can enter in the industry 4.0. The plan will also focus on **developing the industry community** by encouraging relationships between industry 4.0 leaders and other companies.

Helsinki – Oulu Corridor (FI)	**6 Aike (6 Cities)**[430] sets out a vision for a **new type of smart city** and is funded by Finland's structural fund programme for **sustainable growth and jobs** 2014-2020. The project was originally initiated by the National Government to **foster collaboration between cities,** aiming to **support regional growth**. It seeks to explore and experiment the **new role of cities in platform economy and innovation ecosystems** and mainly **targets young people and students** as well as educational organisations. 41,5% of the all jobs in Finland are located in those Six Cities and digitalization has been identified as a key metrics to improve in order to **support economic growth and job creation**. The project is very much integrated at the regional level - the issue of the **standardisation of opening data** being such a difficult task that it cannot be solved by individual cities alone. That being said, cities have a level of autonomy in that they decide the content of the strategy implementation and choose the activities and projects to be funded. The main aims are: - Promoting the **digitalisation of schools** - **Exploiting data analytics** to design new services - **Increasing knowledge and skills of young people** in various industries (gaming industry for instance) - **Favouring innovation** to create new ways of working and new businesses 6 Aika puts an emphasis on learning from other cities to develop **systemic collaboration**. Cities are seen as ecosystems and innovation platforms meant **to favour digitalisation and new production models**.

[430] http://ec.europa.eu/regional_policy/sources/conferences/udn_espoo/6city_strategy.pdf

3.3.3.1 Main technology focus areas of MSs & Regions for SIS & DT

In this section we provide a table listing the relevant regional initiatives, we describe the main technological focus areas of Member States and regions relevant for smart industrial specialisation and digital transformation, and we provide a detailed table on what regions actually focus on specific KETs.

3.3.3.1.1 Incorporation of KETs into National RIS3 Strategies

For the identification of main **technological focus areas** under the national policies for smart industrial modernisation, **Member States' inclusion of KETs into their national RIS3 Strategies** has been used as a proxy.

As noted earlier in this report, the former definition of KETs has been proposed to be re-defined by the **High-Level Strategy Group on Industrial Technologies**[431] quite recently. A broader definition of KETs was introduced underlining their substantial impact on the creation of jobs in the EU and highlighting their systemic relevance regarding production processes. This report adopted the new definition of KETs, which now includes the following categories: **(1) advanced manufacturing technologies (2) advanced materials and Nanotechnologies (3) Life-Science Technologies, (4) Micro-Nanoelectronics and Photonics, (5)Artificial intelligence,** and **(6) Security and Connectivity.**

The table below is based on the most recent information available on the **EYE@RIS3 database**. Two separate runs have been conducted for the extraction of countries for the markers listed in the table below. For the **first run**, '**Industrial Production and Technology'** as the 'scientific domain' of interest and listed '**KETs' as the policy objective** have been chosen while the other categories left open. In the **second run**, scientific domain remained the same as **'Industrial production and Technology**' while **D category** markers applying to our study have been chosen individually.

Table 6: Alignment of digital technologies according to KETs 4.0 definition

KETs 4.0	**Production Technologies**	Advanced Manufacturing Technologies	E.37 - Advanced manufacturing systems D.22 - Cleaner environment & efficient energy networks and low energy computing D.24 - Digitising Industry (Industry 4.0, smart and additive manufacturing) D.35 - Robotics, autonomous and cyber physical systems (e.g. vehicles, embedded systems) D.36 - Smart system integration
		Advanced Materials and Nanotechnologies	E.38 - Advanced materials E.41 - Nanotechnology
		Life-Sciences Technologies (prev. Ind. Biotech.)	E.39 - Industrial biotechnology
	Digital Techn	Micro-Nanoelectronics and Photonics	E.40 - Micro/Nano-electronics E.42 - Photonics D.18 - Advanced or high performance computing D.34 - Quantum computing

[431] https://ec.europa.eu/research/industrial_technologies/pdf/re_finding_industry_022018.pdf

		Artificial intelligence	D.19 - Artificial intelligence, cognitive systems, augmented and virtual reality, visualisation, simulation, gamification & interaction technologies D.20 - Big data, data mining, database management
	Cyber Technologies	Security and connectivity	D.21 - Broadband, spectrum and other communication networks (e.g. G5) D.23 - Cloud computing and software as a service and service architectures D.29 - ICT trust, cyber security & network security D.30 - Intelligent inter-modal & sustainable urban areas (e.g. smart cities) D.31 - Internet of Things (e.g. connected devices, sensors and actuators networks) D.32 - Location based technologies (e.g. GPS, GIS, in-house localization)

Based on the analysis of **KETs being included in Member states' RIS3 Strategies**, the following **technology focus areas** have been observed (see Table 6 below):

1. **Advanced manufacturing technologies** and **advanced materials & nanotechnologies** are the 2 KETs that are deployed the **most widely across the Member States**, 23 of 28 having included them in their RIS3. The preponderance of these 2 KETs can be explained due their importance to the EU industry. Advanced materials and nanotechnologies allow the reduction of resource dependency, environmental waste and hazards. The adoption of advanced manufacturing technologies into new and existing manufacturing processes, on the other hand, is expected to further increase the competitiveness of the EU industry.
2. **Life science technologies** are also widely adopted across the EU, with 19 out of 28 Member States having included them in their RIS3. As the EU industry is already well represented in the development and production of enzymes, biochemical, bio-base polymers etc. the implementation of life science technologies.
3. Th**e least** widely included KET is **'artificial intelligence'**. Only 11 out of 28 Member States included this KET in their RIS3 and are currently deploying it. This might be due to its recent adoption as a KET category. However, it also underlines the recent emergence of AI in the international community and especially in the industrial sector. The attention being paid 'artificial intelligence' is therefore expected to increase in the following years.

Overall, as the table below demonstrates, a clear focus can be seen on the **implementation of production technologies** across the EU, with **digital and cyber technologies** slowly gaining importance. This finding was further completed by an analysis of the KETs Technology Centres present in the EU, based on the findings of DG Growth's assessment of said centres.

Table 7: Incorporation of KETs into National RIS3 Strategies

	Production technologies			Digital technologies		Cyber technologies
	Advanced manufacturing technologies	Advanced Materials and nanotechnologies	Life science technologies	Micro nano-electronics and photonics	Artificial intelligence	Security and Connectivity
MSs	Austria Belgium Czech Republic Denmark Estonia Finland France Germany Greece Hungary Ireland Italy Latvia Lithuania Malta Poland Portugal Romania Slovakia Slovenia Spain Sweden UK	Austria Belgium Czech Republic Denmark Estonia Finland France Germany Greece Ireland Italy Latvia Lithuania Luxembourg Netherlands Poland Portugal Romania Slovakia Slovenia Spain Sweden UK	Austria Belgium Croatia Czech Republic Denmark Estonia Finland France Germany Greece Italy Latvia Lithuania Netherlands Poland Romania Slovakia Spain Sweden	Austria Belgium Czech Republic Denmark Finland France Germany Greece Italy Lithuania Luxembourg Poland Portugal Slovenia Spain Sweden UK	Belgium Croatia Estonia Finland France Germany Italy Poland Slovenia Spain Sweden	Austria Belgium Croatia Cyprus Finland France Germany Ireland Italy Lithuania Netherlands Poland Slovakia Slovenia Spain Sweden
Total Nr of MSs	**23**	**23**	**20**	**17**	**11**	**16**

Most Member States have been very active in the development and encouragement of **KETs Technology Centres.** As the table below demonstrates, **24 Member States introduced 229 KETs Technology Centres**. **Spain, France and Germany** have been especially active in this field, each having opened over 30 KETs Technology Centres nationwide. Interestingly, Sweden does not present any KETs Technology Centres even though it performs very highly regarding the deployment of KETs as can be seen in the table above.

Table 8: Distribution of KETs Technology Centres across MSs

Member States	Number of KETs Technology Centres
Austria	8
Belgium	**18**
Bulgaria	0
Croatia	1
Cyprus	1
Czech Republic	5
Denmark	4
Estonia	1
Finland	**13**
France	**38**
Germany	**30**
Greece	3
Hungary	2
Ireland	6
Italy	**11**
Latvia	1
Lithuania	4
Luxembourg	0
Malta	0
Netherlands	**11**
Poland	6
Portugal	8
Romania	5
Slovakia	1
Slovenia	2
Spain	**41**
Sweden	0
UK	**9**

Source: KETs Observatory

3.3.3.1.2 Incorporation of KETs into RIS3 Strategies by the Regions

The table below presents an overview of the technological focus (based on KETs) of European regions. The main source of information is Eye@ RIS3.

Table 9: KETs into RIS3 Strategies by the Regions

Production technologies			Digital technologies		Cyber technologies
Advanced manufacturing technologies	**Advanced Materials and nanotechnologies**	**Life science technologies**	**Micro nano-electronics and photonics**	**Artificial intelligence**	**Security and Connectivity**
Burgenland Lower Austria Carinthia Upper Austria Tyrol Vorarlberg Walloon Region Brussels Region Flemish Region Central Bohemia Moravian Silesia Central Jutland Helsinki-Uusimaa South Karelia Pohjois-Savo North Karelia Kainuu Central Ostrobothnia Northern Ostrobothnia Lapland Ostrobothnia Satakunta Pirkanmaa Île de France Champagne-Ardenne Picardie Upper Normandy Centre Nord-Pas-de-Calais Lorraine Franche-Comté Loire Region Brittany Aquitaine Midi-Pyrénées Limousin	Burgenland Lower Austria Upper Austria Salzburg Tyrol Vorarlberg Walloon Region Flemish Region Central Bohemia Moravian Silesia Central Jutland Päijät-Häme South Karelia Etalä-Savo North Karelia Kainuu Central Ostrobothnia Ostrobothnia Île de France Champagne-Ardenne Picardie Lower Normandy Burgundy Nord-Pas-de-Calais Lorraine Franche-Comté Loire Region Brittany Aquitaine Midi-Pyrénées Limousin Rhône Alpes North Rhine-Westphalia Rhineland-Palatine Saxony Saxony-Anhalt	Salzburg Tyrol Walloon Region Flemish Region Central Bohemia Central Jutland South Karelia Pohjois-Savo North Karelia Kainuu Satakunta Pirkanmaa France Centre Nord-Pas-de-Calais Franche-Comté Loire Region Brittany Aquitaine Midi-Pyrénées Limousin Guadeloupe Saarland Saxony Schleswig-Holstein Baden-Württemberg Hamburg Mecklenburg Western Pomerania	Burgenland Walloon Region Flemish Region Central Bohemia Central Jutland South Karelia Pohjois-Savo North Karelia Centre Nord - Pas de Calais Lorraine Franche-Comté Loire Region Brittany Aquitaine Midi-Pyrénées Limousin Rhône Alpes Guadeloupe Martinique North Rhine-Westphalia Rhineland-Palatine Saarland Saxony Thuringia Baden-Württemberg Berlin	Brussels Region South Karelia Pohjois-Savo Nord-Pas-de-Calais Franche-Comté Brittany Aquitaine Rhône Alpes Guadeloupe North Rhine-Westphalia Rhineland-Palatine Saxony Thuringia Berlin Mecklenburg Western Pomerania Valle d'Aosta Veneto Emilia-Romagna Lodzkie Wielkopolskie Dolnoslaskie Asturias Västra Götaland County	Carinthia Upper Austria Walloon Region Brussels Region Pohjois-Savo Central Ostrobothnia Pirkanmaa Picardie Nord - Pas de Calais Franche-Comté Loire Region Brittany Aquitaine Rhône Alpes Guadeloupe Provence Alpes Côtes d'Azur French Guiana Martinique North Rhine-Westphalia Rhineland-Palatine Saarland Saxony Thuringia Baden-Württemberg Bavaria Berlin Bremen

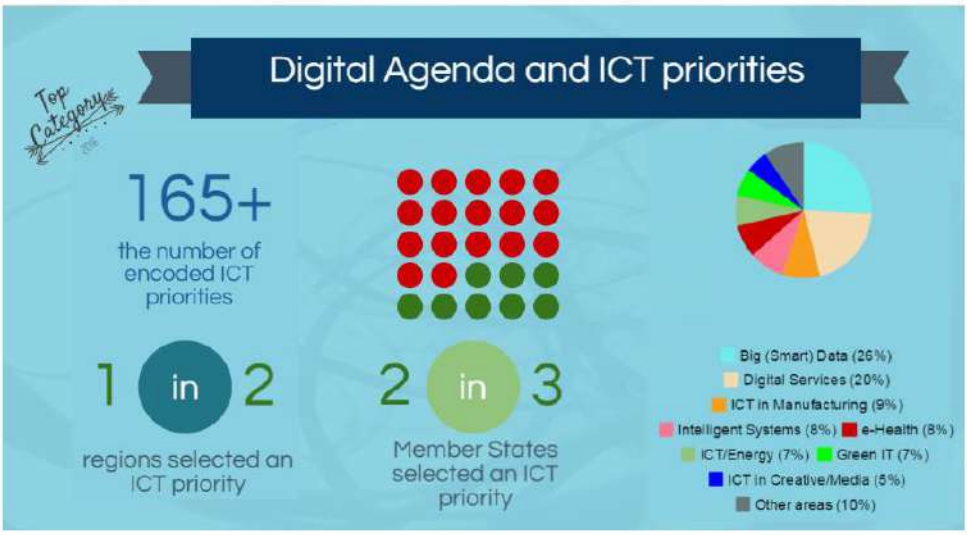
Production technologies			Digital technologies		Cyber technologies
Advanced manufacturing technologies	**Advanced Materials and nanotechnologies**	**Life science technologies**	**Micro nano-electronics and photonics**	**Artificial intelligence**	**Security and Connectivity**
Rhône Alpes Auvergne Guadeloupe Languedoc-Roussilon French Guiana **Martinique** **North Rhine-Westphalia** **Rhineland-Palatine** **Saarland** **Saxony** **Saxony-Anhalt** **Schleswig-Holstein** Thuringia Bavaria Berlin Brandenburg Bremen Hessen Mecklenburg Western Pomerania Lower Saxony East Macedonia Thrace Central Macedonia West Macedonia North Aegean Piedmont Valle d'Aosta Lombardy Apulia Calabria Autonomous Province of Bolzano Veneto Friuli-Venezia Giulia Emilia-Romagna Tuscany Marche Autonomous Province of Trento Lodzkie Malopolskie	Schleswig-Holstein Bavaria Berlin Brandenburg Bremen Hessen Mecklenburg Western Pomerania Lower Saxony East Macedonia Thrace West Macedonia Thessaly Continental Greece Piedmont Valle d'Aosta Campania Apulia Calabria Sicily Autonomous Province of Bolzano Veneto Friuli-Venezia Giulia Marche Autonomous Province of Trento North Netherlands Lodzkie Malopolskie Slaskie Lubelskie Podkarpackie Wielkopolskie Dolnoslaskie Opolskie Kujawsko-Pomorskie North Portugal Romania Centre Bucharest-Ilfov Bratislava Galicia	Zealand East Macedonia Thrace Molise Apulia Calabria Sicily Sardinia Autonomous Province of Bolzano Emilia-Romagna Umbria West Netherlands Malopolskie Slaskie Lubelskie North-East Romania Bratislava Galicia Cantabria Rioja Madrid Castile and Leon Castile La Mancha Valencia Balearic Islands Mursia Stockholm Uppsala County Värmland County Västerbotten County	Brandenburg East Macedonia Thrace Western Greece Calabria Tuscany Lodzkie Malopolskie Slaskie Lubelskie Wielkopolskie Dolnoslaskie North Galicia Asturias Madrid Mursia Stockholm Östergötland County Wales		Mecklenburg Western Pomerania Lower Saxony Valle d'Aosta Calabria Sicily Autonomous Province of Bolzano Marche North Netherlands Lodzkie Podkarpackie Lubuskie Dolnoslaskie Swietokrzyskie Bratislava Asturias Cantabria Aragon Madrid Östergötland County Västra Götaland County Gävleborg County

Production technologies			Digital technologies		Cyber technologies
Advanced manufacturing technologies	**Advanced Materials and nanotechnologies**	**Life science technologies**	**Micro nano-electronics and photonics**	**Artificial intelligence**	**Security and Connectivity**
Slaskie Podkarpackie Podlaskie Wielkopolskie Zachodniopomorskie Lubuskie Dolnoslaskie Opolskie Kujawsko-Pomorskie North Portugal **Romania Centre** **Bratislava** **Galicia** **Asturias** **Cantabria** Basque Country Navarre Rioja Aragon Madrid Castile and Leon **Castile La Mancha** **Valencia** **Andalusia** **Mursia** Stockholm Uppsala County Södermanland County Östergötland County Örebro County Västmanland County Kronoberg County Kalmar County Blekinge County Västra Götaland County Värmland County Dalarna County Gävleborg County	Asturias Cantabria Basque Country Rioja Aragon Madrid Castile and Leon Castile La Mancha Valencia Mursia Stockholm Södermanland County Östergötland County Blekinge County Skane County Örebro County Västra Götaland County Dalarna Count Gävleborg County Västernorrland County Norbotten County Greater Manchester Wales Northern Ireland West Northamptonshire				

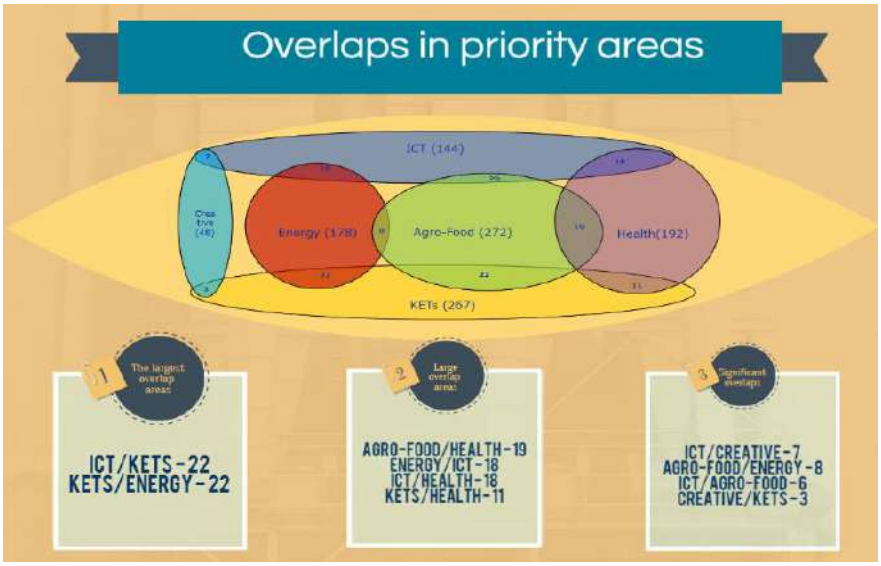
Production technologies			Digital technologies		Cyber technologies
Advanced manufacturing technologies	**Advanced Materials and nanotechnologies**	**Life science technologies**	**Micro nano-electronics and photonics**	**Artificial intelligence**	**Security and Connectivity**
Västernorrland County Västerbotten County Norbotten County Greater Manchester Wales					
117	**98**	**56**	**46**	**23**	**48**

3.3.3.1.3 Incorporation of ICTs into RIS3 Strategies by the Regions and MSs

The following ICT topics are observed to be among the most popular specialisation areas defined by most EU regions and MSs[432]: **data processing & management, (cyber) security, visualisations, sensors, privacy, cloud computing, open data, e-Government, geographical information systems, internet applications & future internet, industry 4.0, factories of the future, robotics and 3D printing.** All these areas have been selected by regional and national authorities as key areas of local strength, market potential and smart specialisation. As seen below, **one in two regions** and **two in three MSs have selected ICT** as an innovation priority.



The **dual role of ICT**, one **as a key enabler for KETs and other technologies across sectors** and secondly as an **area of specialisation** (priority sector), makes it an interesting yet complex issue to tackle in terms of value chains is its cross-cutting nature. The picture below shows how the different innovation priorities relate to one another, with **ICT and KETs being the main enablers.**



[432] http://s3platform.jrc.ec.europa.eu/digital-agenda-and-ict

3.3.3.2 National & Regional Performance through participation to EU Level SIS Initiatives

In this section, we will present the performance of MSs and Regions under SIS related EU platforms as a proxy to their capacity and capability on individual KET technologies as well as identification of main thematic focus areas. Specifically, the Smart Specialisation Platform for Industrial Modernisation (S3P-Industry), the Vanguard Initiative (VI), the Nanofuture Platform, the Manufuture Platform, and the Factories of Future (FoF) initiatives have been looked at. For each initiative, their strategic objectives, thematic focus areas, as well as national and regional participation to the initiatives have been identified.

Smart Specialisation Platform for Industrial Modernisation (S3P-Industry)[433]

Strategic Objectives

The **S3P-Industry** aims to **support EU regions** committed to generate a pipeline of industrial investment projects following a bottom-up approach implemented through **interregional cooperation, cluster participation and industry involvement.** It is **co-developed and co-led by the regions themselves** ensuring an active participation of industry and related business organisations such as clusters, as well as research institutions, academia and civil society.

Regional partnerships may develop their own working process. The work to be performed together by the regions, industrial partners and business intermediaries facilitated and supported by EU activities are normally carried out in three different phases as explained below.

First, regions interested in setting up a new Thematic Area contact to JRC through EoI. Once the partnership is approved as eligible, the following three steps are followed as illustrated on the left figure:

1. Mapping of competences and matching of business opportunities
2. Industrial cooperation and design of concrete investment projects
3. Business Plan and Funding mix

Thematic Focus areas

By October 2018, there are total of **17 thematic initiatives** launched under the S3P-Industry as listed below in which the ones that are heavily linked to the **deployment of KETs** and other digital technologies for SIS&DT are indicated **in bold**. The **first five thematic Areas** have been developed as part of the **Vanguard Initiative** that will be explained below.

[433] http://s3platform.jrc.ec.europa.eu/industrial-modernisation

1. **ADMA Energy**
2. **Bio-economy: non-food biomass**
3. **Efficient and Sustainable Manufacturing**
4. **High Performance Production through 3D-Printing**
5. **New nano-enabled Products**
6. **Artificial Intelligence and Human Machine Interface**
7. **Chemicals**
8. **Cybersecurity**
9. **Digitalisation and Safety for Tourism**
10. **Medical technology**
11. **Personalised medicine**
12. **Photonics**
13. **Safe and sustainable mobility**
14. **Smart Regional Investments in Textile Innovation**
15. **SME integration to Industry 4.0**
16. **Social Economy**
17. **Sport**

National Participation to S3-Indusrial Modernisation Platform (see Table 9)

- 19 of the 28 EU Member States are taking part on this platform through some of their regions taking leading/participating roles or showing interest in at least one of the thematic platforms while 9 MSs are not participating to any platform so far;
- The regions in **Spain, Italy, Belgium, Finland, Sweden, France, Germany and Netherlands** are observed to be the most active ones across most of the individual platforms.

Regional Participation to S3-Indusrial Modernisation Platform (see Table 10)

- Total of 75 regions are taking lead/participative roles or showed an interested under the S3P-Industry;
- **Most participative regions** are coming from **Italy (10)** followed by **Spain (9 regions)** and **Germany (7 regions)**;
- The thematic areas that holds the highest regional participation are **'Bio-economy', 'HPP through 3D'** and **'Efficient and Sustainable Manufacturing'** thanks to their relatively long presence compared to AI, Cybersecurity and some other that have been launched most recently by the beginning of 2018 ;
- **Catalonia, Navarra, Basque Country, Asturias (ES); Flanders and Wallonia (BE); Emilia-Romagna and Lombardy (IT); Baden-Württemberg and North Rhine-Westphalia (DE); Skane (SE); East and South Netherlands (NL); Tampere (FI)** can be seen as most active Regions taking lead and/or participative roles across different thematic platforms.

Table 10: Participation of Member States to S3P-Industry and Vanguard Initiative Platforms

	S3-Industrial Modernisation Platform																	Vanguard Initiative				
EU States	ADMA Energy	Artificial Intelligence and Human Machine Interface	Chemicals	Cybersecurity	Digitalisation and Safety for Tourism	Efficient and Sustainable Manufacturing	Bio-Economy – Interregional cooperation on innovative use of non-food Biomass	High Performance Production trough 3D-Printing	Medical Technology	New nano-enabled Products	Personalised Medicine	Safe and sustainable mobility	Smart Regional Investments in Textile Innovation	Sport	Social Economy	SME Integration to Industry 4.0	Photonics	Bio-Economy – Interregional cooperation on innovative use of non-food Biomass	Efficient and Sustainable Manufacturing (ESM)	High Performance Production through 3D-Printing	Making EU the global leader in components for marine renewables and offshore energy applications	Vanguard Initiative pilot project on New nano-enabled Products
Austria						✔		✔						✔			✔			✔		
Belgium	✔		✔			✔	✔	✔	✔	✔	✔		✔	✔		✔	✔	✔		✔	✔	✔
Bulgaria																						
Croatia																						
Cyprus																						
Czech Republic			✔										✔									
Denmark	✔								✔												✔	
Estonia				✔																		
Finland	✔			✔	✔	✔	✔	✔		✔				✔	✔	✔	✔	✔		✔	✔	✔
France				✔		✔		✔	✔	✔		✔	✔	✔			✔			✔		✔
Germany		✔		✔		✔	✔	✔	✔	✔		✔	✔				✔	✔		✔		✔
Greece																						
Hungary																✔						
Ireland																	✔					
Italy	✔	✔	✔		✔	✔	✔	✔	✔	✔			✔	✔	✔	✔		✔	✔	✔	✔	✔
Latvia																						
Lithuania																						
Luxembourg																						
Malta																						
Netherlands		✔	✔			✔	✔	✔	✔	✔	✔						✔	✔		✔		✔
Poland			✔				✔						✔			✔	✔	✔		✔		
Portugal	✔					✔		✔		✔			✔							✔	✔	
Romania													✔									
Slovakia																						
Slovenia					✔	✔		✔			✔				✔	✔						✔
Spain	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Sweden	✔	✔				✔	✔	✔		✔			✔	✔	✔		✔	✔		✔	✔	✔
United Kingdom	✔					✔	✔	✔		✔								✔			✔	✔

Table 11: Participation of Regions to S3P-Industry Initiative (This table needs to be further formatted to fit in)

	S3-Industrial Modernisation Platform																
EU States	**ADMA Energy**	**Artificial Intelligence and HM Interface**	**Chemicals**	**Cybersecurity**	**Digitalisation and Safety for Tourism**	**Efficient and Sustainable Manufacturing**	**Bio-Economy**	**High Performance Production w 3D-Printing**	**Medical Technology**	**New nano-enabled Products**	**Personalised Medicine**	**Safe and sustainable Mobility**	**Textile Innovation**	**Sport**	**Social Economy**	**SME Integration to Industry 4.0**	**Photonics**
Austria						Austria		Upper Austria Lower Austria						Upper Austria	-	-	Styria
Belgium	Flanders		Wallonia			Flanders Wallonia	Flanders	Flanders Wallonia	Flanders	Flanders Wallonia	Flanders		West Flanders	Flanders		Flanders	Flanders
Czech Republic			Usti nad Labem										Hradec Kralove Region				
Denmark	Syddanmark								Copenhagen Region								
Estonia				Estonia													
Finland	Ostrobothnia			Central Finland	Lapland	Tampere	Central Finland West Finland Tampere	Tampere		Tampere				Lapland Kainuu	Lapland	Lepland	North Karelia
France				Bretagne		Hauts de France		Auvergne Rhône-Alpes	Auvergne Rhône-Alpes Ile de France (Paris Region) Provence Alpes Cote d'Azur-Occitanie (Langued	Auvergne Rhône-Alpes		Ile-de-France	Auvergne-Rhone-Alpes	Auvergne-Rhone-Alpes			Bretagne Provence Alpes Cote d'Azur-Occitanie (Languedoc-Roussilon)

									oc-Roussillon)								
Germany		Baden-Württemberg		North Rhine Westphalia		Baden-Württemberg Saxony	Nordrhein-Westfalia Brandenburg Baden-Württenberg	Baden-Württemberg North Rhine-Westphalia Saxony	North Rhine-Westphalia Baden-Württemberg	Baden-Württemberg North Rhine-Westphalia		Bavaria	Baden-Württemberg				Baden-Württemberg Berlin North Rhine-Westphalia Thuringen
Hungary																Hungary	
Ireland																	Cork South west Region
Italy	Lombardy Emilia-Romagna	Emilia Romagna Trento	Lombary		Lazio Tuscany	Lombardy Emilia-Romagna	Lombardy Emilia Romagna Basilicata	Emilia-Romagna Lombardy Trentino	Lombardy Tuscany	Emilia Romagna			Campania Emilia Romagna Lombardy Piedmont Tuscany	Trento Emilia Romagna	Emilia Romagna	Tuscany Friuli Venezia Giulia Marche	
Nether-lands		North Netherlands	Limburg/ South Netherlands			East-Netherlands	East Netherlands South Netherlands North Netherlands Randstad	East Netherlands South Netherlands	South Netherlands East Netherlands	East Netherlands South Netherlands	East Netherlands Limburg			South Netherlands			South Netherlands East Netherlands
Poland			Mazowieckie				Malopolska Lodzkie						Lodzkie			Mazowieckie Bielski	Lubelskie Mazowieckie
Portugal	Norte					Norte		Norte		Norte			Norte				
Romania													North-East Romania				
Slovenia					Slovenia	Slovenia		Slovenia			Slovenia				Slovenia	Slovenia	
Spain	Basque Country	Navarra	Catalonia	Castilla y Leon	Andalusia	Navarra	Asturias	Aragon	Catalonia	Asturias		Aragon	Valencia	Catalonia	Navarra	Castilla y Leon	Catalonia

	Asturias Andalucia Navarra				Castilla y Leon Catalonia Valencia	Galicia Catalonia Basque Country	Andalucia Basque Country Navarra	Asturias Catalonia	Navarra Aragon	Navarra			Catalonia	Valencia	Murcia	Catalonia Valencia Navarra	
Sweden	Dalarna Skane	Orebrö Lan				Skane	Värmland Skane	Dalarna Skane Orebrö Lan		Skane			Vastra Gotalands Ian	Dalarna	Orebro Lan		Osrergotlands Stockholm
United Kingdom	Scotland					Scotland	Scotland	Wales		Wales							

Blue: Leading Regions; **Orange:** Participating Regions; **Green:** Interested Regions

Vanguard Initiative[434]

Strategic Objectives

The Vanguard is an Initiative aiming to achieve **growth through smart specialisation** driven by a **political commitment made by regions in 2014 by signing Milan Decleration**[435] to use their smart specialisation strategy to boost new growth through bottom-up entrepreneurial innovation and industrial renewal in European priority areas.

This Vanguard Initiative has its foundations at the **regional level** where **innovative partnerships and clusters** form the Regional innovation eco-systems that act as catalysts for fast-growing innovative SMEs.

The Vanguard Initiative seeks to lead by example in developing **interregional cooperation and multi-level governance** for supporting clusters and regional eco-systems to focus on smart specialisations in priority areas for transforming and emerging industries. Vanguard regions want to build the synergies and complementarities in smart specialisation strategies to boost world-class clusters and cluster networks, in particular through pilots and large-scale demonstrators.

Thematic Focus areas

The thematic areas under the Vanguard Initiative is currently grouped under 5 pillars:

1. **Bio-Economy** aims to stimulate interregional cooperation on innovative use of non-food by supporting the deployment of high TRL technologies, through the setting up of transregional vaue chains in an industry-driven process, where public support comes into play to help bridging the valley of death;
2. **Efficient and Sustainable Manufacturing (ESM)** aims to create a bigger competitiveness of companies thanks to enhanced manufacturing efficiency based on smart specialization, knowledge acquisition and high-added-value capacities, reducing the use of energy and other core resources like water;
3. **High Performance Production through 3D Printing** aims to speed up market uptake of 3D applications across EU for boosting additive manufacturing;
4. **New nano-enabled products** aims to connect regions in order to build an industrial ecosystem in nanotechnology and to create pilot production facilities for products based on nanomaterials;
5. **Advanced Manufacturing for Energy Related Applications** seek to make the EU the global leader in manufacturing robust high-integrity components for **marine renewables and offshore energy applications.**

Table 12: Participation of Regions to Vanguard Initiative

	Vanguard Initiative				
EU States	**Bio-Economy – innovative use of non-food Biomass**	**Efficient and Sustainable Manufacturing (ESM)**	**High Performance Production through 3D-Printing**	**ADMA-Energy**	**New nano-enabled Products**
			Upper Austria		

[434] https://www.s3vanguardinitiative.eu/

[435] https://www.s3vanguardinitiative.eu/sites/default/files/contact/image/final_declaration_of_milan_final_27_10.pdf

Austria			Lower Austria		
Belgium	Flanders Wallonia		Flanders Wallonia	Flanders	Flanders Wallonia
Denmark				Southern Denmark	
Finland	Central Finland West Finland Tampere		Tampere	Ostrobothnia	Tampere
France			Auvergne Rhône Alpes Nord-Pas-de-Calais-Picardie/Hauts-de France		Auvergne-Rhône Alpes
Germany	Nord Rhine-Westfalia Brandenburg Baden-Württenberg		Baden-Wurttemberg Nord Rhine Westphalia Saxony		Baden-Württemberg Nord Rhine-Westfalia
Italy	Lombardy Emilia Romagna Basilicata	Lombardy	Emilia-Romagna Lombardy Trentino	Lombardy Emilia Romagna	Emilia Romagna
Netherlands	East Netherlands South Netherlands North Netherlands Randstad		South-Netherlands South-Holland		East-Netherlands South-Netherlands
Poland	Malopolska Lodzkie		Malopolska		
Portugal			Norte	Norte	
Slovenia					Norte
Spain	Asturias Andalucia Basque Country Navarra	Catalonia	Andalusia Aragon Asturias Catalonia	Basque Country Andalucia Asturias Navarra	Asturias Navarra
Sweden	Värmland Skane		Region Örebro County Skåne	Dalarna Skåne	Skåne
United Kingdom	Scotland			Scotland	Wales

Blue: Leading Regions; **Orange**: Participating Regions

National Participation

- **Regions from half of the 28 EU Member States are participating** in at least one of the five initiatives as it can be seen in Table 9 above;
- The **highest participation** is observed under '**High performance Production through 3D-Printing**' initiative;
- The **lowest participation** is seen under '**Efficient and Sustainable Manufacturing (ESM)**';
- Regions from **Spain (), Italy () and Belgium** () **are the most active ones** being present under most of all of the Vanguard Initiatives;
- **Bulgaria, Croatia, Cyprus, Greece, Latvia, Lithuania, Luxembourg, Malta and Slovakia are not participating.**

Regional Participation

- Total of **39 regions** are taking lead or participating across all five individual platforms;
- **Highest participation** is seen under '**Bio-Economy**', '**HPP 3D-Printing'** and '**ADMA – Energy**' by the regions from **Spain, Italy and Germany.**

NANOfutures Initiative

Strategic Objectives

It is a European initiative for **sustainable development by Nanotechnologies** since it helps addressing global challenges such as climate change, constraints in energy production and shortage of resources, insufficient access to clean water and food safety, as well as widespread diseases and affordable health care worldwide. **NANOfutures**[436] brings together industry, research, networks NGOs at all levels for a joint movement towards a new industry.

NANOfutures environment is an European Technology Integrating and Innovation Platform (ETIP) that is multi-sectorial, cross-ETP, integrating platform with the objective of connecting and establishing cooperation and representation of Technology Platforms that require nanotechnologies in their industrial sector and products. NANOfutures and its operative branch **NANOfutures association** act as a "**Nano-Hub**" by linking JTIs, associations, ETPs with expert groups in a collaborative environment.

NANOfutures at its base is open to industry, SMEs, NGOs, financial institutions, research institutions, universities and civil society with an involvement from Member States at national and regional level. It is an environment where all these different entities are able to interact and come out with a shared vision on nanotechnology futures.

[436] http://nanofutures.eu/

National Participation

In 2012 NANOfutures platform initiated the creation of a local/regional connections network, named '**NANOfutures lighthouses**' for the establishment of coordinated efforts under the framework of Value4Nano project that is leading to worldwide contributions and collaborations. At the beginning of the project, it had 12 members and currently it involves **26 countries of Europe** (less established in Eastern Europe), **Asia and Latin America** as it can be seen from above figure[437].

Austria

- BioNanoNet
- Austrian Nano Forum
- EURO-NanoTox
- NanonetStyria
- National R&D Information Service

Czech Republic

- Academy of Sciences of the Czech Republic
- CzechInvest
- Czech Nanotechnology Cluster
- Nanomedic
- nanotechnology.cz
- National R&D Information Service

Denmark

- Creative Nano
- Danish Technological Institute
- iNano
- MIC National Micro- and Nanotechnology Research Centre at DTU
- NaNet
- Nano-DTU
- Nano Øresund
- Nano-Science Centre
- University of Copenhagen Nano-science Centre
- National R&D Information Service

Estonia

- Estonian Nanotechnology
- National R&D Information Service

Finland

- Finnish translation of the NANOfutures webpage
- FinDNano
- National R&D Information Service
- Tekes

[437] http://nanofutures.eu/sites/default/files/D4.2.%20Local%20national%20contact%20points%20network%20description%20FINAL_1.pdf

France

- NanoThinking
- Nanoscience & Nanotechnology
- Basic Technological Research (BTR) Network of the CNRS
- CarbonInspired
- Commission Particulière du Débat Public Nanotechnologies
- Minalogic Industrial Cluster
- National R&D Information Service

Germany

- NanoBioNet
- Helmholtz-Zentrum Berlin für Materialien und Energie
- Deutscher Verband Nanotechnologie
- Deutsches Elektronen-Synchrotron
- Fraunhofer Verbund Nanotechnologie
- Federal Ministry of Education and Research
- Hessen
- Nano4Women
- nanoValley
- National R&D Information Service
- Nationale Kontaktstelle Nanotechnologie
- Rheinland-Pfalz
- SciPort RLP
- YoungNanoProfessionals

Greece

- CERTH
- Nanonet
- National R&D Information Service

Hungary

- IMNTP
- Nanostructures Laboratory MTA MFA Budapest
- National R&D Information Service

Iceland

- National R&D Information Service

Ireland

- CCAN - Collaborative Centre for Applied Nanotechnology
- Biomedical Diagnostics Institute (BDI)
- Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN)
- Horizon 2020 Ireland
- National R&D Information Service
- Tyndall National Institute

Italy

- Assoknowledge – Confidustria Servizi
- D'Appolonia
- Institute for Nanostructured Materials, CNR Bologna
- nanotec IT
- National Nanotechnology Laboratory
- National R&D Information Service
- NEST
- TASC
- Veneto Nanotech

Latvia

- FOTONIKA-LV
- National R&D Information Service

Lithuania

- National R&D Information Service
- Research Centre for Microsystems and Nanotechnology

Luxembourg

- Luxembourg Materials Cluster
- National R&D Information Service

Netherlands

- TNO
- MicroNanoConference
- Minacned
- NanoLabNL
- nanonextnl
- MiPlaza
- National R&D Information Service
- NanoHouse

Poland

- NanoNet
- International PhD School
- Krakow Interdisciplinary PhD Project in Nanoscience and Advanced Nanostructures
- nanodialog
- NaMic
- National R&D Information Service
- Polish National Scientific Network: ARTMAG - Magnetic Nanostructures for Spintronics

Portugal

- CarbonInspired
- i3N
- INESC MN
- International Iberian Nanotechnology Laboratory (INL)
- National R&D Information Service
- Portugal Nano

Romania

- NANOfutures Romania
- National R&D Information Service

Spain

- Fundación Prodintec
- CarbonInspired
- iberNAM
- International Iberian Nanotechnology Laboratory (INL)
- NanoSpain
- National R&D Information Service

Slovenia

- Centre of Excellence: Nanoscience and Nanotechnology
- complexmatter
- National R&D Information Service

Sweden

- SwedNanoTech
- Myfab
- Angstrom Laboratory
- Chalmers
- CeNano at Linköpings Universitet
- Nanometer Structure Consortium at Lund University
- Nano Øresund
- National R&D Information Service

United Kingdom

- SUNUM - Institute of Nanotechnology (IoN)

- Daresbury Science & Innovation Campus
- Interdisciplinary Research Collaboration in Nanotechnology
- London Centre for Nanotechnology
- NanoKTN
- National R&D Information Service
- NIA
- SAFENANO

ManuFuture Platform[438]

Strategic Objectives

This **European Technology Platform (ETP)- Manufuture aims** to propose, develop and implement a strategy based on Research and Innovation, capable of speeding up the rate of **industrial transformation to high-added-value products, processes and services**, securing **high-skills employment a**nd winning a major share of **world Manufacturing output** in the future knowledge-driven economy.

The **ManuFuture National/Regional Technological Platforms (NRTPs)** are created across some EU Member States and adopt the main strategic and development goals defined under EPT ManuFuture Vision 2020 and Manufuture Strategic Research Agenda. **Additive Manufacturing** and **Micro Nano Manufacturing-MINAM** are among the sub-platforms that are most relevant to manufacturing industry.

National Participation

National Technological Platforms related to the ETP ManuFuture are created in **12 EU Member States** and there are new ones in the development phase in further countries. The **most advanced** in MFNTPs are **Italy, Portugal, Spain, Poland, Austria, Switzerland, Germany, Denmark, United Kingdom, the Netherlands, Ireland and Romania[439].**

Factories of Future (FoF) 440

Strategic Objectives

The **Public-Private Partnership (PPP)** for **FoF** was launched under the European Economic Recovery Plan in 2008 funded under the EU's 7th EU Framework Programme for Research (2007-2013) and extended under the Horizon 2020 for 2014-2020 period.

The FoF multi-annual roadmap for the years 2014-2020 sets a vision and outlines routes towards high **added value manufacturing technologies** for the **FoF**, which will be **clean, highly performing, environmental friendly** and **socially sustainable**. This PPP is a EUR 1.2 billion programme in which the European Commission and industry are collaborating in research to support the development and innovation of new enabling technologies for the EU manufacturing sector. The initiative is helping EU manufacturing enterprises, especially SMEs, to adapt to global competitive pressures by improving the technological base of EU manufacturing systems.

FoF concentrates on increasing the technological basis of EU manufacturing through the development and **integration of enabling technologies**, such as innovative technologies for adaptable

[438] http://www.manufuture.org/
[439] http://www.manufuture.org/wp-content/uploads/MF_National_Platforms.pdf
[440] http://ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html

machines, **ICT for manufacturing**, and novel industrial handling of **advanced materials.** Specific R&D objectives are:

• high-tech manufacturing processes, including 3D printing, nano- and microscale structuring;
• adaptive and smart manufacturing equipment and systems, including mechatronics, robotics, photonics;
• resource-efficient factory design, and data management for increased production performance; • collaborative and mobile enterprises, networked factories linking dynamically supply chains to local production;
• human-centered manufacturing: designing the workplaces of the future;
• customer-focused manufacturing: linking products and processes to innovative services. The initiative will further:
• help to address effectively new markets and consumer demands with customised products;
• facilitate optimum production with less resource use and waste;
• raise industrial investment in equipment and foster innovation;
• create attractive and safe workplaces and engage new talent;
• increase business R&D expenditure in manufacturing.

The **European Factories of the Future Research Association (EFFRA)**[441] is a non-for-profit, industry-driven association that represents the private side of the 'FoF' public-private partnership officially and promoting the development of new and innovative production technologies.

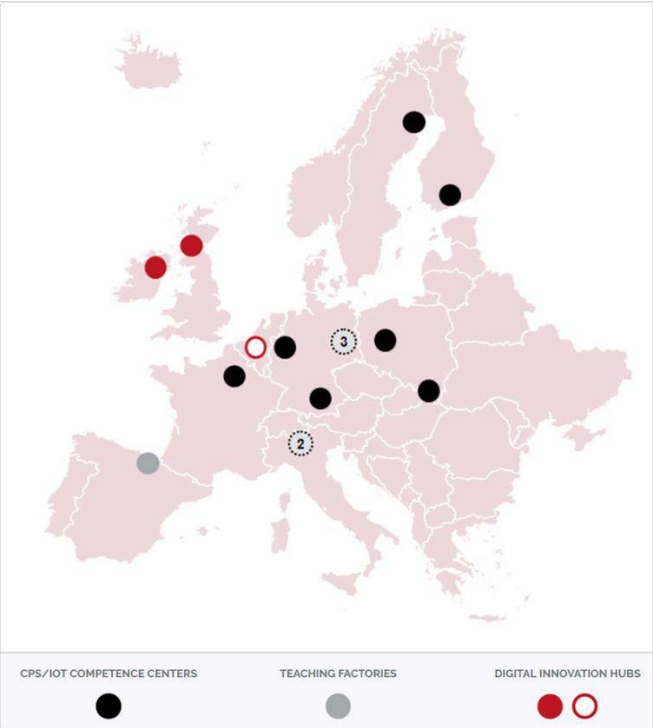
ICT Innovation for Manufacturing SMEs (I4MS)[442] is a 'FoF' initiative designed to support the adaption of innovative ICT in Europe's manufacturing SMEs. I4MS brings together eleven 'FoF' projects as Integrated Projects (IPs) and two 'roadmapping' projects.

When looked at the national participation to different calls under FoF, we see highest participation from **Germany** (305) followed by **Spain** (227) and **Italy** (218) out of 1745 total participation across all EU MSs.

The **Manufacturing Industry Digital Innovation Hubs (MIDIHs)**[443] is complementary to I4MS initiative running under H2020 aiming to create a Network of Manufacturing Digital Innovation Hubs in the area of **CPPS/IIOT** (**Cyber Physical Production System / Industrial Internet of Things**). Technological, business and skills building services as well as access to "ICT for Manufacturing" market and financial opportunities will be provided to SMEs. MIDIHs will leverage networks of local Competence Centres, each specialised in peculiar aspects of the CPPS/IIOT technologies and able to attract, mentor and nurture local Manufacturing SMEs towards Industry 4.0 projects, experiments and business. A common platform of knowledge, methods and collaboration tools will be shared among the MIDIHs network and allow cross-border fertilisation, continuous improvement, open innovation. The network is comprised of 9 Competence Centres, 2 Teaching Factories, 2 Regional MDIHs and 3 pan-European DIHs. As seen from below figure, **Germany, Italy, France, Spain, Finland, Sweden, Belgium, Slovakia, Ireland and Scotland** are seen to be competent on this domain to provide different services.

[441] https://www.effra.eu/effra
[442] https://www.effra.eu/i4ms-ict-innovation-manufacturing-smes
[443] http://midih.eu/project.php

Figure 72: Network of Manufacturing Digital Innovation Hubs in the area of CPPS/IIoT



Source: MIDIH[444]

Photonics21 Platform[445]

The **European Technology Platform (ETP) - Photonics21** unites the majority of the leading photonics industries and relevant R&D stakeholders along the whole economic value chain across Europe with more than 2500 members at the moment.

Photonics21 aims to establish Europe as a leader in the development and deployment of photonics technologies within the various applications fields such as **ICT, lighting, industrial manufacturing, life sciences, safety** as well as in **education and training** for driving growth and employment in Europe and contribute to solve the major societal challenges such as aging society, energy efficiency, inclusion and smart living.

Photonics21, the European Technology Platform (ETP) representing the European Photonics Community since 2005 formed the '**Photonics 21 Association**' in 2013 to become the private contract partner in a contractual **Public Private Partnership** (PPP) arrangement with the EU Commission in the frame of Horizon 2020.

The **Photonics PPP** represents a long-term commitment between the European Commission and the photonics stakeholders to invest in Europe with the aim of securing Europe's industrial leadership and economic growth, a highly skilled workforce, and the capability to generate new jobs that attract young people. It performs under **7 work groups** as shown below across different thematic focus areas.

The platforms provides services mainly under 3 domains for **Finance, Industry and Education.**

[444] http://midih.eu/dih_network.php
[445] https://www.photonics21.org/about-us/photonics21.php

The **Photonics services for Education**[446] are mainly delivered through two major initiatives which are:

PHABLABS 4.0[447] aims to achieve a lasting, positive impact on the way photonics is integrated into the rapidly expanding ecosystem of European **Fab Labs and Makerslabs**, resulting in a larger and better skilled photonics workforce with superior innovation capacity in photonics to support the next revolution in digitization.

Photonics4All[448] was a European outreach project which was funded by one of the calls under the Photonics Public Private Partnership (PPP) and thus received funding by the European Union. The tools mentioned below and developed within the project are open access and should be used as widely as possible for all people and organisations engaged in photonics outreach.

3.3.4 Overview of the latest strategies, policies and initiatives on SIS & DT at City level

In this section we describe what is happening at city level in Europe, and describe local conditions and developments for the most promising and active cities in Europe. We find that especially London, Paris and Munich are especially relevant to smart industrial specialisation and digital transformation.

Cities are playing an increasingly important role in the smart industrial specialisation of Member States. The smart city concept, which is gaining momentum globally, highlights the key investments being made in this regard. As cities and regions continue to grow, the prospects for them to act as launch pads for digital transformation become even more prominent. Being a digital launch pad entails the creation of the right environment to accelerate the digital transformation of businesses, organisations and public administrations. It is ultimately about improving the ecosystem in which residents live, businesses succeed, as well as the services and activities that governments, firms, and organisations deliver.[449]

This report identified the following framework conditions that mark the success factors of cities to activate the digital transformation process. The framework conditions identified are based on the

[446] https://www.photonics21.org/ppp-services/photonics-for-university.php
[447] http://www.phablabs.eu/
[448] https://zenodo.org/search?page=1&size=20&q=Photonics4All
[449] Blueprint for cities and regions as launch pads for digital transformation, SPF on DT Report, May 2016

findings of the '*Blueprint for cities and regions as launch pads for digital transformation*' and the '*EDCI-European Digital City Index 2016 Map*'.

The table below demonstrates how the different criteria were aligned under four framework conditions as listed below, and subsequently the text will provide more explanation of each of the criteria.

Table 13: Framework Conditions – Blueprint for Cities and EDCi Criteria

	Blueprint criteria	**EDCi Criteria**
Framework Conditions	Leadership and collaboration for a smart governance of the local digital ecosystem	Mentoring and managerial assistance
	Digital skills and entrepreneurs to accelerate the digital transformation process	Entrepreneurial culture Knowledge spillover Lifestyle Skills
	Access to data and technologies for applied solutions to local challenges	Digital infrastructure
	Key infrastructures and investments for digital launch pads	Access to capital Business environment Market Non digital infrastructures

1. **Leadership and collaboration for a smart governance of the local digital ecosystem**

Visionary, proactive and engaged leaders are crucial to introduce and drive new digital initiatives. Not only do they have the ability to envision their company in the future but they imagine the continued development of their surrounding environment. They challenge the status-quo and encourage others to realise their visions by mentoring them in their development and their managerial skills.

2. **Digital skills and entrepreneurs to accelerate the digital transformation process**

The digital transformation of a territory is only possible if local businesses have the right talent with the relevant skillset to acquire and harness the required digital technologies. Cities need to foster an environment in which entrepreneurs can flourish. Cities do not only need to attract talent but keep it by offering a high quality of living and creating an inspiring environment. Trainings on ICT skills and on how to start are business are easy initiatives that cities can implement to foster an entrepreneurial culture and encourage knowledge spill over between the different actors and sectors of activity. Simultaneously, companies need to be able to easily interact with the administration and receive information/support.

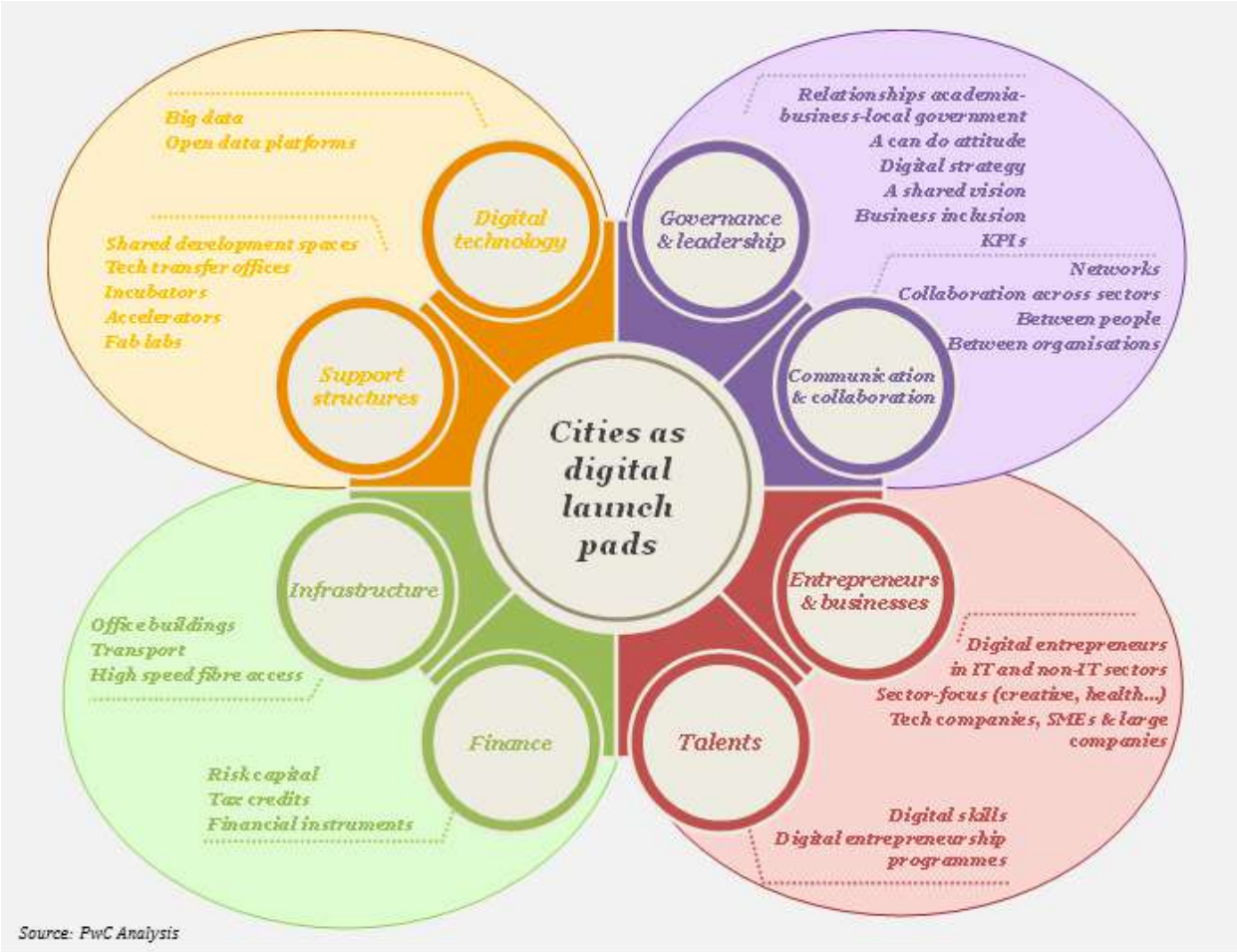
3. **Access to data and technologies for applied solutions to local challenges**

While an entrepreneurial culture and a close relationship with the administration are crucial to the smart industrial specialisation of cities, its digital infrastructure and access to data and technologies for applied solutions are crucial to the city's position as a leading actor in smart industrial specialisation. In every organisation, digital solutions have the capacity to replace old and sub-optimal management styles by newer, more efficient ones. The availability of fast, cheap and reliable internet, both on a mobile- and landline, is thus a must. Simultaneously, the city needs to be well connected to facilitate travel and thus facilitate the exchange of knowledge.

4. **Key infrastructures and investments for digital launch pads**

Physical and digital infrastructures are required to optimise the use of resources and enable a higher quality of life in every territory. Innovative financial and business models are increasingly emerging to finance these sometimes costly but indispensable local technological infrastructures. Access to capital thus becomes a gruelling requirement for all young companies. The presence of local Venture Capitalists and Angel Investors is crucial for the growth of an entrepreneurial culture and the funding of innovative technologies. At the same time, a market willing to integrate these new technologies is crucial.

Figure 73: Cities as digital launch pads



To give a first overview of cities that have been very active regarding the implementation of strategies, policies and initiative sin SIS&DT, this report reviewed the 10 highest scoring cities in the EDCi index, which describes how well different European cities support digital entrepreneurship. The findings of the EDCi index provide a comprehensive foundation for the identification of existing and promising hubs of activity. Table 16 below lists the 20 highest performing cities in the EDCi index based on the environment they provide for startups and scaleup efforts.[450] We analyse the top 10 cities in greater detail in Table 17, to allow for a deeper understanding of the characteristics that turn these cities into hot spots for SIS&DT.

[450] https://digitalcityindex.eu/about

Table 14: Ranking by Start-up and Scale-up

Ranking	Start-up	Scale-up
1	**London**	**London**
2	**Stockholm**	**Stockholm**
3	**Amsterdam**	**Paris**
4	**Helsinki**	**Helsinki**
5	**Paris**	**Amsterdam**
6	**Berlin**	**Copenhagen**
7	**Copenhagen**	**Berlin**
8	**Dublin**	**Munich**
9	**Barcelona**	**Dublin**
10	**Vienna**	**Vienna**
11	Munich	Cambridge
12	Cambridge	Oxford
13	Bristol	Barcelona
14	Madrid	Madrid
15	Oxford	Hamburg
16	Manchester	Bristol
17	Brussels	Manchester
18	Tallinn	Brussels
19	Edinburgh	Lyon
20	Hamburg	Frankfurt

Table 15: Description of the cities

City	Description
London	London scores at the top of the EDCi index regarding both the scale-up and startup environment. The presence of many financial service firms in the city promotes the growth of fintech and crowdfunding startups as well as accelerators and coworking spaces. The city also houses numerous world-class universities which promote the development of innovative ideas and entrepreneurship in the area. The two Digital innovation Hubs 'Digital Catapult' and 'Future Cities Catapult' further strengthen London's position in the startup and scale-up environment. However, rising housing and office rental costs are slowly starting to limit the city's appeal to emerging entrepreneurs. Further efforts will have to be made in this regard in the future.

Stockholm	Stockholm also performs very highly on the EDCi index, scoring second for scale-ups and third for startups. Stockholm is the leading city regarding policy intitiatives for digital infrastructure and houses a significant population of ICT-specialist users. The government actively supports the growth and development of its citizens' entrepreneurial spirit by facilitating its administrative procedures and funding local efforts. The presence of top ranking universities, such as the Karolinska Institute, further promotes knowledge spillover.
Amsterdam	Amsterdam is well known for its appeal to entrepreneurs and startups. The city scores among the top 3 cities in the EDCi index and has been investing heavily in its overall innovation strategy for years. Amsterdam is a leader in digital transformation, housing one of the largest Internet hubs (AMS-IX) and being known as one of the most digitally connected economies in the world. The city is a thriving tech hub leading the way in smart cities technologies and boasting one of the best well-known tech start-up ecosystem in Europe. Amsterdam is further known for its high level of infrastructure, its proximity European markets and generous tax regime making it an interesting location for startups and entrepreneurs.
Helsinki	Helsinki is well-known as a powerful start-up and scaleup ecosystem. The city is especially known for its strong ICT and software talent pool due to the presence of electronics giant Nokia. It houses hundreds of tech startups as well as numerous incubators and accelerators and is know for its well developed infrastructure. The government is very active regarding the support given to start-ups and the support of the entrepreneurial culture.
Paris	The city's well developed venture capital industry and its world-class research institutions position Paris among the top ten cities for SIS&DT. An increasing number of accelerators and co-working spaces are further facilitating the development of SIS&DT. These efforts are being further supported by the work of KETs Technology Centres such as the 'Carnot Télécom & Société Numérique' and the 'RENATECH Network' as well as the digital innovation hub 'TeraLab: Big data platform for research, education and innovation'. Areas of improvement include the slow upgrading of digital infrastructure as well as rising housing and office prices.

Berlin	Berlin is known for its flourishing startup culture influenced by its diverse creative sector. The city is known for its relatively cheap living and rental costs as well as its co-working spaces (eg. Factory Berlin) which further contribute to the city's growing appeal regarding the development of SIS&DT. The presence of the 'European Technology Platform on Smart Systems Integration, EPoSS' a digital innovation hub further promoted knowledge spillover and innovation.
Copenhagen	Copenhagen performs highly with regards to its business environment, access to capital and relevant skills thus providing supporting framework conditions for SIS&DT. The city is well known for its growing tech community and has been identified as one of the leading smart cities. The presence of accelerators and digital innovation hubs such as the 'MADE-Manufacturing Academy of Denmark' turn Copenhagen into a hot spot for SIS&DT.
Dublin	The city's favourable economic and lifestyle conditions as well as its blooming entrepreneurial culture have attracted young talent from around the world and have turned Dublin into one of the hot spots for SIS&DT. Strong talent combined with the city's business-friendly environment have attracted many global tech giants to Dublin and are further pushing the city's efforts regarding the development of SIS&DT. Dublin is especially well known for being Europe's centre for B2B SaaS and fintech and houses various KET technology centres such as the 'AMBER' and the 'CeADAR National Centre for Applied Data Analytics' as well as the digital innovation hub 'Irish Centre for Cloud Computing and Commerce (IC4)'.
Barcelona	Barcelona has been developing a set of policies and reforms to facilitate its efforts in becoming a smart and digital city. A key element of Barcelona's digital strategy is the presence of an easy access to financing based on the participation of both public and private stakeholders (e.g. Barcelona Activa, INICIA, ACC10). These funding projects are being further supported by numerous incubators and accelerators such as Seedrocket, LaSalle Technova, and Wayra. The presence of strong academic institutions and numerous digital innovation hubs such as the 'Big Data Centre of Excellence Barcelona (BigData CoE)', the 'Barça Innovation Hub (BIHUB)', the 'Associació Clúster Digital de Catalunya', the 'Data Management-UPC (DAMA-UPC)' and 'Digital Urban Development (DUD)' further attract top talent to the city and promote knowledge spillover.
Vienna	While not as widely known as a hot spot for SIS&DT, Vienna has developed into a promising ecosystem for startups and

	innovators. Its geographic location and high lifestyle facilitate the integration of new business and facilitates knowledge exchange. The city offers various kinds of business support regarding finance, product development or marketing and has been working actively to facilitate access to capital. However, further efforts need to be made to boost the development of an entrepreneurial culture in Vienna.

To further strengthen the findings above, this report decided to further highlight the 3 top hot spots for SIS&DT identified below in greater detail.

According to the most recent news released by WEF[451] in 2018, **London, Munich and Paris** was listed among **5 top tech hotspots globally** together with Tel Aviv and Singapore.
According to this newsfeed, the **critical success factors** for these cities are as follows:

[451] https://www.weforum.org/agenda/2018/02/5-hotspots-for-tech-innovation-outside-of-the-us/

London

- **Access to Finance:** Out of 5, start-ups in London have received the most investment in the past 10 years – $118 billion. London is ambitious to keep this position as declared by its Mayor to keep the city as Europe's Start-up Hub[452]. Last year, $9.2 million fund has been earmarked to give the city's younger population access to jobs in the tech industry. This capital has attracted significant investment from the biggest tech players such as Google, Facebook and Apple.
- **Regulatory framework:** It has been stated that the 800-year old history of finance thanks to favourable regulatory landscape in support of it. Over the last few years alone, initiatives such as Innovate Finance's Industry Sandbox and the Financial Conduct Authority's Regulatory Sandbox have helped fintech start-ups connect with established financial institutions and regulators. It has enabled the industry to pool its resources to develop solutions to shared problems, and for fintechs to test their products in a safe space. Thanks to that spirit of collaboration, London is widely accepted as the fintech capital of the world.
- **Innovation Hub:** London is making efforts to remain an innovation hub. In late 2017, announced a programme of investment days for London start-ups to provide coaching and connections for investors. City also recently appointed the city's first ever Chief Digital Officer.
- **Talents:** Access to talent as well as the vibrancy of innovation in London are shown as key success factors. London as a hub has historically benefitted from a rich stream of international tech talent, recruiting from a number of world-leading local universities within a relatively small radius.
- **Collaboration Network:** Network is what makes London strong. Easy access to international destinations thanks to many international airports, which make it easier to have clients across the world.

Paris

- **Access to Talents:** French government is actively taking steps to attract entrepreneurs. The country has the ambition to be a "start-up nation"[453] and is keen to take advantage of Brexit to boost the country's innovation hotspots. The launch of Station F-a start-up super hub backed by French telecoms is an indication of this ambition. Government has a positive impact on access to talents. There is great access to talent locally as the city hosts top schools in mathematics, engineering and business. In addition, new governmental regulations are facilitating the integration of EU and extra-EU talents from abroad. Access to large companies, capital and talent are mentioned as key success factors by the CEO of a tech company.
- **Access to Finance:** Amount of investment in Paris in the past 10 years is about half that of London at $60.6 billion by a network of around 2100 companies. Country's financial infrastructure can pose a challenge as there are fewer native, wealthy entrepreneurs to invest in angel rounds. However, the city attracts foreign investors such as Intel and Bosch to invest in Paris. Venture capital investments have increased tremendously in the past few years and more and more American (Sequoia, Khosla) and Asian (Naver) investors are either opening offices or investing in tech start-ups in Paris. In the past 10 years, there has been a notable growth in the number of investments in the medical and AI sectors, while the data and cloud services sector has recently experienced a dip. Top investors in Paris include a mix of private equity, venture capital, early-stage investors and accelerators, all of which tend to invest broadly across market segments, rather than concentrating on a few niche areas.

[452] https://www.bloomberg.com/news/articles/2017-11-02/mayor-of-london-launches-drive-to-keep-city-europe-s-startup-hub
[453] https://www.cnbc.com/2017/11/27/french-president-emmanuel-macron-wants-a-nation-of-internet-start-ups.html

- **Collaboration Network & Critical Mass of Companies**: App. 2000 companies in Paris creates a critical mass. These companies are mainly focusing on medical, food and drink, and social networking. AI is the fastest growing segment with a 168% growth rate (2014-2017).

Munich

- **Access to Finance:** The Federal state of Bavaria provides excellent support, both in the early stages of start-ups as well as for growth financing.
- **Collaboration Network:** The local start-up environment is pleasantly small (approximately 440 companies) and uncomplicated, people know each other, which makes networking easy.
- Many established, R&D-heavy corporations also have their headquarters in Munich, such as BMW and Siemens, and these help to incubate start-ups with investments and programmes.
- **Presence of Tech Companies:** International companies are launching hubs in Munich, including IBM's Watson Internet of Things (IoT) centre and Microsoft's IoT and AI Insider Labs. Tech Pioneer KONUX is a Munich-based, Industrial Internet of Things (IIoT) start-up which provides smart sensors and AI-based predictive analytics to the rail industry. Presence of these companies is an obvious enabler on the success of Industry 4.0. Top market segments in Munich are retail and online platforms, finance and fintech, and energy and sustainability.
- **Access to Talents:** Munich is an economic hub that offers entrepreneurs great infrastructure including access to top universities. Access to talent, the innovation environment, government support as well as the general quality of life in Munich stand out as big advantages. The proximity to local universities is very helpful to attract the best talents, especially first-class engineers, computer scientists and product managers. Both the Technical University and the Ludwig-Maximilian-University are rated among the world's top universities regularly. UnternehmerTUM, the Centre for Innovation and Business Creation at the Technical University of Munich.

3.3.5 Specific strategies and related measures lead by industry

In this section we analyse new strategies lead by industrial actors relevant to smart industrial specialisation and digital transformation. Specifically, we analyse strategies and related measures at EU level in section 4.1, at Member State level in section 4.2, and at regional level in section 4.3. Finally, in section 4.4, we analyse industry-led strategies and initiatives particularly relevant to the mobility industry.

3.3.5.1 Strategies lead by industry at EU level

In this section we analyse industry-led initiatives at EU level, relevant to smart industrial specialisation and digital transformation. Specifically, we analyse the SkillSET initiative, the Industrial Data Space Association, the Bosch Centre for Artificial Intelligence, the Cisco Networking Academy and the EU 2030 High-Tech Skills Programmes.

Programme	Leading Organisation	Focus
SkillSET	**WEF**	**SME Skills Learning**
Industrial Data Space Association	**Collaboration of Corporates and Research Institutions**	**Cybersecurity**
Bosch Centre for Artificial Intelligence	**Bosch**	**Artificial Intelligence R&D**
Cisco Networking Academy	**Cisco**	**ICT skills & certifications**
EU 2030 High-Tech Skills Programmes	**IBM**	**IoT, Big Data, Cloud Computing**

SkillSET (WEF)

SkillSET is a programme of the *World Economic Forum* that tackles the **global skills gap** to address job displacement arising from the 4th Industrial Revolution.[454] Therefore, it provides **resources and training opportunities** in form of a portal and it is committed to **reaching 1M people by January 2021**. Although conceived by the WEF, the programme is primarily driven by its **global and European industry leaders**, such as Accenture, Cisco, Hewlett Packard Enterprise (HPE), PwC, Salesforce, and SAP.

The main operation of the programme is the creation of a **platform for online tools** to streamline the reskilling process. Therefore, participating companies open up key elements of their individual training libraries, for which **users will have free access**. This provides a great up-to-date content over a wide array of topics, such as cybersecurity, big data or IoT. Furthermore, a **tailored Skills Assessment** – developed by PwC – helps users to select coursework and learning pathways. The platform is hosted on EdCast[455], an **AI-powered Knowledge Cloud** platform. The first iteration will be available from **April 2018**.

SkillSET is an early stage programme; yet, the common vision of signed industrial partners under the WEF's patronage is a significant success, since the programme promises to **benefit all parties**, SMEs, corporates, public institutions and employees. In addition, the coalition still adds members and planned to develop tools and processes to address major barriers, which keep preventing adults from reskilling and successfully completing trainings.

Industrial Data Space Association

The *Industrial Data Space Association* (IDSA) is based in Germany and **serves businesses worldwide b**y integrating research regarding **industrial data space**. Therefore, the association engages in **networking and lobbying on the international level**, shares its experience and expertise with **corporates and SMEs** and is a main **exchange hub between research institutions and businesses**. It was founded in 2016 at the **Fraunhofer Forum in Berlin** with multiple private founding partners, such as Volkswagen, Otto, ThyssenKrupp and PwC.

[454] Note: WEF (2017): "Accelerating Workforce Reskilling for the Fourth Industrial Revolution"
[455] Note: EdCast.com

Industrial data space plays a significant role for **data security and digital sovereignty** for businesses across sectors. Hereby, the association supports SMEs, corporates and research institutions by formulating **binding common rules** between business partners, developing **new business models**, and new use cases in particular regarding the sharing economy.[456] This facilitates a **secure and fluent exchange of data** among business partners across all industries, for instance, in life sciences, traffic management, and high performance supply chains.

Bosch Centre for Artificial Intelligence

The Bosch *Centre for Artificial Intelligence* is a **multinational programme** with locations in **Germany, USA and India** to advance the usability of **AI across multiple products and services**. Next to advancing the state-of-the-art of AI research, this programme also provides for a **short way from R&D to adoption**, as Bosch already implemented innovations such as to **improve quality monitoring systems** and to **analyse process data**. Bosch invested **€300 million** in the centre until 2021.

One of the key collaboration partners of the centre is the **University of Amsterdam**. Collaboratively, they created the "Delta-Lab" in Amsterdam to further **deep learning technologies** jointly with researchers from Bosch and the university.

In the R&D activities of the centre, Bosch pursues by a concept of "security and privacy by design" to promote and ensure highest standards of **cybersecurity**. In this regard, the international programme and the **locations at India and the US benefit from the comparatively strict legal framework of the EU**.[457]

The Cisco Networking Academy

The Cisco Networking Academy is an IT skills and career-building programme for learning institutions and individuals worldwide, providing **education, technical training and career mentorship services**. Currently **present in all 28 Member States**, the programme is a pillar of Cisco's corporate social responsibility policy, and delivers **classroom instruction, online teaching materials, interactive tools and hands-on learning** to students from all socioeconomic backgrounds.

Since its inception in 1997, over 8 million students in 180 countries have been through the programme[458], with about 1.3 million in Europe alone[459]. While online content and courses are also available, the **majority of content is delivered in person through affiliated educational institutions in local communities, of which there are 2,799 in Europe.**[460] Cisco has also partnered with other companies including IBM and Verizon to enhance the employment opportunities for students who graduate with entry-level Cisco certifications.

[456] http://www.industrialdataspace.org/en/industrial-data-space/#anwendungen
[457] https://www.bosch.com/de/explore-and-experience/kuenstliche-intelligenz-interview-mit-peylo/
[458] https://www.netacad.com/
[459] https://www.netacad.com/documents/312601351/0/7f03974e2c1d9e402705a713928defb1.pdf/e803f9de-2841-41a1-baf1-a8bda5796e77
[460] https://www.netacad.com/documents/312601351/0/7f03974e2c1d9e402705a713928defb1.pdf/e803f9de-2841-41a1-baf1-a8bda5796e77

The programme is currently focused on **Internet of Things technologies**, but is designed to provide students with a broad range of skills related to foundational ICT, general ICT, essential technologies, emerging technologies and careers. It provides a **skills-to-jobs learning experience**, a supportive ecosystem and a global delivery platform with the goal of developing graduates who innovate as technologists, think as entrepreneurs and act as social change agents.

IBM High-Tech Skills Programmes

IBM runs several corporate citizenship programmes focused on developing a high-tech workforce in Europe, in recognition of the fact that half of academic and business leaders believe higher education is not meeting the demands of students (51%), industry (59%) or society (53%).[461] These include the IBM Academic Initiative, which provides professors and students access to the latest technologies in open source and IBM software, hardware, course materials, training, technical support and other resources, as well as SkillsBuild – a learning programme for primary and secondary school students that uses exercises and hands-on kits to better understand technologies. SkillsBuild offers easy access materials for use with students and teachers, and has reached over 1 million youth in 2018.[462] IBM is also pursuing a number of innovative models for developing 'New Collar' skills – those that employers in many industries demand, but which most graduates still lack – including supplemental programmes for professional training and badging, and new models for lifelong talent development. Further programmes include IBM Volunteers, P-TECH and the Think Academy.

3.3.5.2 Strategies lead by industry at Member-State level

In this section, we analyse industry-led initiatives at Member-State level, relevant to smart industrial specialisation and digital transformation. Specifically we analyse the High Tech Strategy in Germany, the Sirris Hub in Belgium, the Smart Data Innovation Lab in Germany, the SME Harbour in the UK, the Cybersecurity Competence Centre (C3) in Luxembourg, and the Cisco Kinetics for Manufacturing, which is featured in multiple countries throughout Europe.

[461] https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=GBE03788USEN&
[462] https://www.ibm.com/volunteers/skillsbuild.wss

Table 16: Member State, Lead Organisation and Focus by Programme/Initiative

Programme	Member State	Lead Organisation	Focus
High-tech Strategy	**Germany**	**DFDK**	**AI research and implementation**
Sirris Hub	**Belgium**	**Agoria (Federation of technological industry)**	**SME Technology & Corporate Innovations**
Smart Data Innovation Lab	**Germany**	**Collaborative Corporate and Research Group**	**Research Innovations**
SmartFactory^{KL}	**Germany**	**Technologie-Initiative SmartFactory KL e. V.**	**Industry 4.0 Demonstration**
SME Harbour	**UK**	**Atos**	**SME Skills & Corporate Innovation**
Cybersecurity Competence Centre (C3)	**Luxembourg**	**Security Made in Lëtzebuerg (SMILE)**	**Threat & vulnerability detection, training & testing.**
Cisco Kinetics for Manufacturing	**Multiple**	**Cisco**	**Corporate digitisation with IoT and Big Data**

German Research Centre for Artificial Intelligence-DFDK (Germany)

The *German Research Centre for Artificial Intelligence* (DFKI) is a national public-private player to provide **research facilities and expertise** in the field of **innovative commercial software technology by using AI**. The DFKI receives funding from multiple industrial partners and government agencies, including the EU and national ministries.[463]

The DFKI is the largest AI research centre in Germany. At this time, it has 14 research departments with 413 researchers and over 270 graduate students working on more than **230 research projects**. Industry 4.0, Health & Medicine, Farming and Agricultural Technology, Learning and Education, Mobility, Smart Home / Assisted Living, Environment & Energy, Knowledge & Business Intelligence, Financial Sector are among main fields of application. The centre is home to multiple breakthrough projects, such as "RES-COM", which examines the vision of an automatised conservation of resources through interconnected sensor-actuator systems.[464]

Sirris Hub (Belgium)

Sirris Hub is a centre for and by the technological industry to **promote innovation across SMEs and corporates**. It offers support throughout all stages of businesses, "from the drawing board stage right through to prototype development and pilot tests"[465]. The acquired **know-how of any**

[463] www.dfki.de
[464] www.res-com-projekt.de
[465] http://www.sirris.be/about

cooperation is accessible for other companies at the **collective centre of Sirris**. Therefore, this programme facilitates companies to help each other, as well as the Belgian industry as a whole to forge ahead. Sirris was founded by the Agoria, the Federation of the technological industry.
The services of Sirris include a **nation-wide technology testing infrastructure, a partner network, and cross-industrial expertise**. Furthermore, Sirris has 140 engineers, scientists and technicians and supports approximately 1,500 industrial companies on a yearly basis. 75% of these companies are SMEs.

Smart Data Innovation Lab (Germany)

The Smart Data Innovation Lab (**SDIL**) is a programme of **corporates** and **research institutions** that provides researcher with **access to a variety of big data and in-memory technologies**. The majority of research projects focus on strategic research on **Industry 4.0, Energy, Smart Cities and Personalised Medicine**. Additionally, the SDIL provides extensive **support on all research projects at no costs**. It is run by private and research core partners, such as SAP, Siemens, IBM and the KIT. The main goal of the SDIL is to accelerate innovation cycles using smart data approaches. It combines partners sponsoring technology, industry partners with their real use cases and research partners with algorithms and innovation in a WIN-WIN-WIN collaboration.

The operational services of the programme are manifold. It provides for hardware and software to enable researchers to **perform big data analytics with state-of-the-art facilities**. Additionally, it provides for **anonymisation tools** for all sources, an extensive research and corporate network and support for legal and security agreements.[466]

Smart FactoryKL (Germany)[467]

The SmartFactoryKL technology initiative was established as a non-profit organization in 2005, bringing together for the first time industrial and research partners (i.e. DFKI, BASF, KSB, Pepperl&Fuchs, ProMinent, Siemens, TU Kaiserslautern) in a network to implement joint **Industry 4.0 projects** for the **factories of the future**. In 2016, SmartFactoryKL lead the consortium to open up **SME 4.0 Competence Centre** Kaiserslautern funded by the Federal Ministry for Economics and Energy (BMWi) to support SMEs in the areas of digitalization and Industrie 4.0.
Currently, SmartFactoryKL is a network of around 50 member organizations from industry and research. These partners perform research and development projects related to Industrie 4.0 and the factory of the future collectively. The work ranges from developing their vision and preparing descriptions all the way to industrial testing and implementation. Thus, it is a kind **manufacturer-independent demonstrator and research platform**, where promising, innovative Information and Communication Technologies (ICT) are evaluated and further developed in a realistic, industrial production environment. The Technology Initiative has already developed products and solutions as well as universal **Industry 4.0 standards** thanks to the active participation of its members. It also provides an **interactive digital twin platform**[468].

[466] http://www.sdil.de/en/partners#core
[467] https://smartfactory.de/en/, https://smartfactory.de/wp-content/uploads/2018/05/SF_BR_2018_FortschrittImNetzwerk_A4_EN_XS.pdf
[468] http://cognitive-factory.mybluemix.net/

The SME Harbour (UK)

The *SME harbour* is a programme to encourage an increased **participation of SMEs into projects of *Atos***. Atos is the leading organisation of SME Harbour and is a global digital services firm with presence in 73 countries. The key points of the programme are to gain access to the **SME ecosystem**, to collectively **develop business models** and to provide further **networking opportunities** with social and enterprise bodies.

The overarching objective of SME harbour is to **enable SMEs to partner with Atos** and to become **suppliers to the Public Sector**, in particular via the Government's G-Cloud procurement platform. Therefore, Atos also collaborates with the **Science and Technology Facilities Council** (STFC). The scope of the programme focuses on opportunities in the United Kingdom.

The provided services for SMEs are as follows:

- Short payment terms (30 days);
- Access to Atos's client base;
- Aales support across several markets;
- Tailored legal terms and conditions to limit risk;
- Advice, information and mentorship;
- Potential to develop a specific offering and subsequent sales.

Furthermore, also **Atos's public and private sector clients benefit** from the SME Harbour. As a model to harness innovation, it enables Atos to provide new services of leading edge technologies and specialist business knowledge to their clients.

Infoshare is one of the cases to demonstrate the **success of the SME Harbour**. According to Infoshare Managing Director, Pamela Cook, the SME Harbour was "impressive both with their attitude towards **welcoming Infoshare as an innovative SME** into their world and to **championing Infoshare across the organisation**".[469]

Cybersecurity Competence Centre (C3) (Luxembourg)

The Cybersecurity Competence Centre (C3) was launched in October 2017 with the goals of empowering businesses to better protect themselves and further strengthening the field of cybersecurity in Luxembourg.[470] C3 is part of a comprehensive cybersecurity ecosystem in Luxembourg driven originally by the needs of the extensive financial sector, though it focuses particularly on areas such as Internet of Things, space technologies, fintech and autonomous driving.[471] C3 is specialised in threat and vulnerability detection, and offers training and testing services across observation, training and testing competencies, through three different membership packages. In addition to the regular service offering, C3 offers innovative approaches to cybersecurity such as its *Room#42* cyber-attack simulation game – a realistic, immersive experience for all participants that simulates a cyberattack situation alongside a session focused on awareness raising and good cyber crisis management practices.[472]

[469] https://atos.net/en-gb/united-kingdom/sme-harbour
[470] https://www.c-3.lu/#about
[471] https://www.luxinnovation.lu/wp-content/uploads/sites/3/2017/05/Luxembourg-the-smart-choice-for-your-digital-business_Luxinnovation.pdf
[472] https://www.c-3.lu/room42/

Cisco Kinetics for Manufacturing (multiple)

Cisco Kinetics for Manufacturing implemented multiple programmes across EU Member States to increase manufacturer's capabilities to **monitor energy consumption** in real-time. This amounts to an average saving of 18% of energy consumption, saves costs and **simplifies the sustainability reporting**. Therefore, Cisco leverages on technologies in the field of **IoT, Clouds and Big Data Analytics**.

For instance, in **Germany** the Cisco Country Digitization Accelerator delivered a platform to support companies to **digitize businesses** by supplying them with experience and technology across the whole Cisco portfolio. Similarly, in **Italy** Cisco developed such an accelerator in cooperation with ENEL to create new business opportunities, in particular by focusing on **Cybersecurity, IoT Services, and Automation**.

3.3.5.3 Strategies lead by industry at Regional and City level

In this section, we analyse industry-led initiatives at regional and city level in Europe, relevant to smart industrial specialisation and digital transformation. Specifically we analyse the Watson IoT Headquarter in Germany, the South Poland Cleantech Cluster in Poland, Station F and Prophesee, both in Paris, and Huawei Innovation & Experience Centre in Lisbon and Nuremberg.

Programme	Member State	Lead Organisation	Focus
Watson IoT Headquarter	**Germany**	**IBM/Watson**	**Internet of Things**
South Poland Cleantech Cluster	**Poland**	**NordicHouse Sp.Z.o.o.**	**SME Skills & Technology for Sustainability Innovations**
Station F	**Paris**	**Xavier Niel**	**Innovation & Entrepreneurship**
Prophesee	**Paris**	**Prophesee**	**Neuromorphic Vision / AI**
Huawei Innovation & Experience Centre	**Lisbon, Nuremberg**	**Huawei**	**SME Skills & R&D**
Pomurje Technology Park	**Slovenia**	**Pomurje Technology Park**	**Network, Expertise, Facilities for Technology SMEs and Start-Ups**
House of Start-Ups	**Luxembourg**	**Nyuko, LHoFT, Luxembourg City Incubator**	**Start-Up Training and Networking**
Cybersec Hub	**Poland**	**Kosciuszko Institute**	
Greater East Industry 4.0	**France**		
IMEC academy	**Belgium**	**IMEC**	**Digital learning/Nanotechnology**

Station F

Station F is a business incubator in Paris and noted as the **world's largest start-up facility**.[473] Based in a former railway depot it accommodates more than **1,000 start-ups** on a space of 34,000m^2. Furthermore, Station F provides for an **entire start-up ecosystem** with investors, public services and various start-up programmes under one roof. The objective of the programme is to **provide access to entrepreneurial business activities to a wide range of society**, also including people from disadvantaged social stratas.[474] French President **Emmanuel Macron** is a dedicated supporter of Serie F, yet, it is a private programme, initiated by the French entrepreneur **Xavier Niel**.

Prophesee

Prophesee is a key company in advancing the new technology of **advanced neuromorphic vision systems**. Inspired by the very human nature of eyesight, the Prophesee technology gives **metavision to machines** and reveals what previously has been hidden to them. Therefore, it captures hyper fast fleeting scene dynamics and manages extreme light chances of below 120db. As result, **machines react more intelligently, autonomously, faster and safer**.[475]

Recently, the company secured a **series B funding** and raised **$40 million throughout the last 3 years**. Furthermore, it is currently partnering with an unnamed consumer electronics company to further test and develop its technology. The company is French and based in **Paris**.[476]

Pomurje Technology Park Slovenia

The *Pomurje Technology Park* is a collaboration of 140 companies and over 50 universities, research institutes and schools with strong international outreach. The organisation is privately hold and mainly aims to support local SMEs by facilitating their R&D on technological innovations with expertise, networking and research facilities. Furthermore, the organisation also advances early stage entrepreneurs to found start-ups. In past 12 years, the *Pomurje Technology Park* supported projects across multiple tech-fields, such as telecommunications, polymere, metal technology and IT.[477]

South Poland Cleantech Cluster

South Poland Cleantech Cluster[478] is a programme to **promote innovations for a sustainable energy production and usage**. It focuses on renewable energy and materials, efficient resource utilisation, harm reduction and on reducing pollution problems. The programme is initiated and led by NordicHouse Sp.Z.o.o. which includes **30 shareholders of private companies, NGOs, and semi-state players**.

The scope of the programme comprises the **South Polish regions** of Maloposka, Silesia, Podkarpace, and Scietokrzyskie, which form one of the biggest industrial regions in the EU with a **total of 12M inhabitants**. In these regions, the programme focuses to develop **intellectual capital** to create a supportive infrastructure for an innovative and environment-friendly industry.

---

[473] https://www.wired.co.uk/article/station-f
[474] https://stationf.co/
[475] http://www.prophesee.ai/
[476] https://www.eetimes.com/document.asp?doc_id=1333062&cid=SM_ELE_EET_Edit&_mc=sm_eet_editor_junkoyoshida
[477] http://www.p-tech.si/eng/
[478] https://www.clustercollaboration.eu/cluster-organisations/south-poland-cleantech-cluster

The operations of the Cluster encompass multiple activities. These are categorized in **five streams**:

- Supporting start up creation and attracting investors
- Matchmaking in a network of B2Bs, R&D companies, start-ups
- Providing and conducting coaching and mentoring for SMEs and research institutions
- Testing and demonstrating products by providing research facilities
- Liaising with international organizations to further financial and research opportunities

Furthermore, the programme includes a dedicated secretariat, which organizes and operates a great share of these activities.

Currently, the South Poland Cleantech Cluster records **80 members**, which include 44 SMEs, 7 corporates, 9 research organisations, and 20 ecosystem actors. The main impact of the cluster for promoting European KETs is inextricably linked to the overall economic impact on the economy of the region. Thus, the programme defined a 5 years roadmap with the following expected milestones until 2019:

- Creating 50 new jobs
- Introducing 25 companies to the cluster
- Helping 50 entrepreneurs in their business development
- Facilitating 35 collaborative projects between companies and research institutions
- Starting 15 collaborations with international cleantech clusters
- Organizing a minimum of 100 events
- Becoming financially independent with a minimum of 250 members

Huawei Portugal Innovation & Experience Centre

In 2016, the *Huawei Portugal Innovation & Experience Centre* opened in **Lisbon, Portugal**. The centre aims to **create a local ecosystem of collaborating partners** and to support the domestic market by **creating innovative products and teaching young talents** in the ICT sector. For this aim, Huawei brings **global R&D technologies** and best practices to Lisbon. Furthermore, it seeks to **expand its training network**. In addition, Huawei launched similar *Innovation & Experience Centres* in other countries, such as **Nigeria, South Africa, and Germany.**

House of Start-Ups

The *House of Start-Ups* is a collaborative project of **multiple private actors in Luxembourg**, which recently gained **support by the Chamber of Commerce**. On **4200m²** it aims to support up to **200 Start-Ups and SMEs** under one roof to promote **new business models** and the **entrepreneurial ecosystem** in the Grand Duchy of Luxembourg.

At the core of the project is *Nyuko*, which was launched in 2015 to host and support entrepreneurs to **articulate business plans** and **early stage ideas** of innovations. Therefore, Nyuko accelerates ideas to transform into start-ups which enables founders to engage with incubators and investors. At this point, the *Luxembourg City Incubator* and the *Luxembourg House of Fintech* come to play to support the business development and expansion. As a result, the Luxembourg House of Start-Ups provides a comprehensive support from idea to advanced technology businesses under one roof.[479]

[479]Nyuko, 2016, Start Up Nation Luxembourg, Available at: https://nyuko.lu/

Cybersec Hub Poland

The *Cybersec Hub* is the first and foremost **competency centre in the Maloposka Region, Poland**. It combines 23 universities and colleges, 2000 ICT workers and 200 start-ups with global ambitions. It is led by the **Kosciuszko institute**, an independent, nonprofit, non-governmental **think tank** and **research institute**, which aims to leverage the regional ecosystem in order to promote the foundation of a Cyber Silicon Valley.

The *Cybersec Hub* gathers stakeholders in order to **create R&D and investment opportunities**. The first project launched is the *Cybersec Hub Accelerator* that supports **most promising and innovative start-ups** to scale up to their global market share. These projects comprise businesses such as **CyberusLabs**, **Securing** and **Voicepin**. The institute **launched its accelerator in 2016**.

IMEC Academy

IMEC Academy is part of IMEC, an innovation hub in nano electronics and digital technology which employs over 3,500 researchers. The Academy offers specialised online courses on nanotechnology and promotes research into educational technology. IMEC uses both technical and non-technical courses to engage with partners from industry and academia in their respective areas of expertise.
IMEC Academy's revenue stands at well over €1 million per year and its customised programs are used by 500+ participants, attracted by a continuously growing online offering. The company promotes its courses worldwide in order to secure talent for itself while **investing significantly in smart education R&D programs.**

Watson IoT Headquarters

The *Watson IoT Headquarters* in Munich is a **centre to foster IoT innovations**. It is created and part of IBM and works with and **for global clients and partners**. It is bringing together **extensive knowledge regarding IoT R&D under one roof**, including software engineers, programmers, architects, designers, cognitive scientists, and researchers of all career levels from student to CEO. The centre is ambitious to become the **"centre of the universe for cognitive IoT"**.[480]

Locally, Watson IoT Headquarters collaborates with **partners such as BMW or start-up accelerators** such as UnternehmerTUM. Next to extensive knowledge, the centre also provides for **state-of-the-art tools and electronic gear, such as laser cutters and 3D printers.** Furthermore, the centre invites IBM employees from around the world stay in the Watson IoT Residency Program, which allows a **high concentration of global knowledge in one location** to empower the R&D of prototypes at a very high speed.[481]

3.3.6 Initiatives specific to the 'Mobility Sector'

As seen in above section, there are numerous industry-lead initiatives in support of SIS&DT without any sector specificity. In parallel, there are many other initiatives specific-to-specific industrial sectors. However, within the scope of this assignment, sectorial demonstration is suggested for the 'Mobility Sector' only by the Commission Services so that some relevant good practices on SIS&DT specific to the Mobility sector are presented under this sub-section.

[480] https://www.ibm.com/blogs/internet-of-things/munich-hive-innovation/
[481] https://www.ibm.com/internet-of-things/spotlight/watson-iot-platform/idc-reports

Programme	Leading Organisation	Focus
Skillman	**Sector Skills Alliance for Advanced Manufacturing in the Transport Sector**	**Improving VET pathways for**
Engineer of the Future	**Airbus**	**Future engineering skillset, industry-academia cooperation**
Cyber Valet Services	**Cisco**	**Smart Mobility in Cities**
Training Academy	**BMW**	**Improve sales and after sales service**
Manufacturing Leadership development program	**Goodyear**	**Leadership and engineering skills**
Industry 4.0 Training Program	**SEAT**	**Raising awareness of industry 4.0 challenges**
Real World Training 4.0	**Bosch Rexroth**	**Technical training for Industry 4.0**
FEBIAC Lux Training	**The House of Automobile**	**Training for Industry 4.0**
Robotix-Academy	**Cross border research centre for industrial robotics**	**Robotics feasibility studies and demonstrations**

Skillman – Sector Skills Alliance for Advanced Manufacturing in the Transport Sector

The Sector Skills Alliance (SSA) Skillman is a worldwide network based in the EU tasked with **introducing skills, competences and innovative curricula** for the advanced manufacturing sector to vocational education and training (VET) pathways. The organisation has wide geographical coverage, and functions to connect industry and training providers with civil society to provide support services that drive growth and effectiveness for its members. It was launched in 2015 with funds from the European Commission and has become the largest multilateral EU network, combining deep knowledge of skills needs and training practices with a well-organised, systemic and sector-related information system. Skillman is a one-stop-shop providing **state of the art solutions to the competency and skills needs of the automotive, aerospace and train industries**, and was founded by a combination of educational providers, industry leaders and accreditation bodies in cooperation with research centres and regulatory bodies.[482]

The educational programmes promoted by the SSA are mainly aimed at younger people undertaking tertiary VET qualifications, workers involved in short-cycle qualifications aimed at **reskilling or upskilling**, and trainers desiring access to state of the art educational materials concerning advanced manufacturing in the transport sector. The SSA takes an open approach allowing external stakeholders to participate in and contribute to the sharing of knowledge and experience, creating synergies and opportunities for lessons learned in the past to inform the curricula of the future. Key players cooperate with educational providers to **diagnose skills needs and jointly design VET programmes in line with current and emerging technologies,** with a focus on three key

[482] http://skillman.eu/

problem areas: energy performance of production processes and end products; advanced processes, robotics and use of advanced combined materials; and 'infotechment' and the use of ICT and wireless technologies.[483]

Airbus - the Engineer of the Future

Airbus' *Engineer of the Future* is a yearly evolving whitepaper started in 2014 by the Airbus Global University Partner Programme (AGUPP). Its purpose is to **capture key points from the ongoing dialogue** among AGUPP stakeholders about the **skills and competencies needed by future Airbus engineers**, and **how Airbus can work together with universities to develop them**. It is developed and shared within the AGUPP community to provide insights and inspiration, and Airbus employees participate in the programme development structure of each partner university[484]. The AGUPP has 21 partner universities in 11 countries and has produced approximately 40,000 master graduates in IT, design and engineering disciplines.[485]

The whitepaper is a mechanism by which Airbus **articulates a clear vision of the graduate engineering skills it needs**, partner universities remain informed of this vision, and Airbus and partner universities **work effectively together to develop and realise this vision** on an ongoing basis. It is both a recognition that the skills and competencies required by Airbus are changing faster than the systems in place to provide those skills and competencies, and an platform for facilitating communication and collaboration with higher education institutions to mitigate the talent shortages prevalent in key fields. To this end, the activities of the AGUPP include developing strategic competencies (technical and soft skills), developing training courses with specific focus on innovation, and supporting universities to encourage diversity among young engineering students and graduates[486].

Airbus' focus on innovation capacity is strongly linked to an engineer's ability to understand and appreciate other business functions. As such, the traditional 'T-shaped' engineer is becoming a 'Pi-shaped' engineer, with the extension to the 'π' shape representing an engineer's understanding of and ability to work with other business disciplines. In this regard, soft transferrable skills are of great significance, given the rapid pace of technological change, with the one of the most important ability being communication, team work, international as well as inter-cultural understanding.

BMW – Training Academy

German automobile manufacturer **BMW[487]** has made a substantial investment in an **industry-leading training facility** where it plans to provide advanced training to its **45,000 employees worldwide**. Up to 450 participants will be taught in the EUR 33 million facility every day, salespeople and service engineers will follow lessons using **state of the art devices** (for instance a virtual reality room) with an emphasis on **practical learning**. Service engineers will focus on electrical engineering and electronics using some of the 70 training stations for BMW and Mini models while over 10,000

[483] https://www.up2europe.eu/european/projects/sector-skills-alliance-for-advanced-manufacturing-in-the-transport-sector_101145.html

[484] https://company.airbus.com/dam/assets/airbusgroup/int/en/jobs-and-careers/Partnerships-Competitions/The-Engineer-of-the-Future-2018/The%20Engineer%20of%20the%20Future%202018.pdf.

[485] https://company.airbus.com/dam/assets/airbusgroup/int/en/jobs-and-careers/Partnerships-Competitions/AGUPP-Annual-Report-2017_/AGUPP%20Annual%20Report%202017_.pdf

[486] http://company.airbus.com/news-media/press-releases/Airbus-Group/Financial_Communication/2017/04/Airbus-Global-University-Partner-Programme.html

[487] https://www.press.bmwgroup.com/united-kingdom/article/detail/T0016629EN_GB/bmw-group-opens-training-academy-in-unterschleissheim-near-munich?language=en_GB

German dealer staff will receive additional **sales training** at the centre. Employees from **overseas dealership locations** will be invited to the premises as well to pass on the knowledge acquired in their home countries. **BMW has been awarded an outstanding grade for its modern apprenticeship programmes** by the German government's Adult Learning Inspectorate.

Cisco Cyber Valet Services

Cyber Valet Services is a **smart mobility solution** and a joint programme of *Cisco* and French automotive supplier *Valeo*. It allows vehicles to **park automatically in connected car parks** without drivers on board, based on a smartphone app. The technology is based on the Valeo **automatic parking technology**, **wi-fi**, **video sensors**, and **AI**. The aim is to have acquired 9 million connected cars (20% of French automotive fleet) and 460,000 indigo parking spaces **by the year of 2021**. Even though the public sector does not have a direct role in this project, the **public strongly benefits** due to the improved mobility in the urban area.[488]

Goodyear Manufacturing Leadership Development Programme

Goodyear Tire & Rubber Company has developed a one-year leadership programme to foster the leadership skills among its employees. Through several hands-on manufacturing assignments, participants acquire and hone skills in technology and maintenance engineering as well as area management. The workshops are designed to favour interdisciplinary flexibility among workers, whom will have to work closely with manufacturing professionals from different disciplines. What's more, participants also take part in a leadership development workshop designed to give them insights into problem-solving methods and improve their managerial skills.[489]

SEAT Industry 4.0 Training Programme

Spanish Car manufacturer *SEAT* has been developing a **training program aimed at tackling future challenges facing Industry 4.0**. All of its 14.000 employees will get a chance to participate in the program to gain an in-depth understanding of smart industrial technologies by learning with interactive platforms (VR, AR, collaborative robots, 3D printing etc.). SEAT also wishes to **stress the relevance of continuous training of its employees** by spending an average of 16 million Euros on leadership and technical training, of which most supports the frequent modernisation of its **centre of excellence in professional training**.[490]

The House of Automobile - FEBIAC Lux Training

FEBIAC Luxembourg has designed a training program for **automobile manufacturing companies** - giving them the tools needed to **adapt to the numerous changes happening with digitalisation**. The program has 3 specific aims: First, adapting to changes in **customer needs and behaviour**; secondly, benefiting from opportunities linked to **market evolution**; and thirdly, **supporting profitability** of business in the industry.

The training focuses on **enabling strategic thinking** in participants - being forward thinking is essential in order to adapt in a rapidly changing industry. Courses like operational management of a dealership, team management and coaching, recruitment as well as digital marketing and social media are addressed to managers and salespeople while more technical classes (e.g. crash courses on new engine types) will target technicians.

---

[488] https://www.valeo.com/en/valeo-and-cisco-innovate-for-smart-parking-service/
[489] https://corporate.goodyear.com/en-US/careers/recruiting/manufacturing.html
[490] https://www.volkswagenag.com/en/news/stories/2017/08/fully-engaged-in-the-digital-transformation.html

Bosch Rexroth Real-World Industry 4.0 Training

Bosch Rexroth has been implementing Industry 4.0 solutions in its own factories and thus gained profound experience in **designing training courses, systems and media to provide technical training for technologies of the Industry 4.0**. Rexroth recently unveiled the training content t**argeted at university students and apprentices in production and logistics for working in networked environments.**

Its hands-on training packages reveal how work life will be impacted by networked environments and highlights the new key qualifications that technical specialists will require in the future. The courses rely on the **mMs4.0, a physical training system,** which Rexroth developed to teach content in a practical manner. The flexible working station can be adapted to different needs and includes all of the functions of a complete production system (including logistics), allowing students to grasp and practice Industry 4.0 content rapidly.[491]

Robotix-Academy – Cross border research centre for industrial robotics

The Robotix-Academy research centre provides three types of expertise, all focused on the **implementation of robotics in manufacturing processes.** Its core competencies are in the three areas of Consulting, Demonstrators and Workshops. In terms of consulting, the lab performs **feasibility studies** and research projects with partners for firms in the technology industry. Furthermore, it showcases new equipment based on practice for new technologies such as different kinds of robots and automated systems. Finally, in order to **exchange with industrials** and users of technologies and technology providers in robotics, the Robotix Academy also regularly organises roadshows, meetings in industry and workshops.

3.4 Specific efforts targeting SMEs and Start-ups

EU already set-up policy framework in support of SMEs, namely 'Small Business Act', in order to create right SME friendly ecosystem for boosting the performance of SMEs across all sectors. Recently, specific focus has also been given to specific SME segments such as micro-SMEs, Start-ups, Scale-ups etc. The following can be listed as the most relevant EU policies designed specifically for SMEs in general:

- The EU Small Business Act
- SME Action Programme
- Start-up and Scale-up initiative
- Entrepreneurship Action Plan 2020

Above-mentioned policies have been implemented at the National Levels at varying degrees. In order to achieve the policy objectives, we see various types of initiatives being set-up in support at all levels.

The tables below presents non-exhaustive list of some **initiatives** mainly aiming to provide technical support to **SMEs, start-ups and/or scale-ups** concerning digital transformation and deployment of KETs for achieving Industry 4.0 **at EU, National, Regional and City levels.**

[491] https://www.boschrexroth.com/en/xc/company/press/index2-19968

Table 17: EU level initiatives in support of SMEs, Start-ups and Scale-ups

EU Level Initiatives				
Name of the Initiative	**Brief Definition**	**SMEs**	**Start-ups**	**Scale-ups**
EIT –KICs Acceleration Programmes for Start-ups under thematic KICs[492]	EIT –KICs Acceleration Programmes for Start-ups under thematic KICs is the only EU accelerator programme focused on climate impact by cleantech commercialisation. It is Europe's largest cleantech accelerator for early stage start-ups. It is focused upon getting start-ups ready for their first investors and customers and helps them scale their business.		X	
Supercomputing Expertise for SMEs: Sesame Net[493]	SESAME Net boosts the usage of high performance computing-technology by small and medium-sized enterprises. The network works on strategies for improving the services offered to SMEs and raise awareness of the benefit and opportunities of High Performance Computing technologies.	X		
ACTPHAST 4.0 - Accelerating Photonics Innovation for SME's: a One-Stop-Shop Incubator[494]	ACTPHAST 4.0 (ACceleraTing PHotonics innovAtion for SMEs: a one stop-shop-incubator) is a unique photonics innovation incubator for Europe which is perfectly aligned with the needs of SMEs in overcoming the challenges and seizing the opportunities afforded by the new digital revolution of Industry 4.0 in which photonics technologies are a key enabler.	X		
S3-Industrial Modernisation Platform-Thematic topic on : SME integration to Industry 4.0[495]	The main objective of this partnership is to involve SMEs to the Industry 4.0 paradigm by increasing their absorption of specialised digital services. There is an identified need to facilitate the transition of SMEs towards the Industry 4.0 paradigm,	X		

[492] https://eit.europa.eu/eit-community-start-ups
[493] https://sesamenet.eu/
[494] http://www.actphast.eu/about-us
[495] http://s3platform.jrc.ec.europa.eu/sme-integration-to-industry

	to boost their integration into digital (global) value chains by fostering the adoption of specialised digital services and to increase data collection in order to monitor the production.			
Digital Innovation Hubs [496]- National/Regional Excellence Centres	Digital Innovation Hubs are one-stop-shops that help companies to become more competitive with regard to their business/production processes, products or services using digital technologies. They are based upon technology infrastructure (competence centre) and provide access to the latest knowledge, expertise and technology to support their customers with piloting, testing and experimenting with digital innovations.	X	X	X
Startup Scaleup- Startup Europe IoT Accelerator[497]	Startup Scaleup is a 6-month accelerator program for IOT start-ups funded by the European Commission. Startup Scaleup does not offer any financial contributions to selected start-ups. The added value of Startup Scaleup is access to tools and people that can help speeding-up the process of bringing your IOT innovation to the market and to the clients.		X	X
My-Way Web Entrepreneurship[498]	MY-WAY aims at enhancing and improving the collaboration and efforts of web entrepreneurship initiatives (hubs, projects, accelerator networks, contests, etc.), web/business experts (accelerators, mentors, etc.), educational actors (business teachers and trainers) and the young adults as the final beneficiaries (through student networks and student entrepreneurship centres).		X	

[496] http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool
[497] http://startup-scaleup.eu/
[498] http://www.mywaystartup.eu/about

Start-up Europe[499]	The 4 main objectives of Startup Europe are to connect people, connect local start-up ecosystems by supporting regional initiatives, help start-ups soft-land in other markets, and celebrate entrepreneurs' success.		X	

[499] http://startupeuropeclub.eu/about-us/

Table 18: National level initiatives in support of SMEs, Start-ups and Scale-ups

National Level Initiatives				
KETs Technology Centres[500] at National Levels	These centres can help SMEs to speed up the commercialization of their innovation ideas by providing services such as help with prototyping, testing, upscaling, first production and product validation.	X		
Labs Network Industrie 4.0[501] (DE)	It aims at supporting the German mid-sized sector in taking a leading role in the global digitalization. As a member, companies can experience and test new technologies, innovations, and business models in test centres in the environment of Industrie 4.0 and review their economic feasibility prior to their market launch.	X		
Sirris Hub[502] (BE)	Sirris is the collective centre for and by the technological industry. It offers Belgian companies three key assets to help them remain innovative: years of experience and comprehensive expertise in a wide range of industries; high-tech testing infrastructure spread across the country; and an extensive network of partners. This way it helps large and smaller players in Belgian industry make the right technological choices and achieve sustainable economic growth.	X		
Scale-Up Denmark[503] (DK)	Scale-up Denmark is a training concept for entrepreneurs and small enterprises. The aim is to establish an elite group of high growth companies in Denmark. Scale-Up Denmark is a cross regional initiative founded on the regional business development strategies.			X
Mittelstand 4.0 — Digital Production and Work Processes[504] (DE)	Digital Production and Work Processes' initiative is to support SMEs in digitising, networking and introducing Industry 4.0 applications. The objectives of the programme include raising SMEs' awareness of the technical and economic challenges of digitisation and supporting the development of secure digital solutions and processes tailored to meeting market needs.	X		
Innovation Voucher[505] (FI)	The incentive introduced by Tekes (Finish Agency for Innovation) in order to encourage SMEs and micro businesses to launch innovation activities seeks to provide SMEs with access to knowledge providers such as research institutes, universities and consultants which could help them translate innovative ideas into market success.	X		
Start-up-grant[506] (FI)	The initiative aims to encourage new business and promote employment. The grant ensures an income for entrepreneurs during an estimated period required to set up the business, with a maximum of 12 months.		X	
TEPICH II (GR)	This policy measure aims at facilitating the access to finance for new and existing companies, particularly microenterprises and SMEs. The Fund will provide access to	X		

[500] https://ec.europa.eu/growth/tools-databases/kets-tools/kets-tc/map
[501] https://lni40.de/?lang=en
[502] http://www.sirris.be/about
[503] https://scale-updenmark.com/
[504] https://www.mittelstand-digital.de/MD/Redaktion/DE/PDF/faktenblatt-mittelstand4.0-englisch,property=pdf,bereich=md,sprache=de,rwb=true.pdf
[505] https://www.enterprise-ireland.com/en/research-innovation/companies/collaborate-with-companies-research-institutes/innovation-voucher.shortcut.html
[506] http://www.te-palvelut.fi/te/en/employers/for_entrepreneurs/services_new_entrepreneurs/startup_grant/index.html

	finance through loans and guarantees for establishing new innovative, outward-looking and dynamic businesses; developing already existing businesses through their technological and organisational modernisation; strengthening their operation by introducing innovative practices; and strengthening businesses or other organisations active in the social economy.			
Operational Programme in Region Western Greece[507]				
Magyar vállalkozói porlál elindítása (HU)	The key objective of the "Hungarian business e-portal" is to provide relevant information for new and existing entrepreneurs, SMEs and start-ups, according to a life cycle-based structure.	X	X	
"Italia Venture I" Fund[508] (IT)	The Fund aims to support innovative SMEs and innovative start-ups operating in high-growth sectors or launching new products/services innovations.	X	X	
Patents+2 (IT)	The program seeks to support micro enterprises and SMEs in the economic exploitation of patents	X		
Law on Aid for Start-up Companies[509] (LV)	The main aim of this piece of legislation is to promote the creation of new companies and to foster the development and research of innovative ideas, products and processes.		X	
Startup Visa program[510] (LT)	The program is a legislation of simplified rules and regulations for non-EU Start-ups to get a temporary permit, provided they operate in an innovative field and have enough financial resources to achieve their goals for one year. The programme aims to bring high-impact, operating in new technologies that will help to spread innovative ideas and in the same time create new jobs in the field of ICT.		X	
Fit 4 Digital[511] (LU)	It is an initiative launched by the Ministry of Economy and Luxinnovation aimed to improve competitiveness of Luxembourgish companies, in particular SMEs, by introducing new digital tools. The programme was adopted in 2016 and identifies what information and communication technologies (ICT) opportunities exit and how the new processes can be introduced in the respective company.	X		
Start-up Investment Grant Scheme[512] (MT)	The initiative assists start-ups engaged in activities such as research and technological innovation, ICT development or eco-innovations, among many others.		X	
TekDelta[513] (NL)	The initiative aims to provide start-ups easy access to high-end research labs, world-class experts and state of the art technology. The initiative is forging connections between start-ups and corporates, facilitating connections between the two domains.		X	

[507] http://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/greece/2014gr16m2op005
[508] http://www.invitaliaventures.it/site/ventures/en/home/fund/welcome-to-italia-venture-i-fund.html
[509] https://www.em.gov.lv/en/news/13242-adopted-law-on-aid-for-start-up-companies
[510] http://www.startupvisalithuania.com/
[511] https://www.luxinnovation.lu/innovate-in-luxembourg/performance-programmes/fit-4-digital/
[512] https://businessenhance.gov.mt/en/schemes/Start-upInvestmentGrantScheme/Pages/Start-up-Investment-Grant-Scheme.aspx
[513] http://tekdelta.nl/

ScaleUP (PL)	The main objective is to accelerate the development and growth of start-ups by, at the same time, fostering cooperation with large and state-owned companies. This goal will be achieved through the combination of entrepreneurs' potential and creativity with companies' infrastructure, experience and resources.		X	
Vale Incubação (PT)	It is a measure aims to support companies with less than a year of activity by providing incubation services in the area of entrepreneurship. The objective is to boost entrepreneurial capacity and foster the acceleration and success of new companies.		X	
CTT E-commerce in box (PT)	Project mobilized by CTT to create a Marketplace of national companies to boost the process of digitization and sale online of Portuguese companies. It is intended to create a solution with the support of national reference partners that confers trust, traction and complementarity in terms of e-commerce skills.	X		
Road show "Robotics" (PT)	Launching of a roadshow with the theme of integration of robotics, sensing and automation in Portuguese companies. It will be aimed at industrial SMEs interested in innovating their production process with the latest technology, demonstrating new business models.	X		
Oslobodenie od dane z príjmu pre start-upy (SK)	According to the measure, start-ups offering innovative solutions are exempted from income tax, including the exemption from the tax license for the first two years of their existence. The main objective of the measure is to support the growth of start-ups in Slovakia in order to minimise the financial burdens limiting the growth of the new companies.		X	
Programme of financial instruments and measures of the MEDT for the period 2015-2020[514] (SI)	The main objective of the financial programme 2015-2020 is to promote and support entrepreneurship, in particular to boost the creation of new businesses, start-ups, the growth of SMEs, the promotion of innovation activities in SMEs as well as international competitiveness and clustering.	X	X	
CEVIPYME (ES)	The platform provides information and personal assistance to SMEs on how to protect their intellectual property rights.	X		
"Opportunities for SMEs and micro-businesses to investigate new approaches to user experience" (UK)	Programme launched by Innovate UK in 2015; the main goal is to help companies to discover new and improved ways for machines, their computing systems and people to interact.	X		

[514] http://www.eu-skladi.si/sl/dokumenti/kljucni-dokumenti/op_ang_final_web.pdf

Table 19: Regional and City level Initiatives in support of SMEs, Start-ups and Scale-ups

Regional and City level initiatives				
Name of the Initiative	**Brief Definition**	**SMEs**	**Start-ups**	**Scale-ups**
Île de France (FR) : French Tech	The programme identifies cities providing proactive support to ICT start-ups. The label aims to foster and streamline the development of local digital innovation ecosystems- mainly those outside of the Paris area which concentrates today 50% of France´s potential- and to promote them at the international level.		X	
Paris (FR): Start-up scene Station F[515]	Station F is the biggest start-up campus in the world and it is located in Paris.		X	
Vienna (AT): Call Start Tech Vienna[516]	The Call Start Tech Vienna promotes research projects leading to product, service and process innovations. They are based on a growth-oriented, scalable business model, not older than five years, and advanced technology, which is ahead of its time. These projects are characterized by their high versatility and cross-sectional technologies.		X	
Valencia (ES): Valencia Urban Laboratory for Innovation[517]	The Lab is an entity promoted by Valencia City Council, responsible for municipal innovation policy. It aims to promote innovative solutions to real problems of citizenship and urban challenges, strengthening social structures of territory, through knowledge and technology, putting innovation at the service of citizenship.		X	
Antwerp (BL): City Of Things[518]	It is a one-of-a-kind initiative, connecting 200.000 urban citizens with developers and tech entrepreneurs, through a massive amount of smart devices spread over the city of Antwerp		X	X
Bristol (UK): Bristol is Open[519]	Bristol is Open, which is a joint venture between Bristol City Council and the University of Bristol. This has resulted in a Smart City Research and Development network platform of multiple communications technologies installed around the city. This platform is allowing companies of all sizes to come and test new technology in a real-world environment.	X	X	X
Paris (FR): Option Startup[520]	Option Startup allows more than 10,000 young people from 20 academies to discover with their teachers' start-up projects, entrepreneur and job profiles.		X	

[515] https://stationf.co/
[516] https://viennabusinessagency.at/funding/programs/abgeschlossen-call-start-tech-vienna-2016-57/
[517] https://ec.europa.eu/eip/ageing/commitments-tracker/d4/val%C3%A8ncia-urban-lab-innovation-build-more-age-friendly-city-and-environments_en
[518] https://www.imec-int.com/en/cityofthings
[519] https://www.bristolisopen.com/
[520] https://www.optionstartup.paris/presentation/

Vienna (AT): WienWin[521]	The WienWin project in the Austrian capital Vienna, aims at strengthening the location of Vienna as a centre for innovation by using the city's purchasing activity of approximately EUR 5 billion per year to support innovative businesses in the region.	X	X	X
Barcelona (ES): Citymart[522]	Citymart is a platform for city government employees to deliver better services, connecting them to solutions, projects and peers across departments and cities.	X	X	X
Paris (FR): DataCity[523]	DataCity is a global open innovation program that brings together cities, companies, and start-ups to address together city challenges and develop solutions to build sustainable and efficient cities, using data and technologies.	X	X	X
London (UK): Smart London Innovation Network[524]	The Smart London Innovation Networks (SLINs) have been created to support the development of the Mayor of London's vision for "smart city" innovation that addresses resource pressures whilst creating new economic and research opportunities.	X	X	X
Barcelona (ES): Numa Barcelona	Numa Barcelona, the first acceleration programme specifically created to target start-ups in their growth and expansion stages in European markets		X	
London (UK): Ready to Supply the City[525]	It provides small, micro and medium-sized enterprises with support to compete for contracts with City-based businesses and their supply chains. This support includes face-to-face business advice, fitness-to-supply support, a comprehensive programme of events and access to contracts.	X		
Helsinki (FI): Girls in Tech	Girls in Tech (GIT) is a global non-profit focused on the engagement, education and empowerment of girls and women who are passionate about technology. It aims to accelerate the growth of innovative women entering into the high-tech industry and building start-ups.		X	
Dublin (IE): Mentoring for scale[526]	Mentoring for Scale is a monthly, invite-only event where tech companies in the early stages of scaling get the opportunity to sit down one-on-one with experienced, serial entrepreneurs who have walked in their shoes.			X

[521] http://ec.europa.eu/regional_policy/en/projects/austria/using-a-citys-purchasing-power-to-promote-local-innovation
[522] http://www.citymart.com/barcelona-open-challenge/
[523] https://datacity.numa.co/
[524] http://smarterlondon.co.uk/
[525] https://www.growthhub.london/schemes/ready-to-supply-the-city/
[526] http://startupdublin.com/what-we-do/mentoring-for-scal

Barcelona (ES): 22@Barcelona[527]	22@Barcelona project transforms two hundred hectares of industrial land of Poblenou into an innovative district offering modern spaces for the strategic concentration of intensive knowledge-based activities. This initiative is also a project of urban refurbishment and a new model of city providing a response to the challenges posed by the knowledge-based society.	X	X	X
London (UK): Tech City[528]	Tech City UK is an accelerator that delivers programmes and initiatives to accelerate the growth of digital businesses across the UK at all stages of their development.		X	X
Sophia (BG): Sofia Tech Park [529]	Sofia Tech Park is a state-owned company. The main goal of the company is to boost the development of research, innovation and technological capabilities of Bulgaria through the implementation of various projects. The objective of this project is to accelerate the competitiveness of science and entrepreneurship in Bulgaria by improving the knowledge exchange between academia and business, supporting start-ups and innovative ideas and thus catalysing the process of commercialization of research.		X	
Trieste (IT): AREA Science Park[530]	AREA Science Park is a leading multi-sector science and technology park, which operates internationally. The Park aims to build a structured ecosystem of private companies and public operators capable of generating economic development at various regional, national and international levels, leveraging digitalisation assets, advanced technology and high education in the regional territorial reference areas, to optimize resources and at the same time attract national and international investment in new strategic development projects.	X		
Barcelona (ES): Big Data Centre of Excellence Barcelona	The Big Data Centre of Excellence Barcelona (Big Data CoE Barcelona) is an initiative led by Eurecat, with the support of Oracle, the Catalan Government and the Barcelona City Council. The mission of this centre is to build, progress, bring together and offer companies tools, data and differentiated Big Data infrastructures. The Big Data CoE Barcelona also offers training services for field professionals (data scientists, data engineers and data business analysts), as well as an outreach programme of the trends and success stories on Big Data.			

[527] http://www.22barcelona.com/content/blogcategory/49/280/lang,en/
[528] https://www.techcityuk.com/
[529] http://sofiatech.bg/en/about/team-and-management/
[530] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/organisation/area-science-park

Table 20: Distribution of Digital Innovation Hubs at National/City Level

MS	City	DIHs
Austria	Graz	Know-Centre GmbH
	Graz	Virtual Vehicle Research Centre
Belgium	Brussels	Accelerating Photonics innovation for SME's (ACTPHAST 4.0)
	Woluwe	BBRI Cluster BIM
	Limelette	Belgian Building Research Institute BBRI
	Gosselies	Centre de recherche en aéronautique ASBL, Cenaero
	Brussels	Flanders' FOOD, FF
	Lommel	Flanders Make
	Gembloux	Réseau LIEU – LIaisons Entreprises-Universités
	Brussels	Sirris Hub / Data and software Innovation
	Antwerpen	Sirris Hub / Offshore Wind Infrastructure Application Lab
	Leuven	Sirris Hub Mechatronics and Digitising Manufacturing
	Kortrijk	Sirris Hub Smart Assembly
	Seraing	Sirris Hub/smart product
	Naninne	SynHERA
	Namur	University college HENALLUX
Bulgaria	Sofia	Sofia Tech Park
Croatia		
Cyprus		
Czech Republic	Ostrava-Poruba	IT4Innovations National Supercomputing Centre
Denmark	Aalborg	BrainsBusiness ICT North Denmark
	Odense	Danish Technological Institute, Robot Technology, DTI Robotics
	Copenhagen	MADE - Manufacturing Academy of Denmark
	Aarhus	The Alexandra Institute - ICT-based innovation
Estonia	Tallinn	Eliko
	Tallinn	Smart Industry Centre (SmartIC)
	Tartu	Software Technology and Applications Competence Centre (STACC)
	Tallinn	Tallinn Science Park Tehnopol
Finland	Turku	One Sea - Autonomous Maritime Ecosystem
	Oulu	PrintoCent
	Pori	ROBOCOAST
	Tampere	Smart Manufacturing
	Oulu	Super IoT
	Oulu	5G Test Network Finland (5GTNF)
France	Solaize	Axelera
	Grenoble	CEA Leti Health
	Grenoble	CEA Micro energy sources platform (CEA Liten)

	Lannion	Images and networks
	Bellignat	Pole Plasturgie (PEP)
	Rousset	Secured communicating solutions
	Grenoble	Silicon Europe Alliance
	Paris	TeraLab : Big Data Platform for Research , Education and Innovation
Germany	Garching	Centre Digitisaton.Bavaria, ZD.B
	Darmstadt	Effiziente Fabrik 4.0
	Berlin	European Technology Platform on Smart Systems Integration, EPoSS
	Chemnitz	Experimental and Digital Factory (EDF)
	Stuttgart	Fraunhofer Future Work Lab (FWL)
	Karlsruhe	FZI Research Centre for Information Technology
	Darmstadt	Institute of Production Management, Technology and Machine Tools (PTW)
	Offenburg	Institute of Reliable Embedded Systems and Communication Electronics
	Norderstedt	Lufthansa Industry Solutions - Digital Lab
	Dortmund	Mittelstand 4.0-Competence Centre Dortmund
	Darmstadt	Mittelstand 4.0-Kompetenzzentrum Darmstadt
	Siegen	Siegener Mittelstandsinstitut (SMI)
	Jena	Software-Cluster
	Aachen	SpectroNet - International Collaboration Cluster for Global Collaboration in Photonics
	Frankfurt a.M.	Technology Transfer via Multinational Application Experiments (TETRAMAX)
	Lübeck	UniTransferKlinik (UTK)
	Magdeburg	VDTC of the Fraunhofer IFF
Greece	Athens	ATHENA Research and Innovation Centre
	Thessaloniki	Nanotechnology Lab LTFN - Centre for Organic & Printed Electronics (COPE-H)
	Thermi	Nanotechnology Lab LTFN - Centre for Organic & Printed Electronics (COPE-H)
	Thessaloniki	nZEB Smart House
	Piraeus	Piraeus Blue Growth Digital Innovation Hub (BG-DIH)
Hungary	Budapest	Demola-Budapest
	Budapest	EIT Digital Budapest Node
Ireland	Dublin	Centre for Applied Data Analytics Research, CeADAR
	Galway	Insight Centre for Data Analytics
	Dublin	Irish Centre for Cloud Computing and Commerce (IC4)
	Cork	Tyndall National Institute, Tyndall
Italy	Trieste	AREA Science Park
	Treviso	DIH Triveneto

	Milano	Lombardy Intelligent Factory Association
	Valenzano	MEDISDIH - Distretto Meccatronico Regionale e DIH della Puglia
	Bologna	National Technological Cluster of Intelligent Factories
Latvia	Riga	TechHub Riga
	Ventspils	Ventspils High Technology Park (VHTP)
	Vilnius	Advanced Manufacturing Digital Innovation Hub
Luxembourg	Luxembourg City	Interdisciplinary Centre of Security Reliability and Trust (SnT) of the University of Luxembourg
	Esch-sur-Alzette	Luxembourg Institute of Science and Technology (LIST)
	Esch-sur-Alzette	Luxinnovation
	Luxembourg City	Nyuko a.s.b.l.
	Luxembourg City	Technoport SA
Malta	Kalkara	MITA Innovation Hub
Netherlands	Eindhoven	AMSYSTEMS Centre
	Delft	Biorizon
	Geleen	Brightlands Materials Centre
	Amersfoort	Cooperative Data Hub (Smart Dairy Farming)
	Eindhoven	PhotonDelta
	Reusel	Practice Centre for Precision Agriculture
	Groningen	Region of Smart Factories (RoSF)
	Eindhoven	Smart Connected Supplier Network
	Emmen	Technologies Added
	Enschede	ThermoPlastic Composites - NL
	Eindhoven	TNO Holst Centre
	Delft	VP Delta
	Haarlem	3D Makers Zone
Poland	Wroclaw	Centre for Advanced Manufacturing Technologies, Wroclaw University of Science and Technology
	Krakow	CYBERSEC HUB
	Warsaw	Institute of Electron Technology (ITE)
Portugal	Porto	Digital Innovation Hub for Customer-Driven Manufacturing @ Norte (iMan Norte Hub)
	Porto	PRODUTECH Digital Innovation Hub Platform
Romania		
Slovakia		
Slovenia	Ljubljana	Centre for Technology Transfer and Innovation of Jožef Stefan Institute

	Murska Sobota	Pomurje Technology Park Ltd., PTP
	Penisca pri Mariboru	Styrian Technology Park, STP
Spain	Lleida	AgriTech BigData, Big Data Innovation Hub at the service of the agri-food sector (Agri Tech BigData)
	Barcelona	Associació Clúster Digital de Catalunya
	Barcelona	Barça Innovation Hub (BIHUB)
	Bilbao	Basque Digital Innovation Hub (BDIH)
	Barcelona	Big Data Centre of Excellence Barcelona (BigData CoE)
	Cerdanyola del Vallès	Catalan Robotics Hub
	Cerdanyola del Vallès	Catalunya Industry 4.0
	Barcelona	Data Management-UPC (DAMA-UPC)
	Burgos	Digital Innovation Hub Burgos 4.0 (DIHBU 4.0)
	Barcelona	Digital Urban Development (DUD)
	Lleida	Digital Water Innovation Hub (Digital Water)
	Salamanca	DIH IoT
	Benidorm	Dinapsis Operation & Lab
	Badojoz	Ecosistema W
	Barcelona	EFFIRENP (Efficient Ren Power HUB)
	Barcelona	eHealth Catalonia
	Barcelona	Experience-based industries Hub (e!xperience)
	Granada	Granada Plaza Tecnológica y Biotecnológica
	Zaragoza	HPC-Cloud and Cognitive Systems for Smart Manufacturing processes, Robotics and Logistics.
	Valencia	Hub 4.0 of Manufacturing Sectors in Valencian Region
	Barcelona	Industrial Ring
	Murcia	Innovation for Manufacturing in the South (I4MSOUTH)
	Barcelona	International Advanced Manufacturing 3D Hub (IAM 3D HUB)
	Tomelloso	i4CAM HUB (Innovation for competitiveness and advanced manufacturing)
	Jaén	Linares 4.0, Knowledge City (DIH)
	Málaga	National Pole of Digital Content, POLO
	Mataró	REIMAGINE Textile
	Madrid	RoboCity2030
	Valladolid	Smart City Valladolid and Palencia (Smart City VyP)
	San Sebastian	SmartCityTech
	Barcelona	Spanish Digital Innovation Hub for HPC (esHPC)
	Madrid	5TONIC Open 5G Lab 5TONIC

Sweden	Skelleftea	Arctic Game Lab
	Luleå	Infrastructure and Cloud data centre test Environment (SICS ICE)
	Västerås	Robotdalen
	Kista	Urban ICT Arena
UK	London	Digital Catapult
	London	Future Cities Catapult
	Coventry	Manufacturing Technology Centre
	Sunderland	Sunderland Software City
	Sedgefield	The Centre for Process Innovation
	Solihull	The High Value Manufacturing Catapult

3.5 Key conclusions on SIS&DT

The **R&D, innovation and adoption** of **KETs together with all other digital technologies has been well recognised at all levels** (i.e. company, city, regional, national, EU) for enabling the development of new goods and services as well as reindustrialisation to make the transition to a knowledge-based and low carbon, resource efficient economy. Thus, as seen from above sections, numerous policy, strategy and initiatives have been launched at all levels by the governments as well as corporates and through PPPs to make SIS&DT happen.

3.5.4 Global positioning of EU

When looked at the global competitive positioning of EU against other leading countries, we have seen the following trends:

- **Automotive semiconductors** (55%) in EU holds the highest global market share among KETs, closely followed by **robotics** (33%), **embedded systems** (30%), **semiconductor equipment** and **photonics components** (20% each);

- When assessing the geographic adoption of technologies, **Europe lags behind North America in 3D printing and AI**, and positioned **behind Asia-Pacific in advanced robotics** while holding the **lead on enterprise wearables**;

- The US, China and Canada clearly lead the **AI** while **Northern and Southern Europe is placed in between** regarding the total impact as percentage of GDP.

However, the most recent open letters from a number of European AI researchers proposing the establishment of '**European Lab for Learning and Intelligent Systems-ELLIS'** and **'Confederation of Laboratories for Artificial Intelligence Research in Europe- CLAIRE'** shows the **bottom-up push in EU** to thrive and for Europe to stay competitive with other major players on this domain. As a response, the **European AI Strategy** has been recently communicated by the EC and it has been included under the proposal for the next EU Multiannual Financial Framework 2021-2027 among the key priority areas together with **Cybersecurity and other digital technologies**, **Supercomputing,** and **advanced digital skills.**

When looked at the '**Readiness for Future Production'** as assessed by the WEF, Europe seems to be well positioned, with **Germany, the Netherlands, the United Kingdom, Denmark, Finland, Sweden, France, Ireland, Austria, Belgium, Spain, Estonia, Italy, Poland, Slovenia and the Czech Republic** being ranked under the **leading countries category** together with top 10 countries. However, **Portugal, Lithuania, Slovakia, Romania, Hungary, Latvia, Bulgaria, Croatia, Greece and Cyprus** are falling relatively behind on readiness for future production where improvements on drivers of production as well as structure of production needed.

3.5.5 Key Focus Areas of MSs and Regions

In order to identify the **key focus areas** of MSs and Regions on SIS&DT based on their capacity and capability, the **S3-Industrial Modernisation Platform** and the **Vanguard Initiative** have been looked at.

The key focus areas based on the highest participation by the regions are the **bio-economy** and **high performance production through 3D printing** followed by **Efficient and Sustainable Manufacturing** according to most recent findings of October 2018 on both platforms. The launch of numerous additional platforms most recently (i.e. **Artificial Intelligence, Cybersecurity, Chemicals, Personalised Medicine, Medical Technology, Safe and Sustainable Mobility, Smart Textile, Smart Tourism, Sport** etc.) under S3 Industrial Modernisation Platform is the true indication of growing ambition lead by the regions to drive SIS&DT further by exploiting and demonstrating use cases for KETs and ICT at sectoral level as well as boosting the lagging areas such as AI and Cybersecurity.

When we looked at the **incorporation of KETs into RIS3 priorities at national and regional levels**, since 2013 to date, **advanced manufacturing technologies**, **advanced materials** and **industrial biotech** (that is included under life sciences definition most recently) were among the leading KETs application areas while other KETs such as **micro and nano electronics, photonics, nanotech, cybersecurity** had lower focus compared to the first group of technologies followed by **AI** at lesser extent as it can be seen below. 2013 vs 2015 comparison below is reported under the KETs report prepared by the HLG-KETs[531] while the 2018 part is based on our own analysis.

Figure 74: Key focus areas among different KET domains since 2013

2013 vs 2015

	Share of all registered priorities		Share of all registered KETs-related priorities	
	Mar-2013	*Jan-2015*	*Mar-2013*	*Jan-2015*
Advanced Manufacturing Systems	3.9%	7.2%	20.0%	34.7%
Advanced Materials	5.8%	6.1%	31.3%	29.5%
Industrial Biotechnology	4.8%	4.2%	26.0%	20.1%
Photonics	1.0%	1.0%	5.2%	4.9%
Micro and Nano-Electronics	1.0%	0.9%	5.2%	4.5%
Nanotechnology	1.9%	0.5%	10.4%	2.6%
All priorities classified as KETs-related	**18.4%**	**19.9%**	-	-

2018

	Production technologies			Digital technologies		Cyber technologies
	Advanced manufacturing technologies	Advanced Materials and nanotechnologies	Life science technologies	Micro nano-electronics and photonics	Artificial intelligence	Security and Connectivity
#MSs	22	23	20	17	11	16
#Reg	117	98	56	46	23	48

When looked at the **generation of patents on KETs**, we see that KETs related patents are developed across most of the EU Regions while the distribution is heterogeneous across EU. The main focus of the patents are **Advanced Manufacturing Systems, Advanced Materials, Micro and nano electronics** while **nanotech** has the smallest portion among all KETs as reported in the same HLG-KETs report.

Regarding the **main ICT focus areas** based on their inclusion into the RIS3, the following areas have been selected by most regional and national authorities as key areas of local strength, market potential and smart specialisation: **data processing & management, (cyber) security, visualisations, sensors, privacy, cloud computing, open data, e-Government, geographical information systems, internet applications & future internet, industry 4.0, factories of the future, robotics and 3D printing. One in two regions** and **two in three MSs have selected ICT** as an innovation priority.

Overall, a clear focus can be seen under the **production technologies** group of KETs 4.0 across the EU, while performance under the **digital** and **cyber technologies** are relatively low at the moment.

[531] KETs: Time to act, HLEG Report, EC, 2015: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=22113&no=2

3.5.6 Performance of MSs and Regions

The **lead role taken by the Regions** is a clear indication of the regional ambition to drive SIS&DT further based on the fact that numerous new thematic platforms have been launched most recently in addition to the existing ones totalling up to **17 different thematic platforms** for adoption through **demonstrations** and **cross-sector, cross-border, across the value-chain co-investments and collaborations.**

Most of the Member States and the Regions have also incorporated **KETs and other digital technologies into their RIS3** plans.

There are also other **public, private and/or PPPs** existing at Regional, National, EU levels acting as hubs and shared platforms combining different stakeholder groups such as **Factories of Future Initiative, Manufuture, Nanofutures and Photonics Platforms, Digital Innovation Hubs and MIDIH** underneath, KETs Excellence Centres, S3IMP&VIs where particular **MSs and regions taking more active and leading roles** thanks to their well developed capacity and capability on those particular domains.

Key Platforms	Key players at the National & Regional levels
Factories of Future	Higher participation to FoF calls from **Germany, Spain, Italy**
Manufuture	Most advanced National Manufuture Platforms are at **Italy, Portugal, Spain, Poland, Austria, Switzerland, Germany, Denmark, United Kingdom, the Netherlands, Ireland and Romania**
Nanofutures	The lighthouses are identified in: **Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Netherlands, Portugal, Romania, Spain, Sweden, UK**
Photonics21	
Manufacturing Industry Digital Innovation Hubs (MIDIHs)	The network is comprised of 9 Competence Centres, 2 Teaching Factories, 2 Regional MDIHs and 3 pan-European DIHs located in **Germany, Italy, France, Spain, Finland, Sweden, Belgium, Slovakia, Ireland and Scotland**
KETs Excellence Centres	**Spain, Germany and Italy** have highest number of KETs Centres
S3-Industrial Modernisation Platform & Vanguard Initiative	Regions taking lead/participative roles across most of the thematic platforms under S3IMP and VI are : **Flanders and Wallonia (BE); Catalonia, Basque Country, Navarra, Asturias, Andalucía, Valencia (ES); Lombardy, Emilia Romagna, Trento, Tuscany (IT); Skåne (SE); Lapland and Tampere (FI); Auvergne Rhône-Alpes and Ile-de-France (FR); Baden-Württenberg, North Rhine-Westphalia, Saxony (DE); East and South Netherlands (NL); Norte (PT); Slovenia (SL); Scotland (UK)**

At **City** level, **London, Munich and Paris** are seen to be listed **among 5 top tech hotspots globally** together with Tel Aviv and Singapore. They are also included under the **top 10 cities according to EDCi index** based on the **framework conditions they provide for digital**

transformation in support of start-ups and scale-ups together with **Stockholm, Helsinki, Amsterdam, Dublin, Vienna, Copenhagen.**

In addition to public initiatives, there are also vast amount of **industry-lead initiatives** across EU in support of SIS&DT aiming to demonstrate technology adoption and skills development. **Corporate Academies** and **Learning & Smart Factories** are found as best practices where one can learn hands-on experience especially on Industry 4.0 implementations.

As a **conclusion**, it can be stated that, there are vast amount of initiatives spread all over the EU either lead by public, private or in combination in the form of partnerships. The problem is not the lack of initiatives, but mainly **lack of coordination and coherence between all existing strategy and initiatives vertically and horizontally**. In order to tackle this, **more orchestrated efforts for the co-development and co-implementation of Skills Strategies at all levels needed** to make SIS&DT a reality by active engagement of different stakeholder groups and by combining all resources and investments through collective

SECTION IV - STATE OF PLAY ANALYSIS ON STRATEGIES, POLICIES AND INITIATIVES ON HIGH-TECH T-SHAPED SKILLS IN EUROPE

7. STATE OF PLAY ANALYSIS ON STRATEGIES, POLICIES AND INITIATIVES ON HIGH-TECH T-SHAPED SKILLS IN EUROPE

7.1. The relevance of high-tech T-shaped skills

The coming sections provide a first analysis of the state-of-play concerning policies, initiatives and strategies to encourage the development of high-tech T-shaped skills and the future professional. In this section we describe high-tech T-shaped skills as an imperative for EU's competitiveness, we highlight the importance of digital and transversal skills and the importance of connectivity between education and the labour market, we describe the struggle employers have to find and train transversal skills within the workforce, and we underline the relevance of a long-term perspective for policy development on this issue.

7.1.1. High-tech T-shaped skills: an imperative for EU's competitiveness

The competitiveness of the EU industry, leveraging on its innovativeness and productivity, is highly dependent on the knowledge, skills, competencies and creativity of the workforce. **Potential gaps on skills development combined with mismatches directly influence the job creation negatively**. This is widely recognised within the industry, as became apparent e.g. in the KETs Skills Vision project. Among policy makers at EU level, at Member State level and locally at the city level, increasingly more data is gathered to evidence and articulate concerns, e.g. in the KETs Observatory projects. Moreover, banks and investor communities in Europe consider skills issues as fundamental to the long-term sustainability of profitable investments.

The World Economic Forum expects that the Fourth Industrial revolution will bring **major disruption to the scale in which upskilling and reskilling efforts currently take place**. The Forum calls for broad, multi-stakeholder collaboration and coordination between governments, industrial actors, labour unions and more to develop and implement solutions that engage skills gaps and mismatches through shared and combined efforts.[532]

Also, the Word Economic Forum expects **two distinct skills mismatches around the regions of the world**. Within regions with a disparity between higher skilled and production workforce, such as East Asia and Western Europe, there will likely be a higher demand for high-skill production workforce than can be produced by the labour market.[533]

Secondly, places characterised by large consumer markets, such as **China and the US, could be confronted with the highest skills mismatches**. It is estimated that demand for both high- and low-skilled labour could rise to 43%. However, this estimate does not take into consideration the impact of automation. Jobs created through automation will account for further skills mismatches, as the jobs that will be created due to automation will differ significantly in skill requirements. This newly created labour reality will render human strengths such as problem solving, leadership and creativity to be more important to employers.[534]

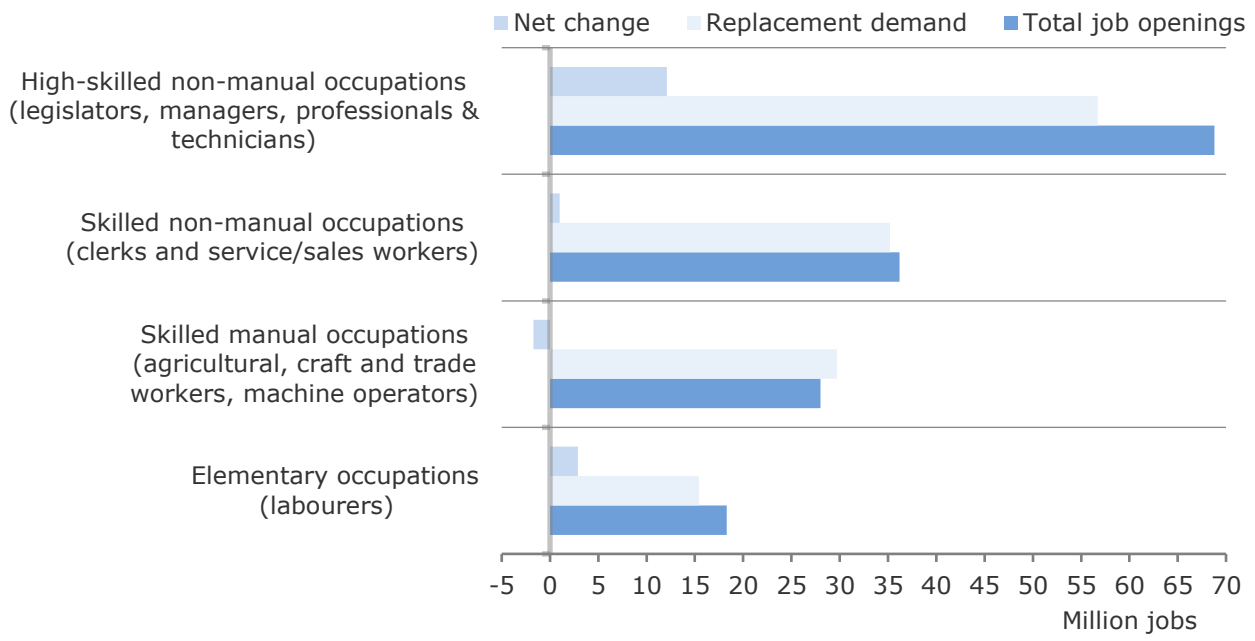
---

[532] *World Economic Forum* [website], https://www.weforum.org/projects/employment-and-skills-for-the-future-of-production, (accessed 15 February 2018)
[533] 'The New Production Workforce: Responding to Shifting Labour Demands', *World Economic Forum White Papers*, 2018 (accessed 15 February 2018)
[534] 'The New Production Workforce: Responding to Shifting Labour Demands', *World Economic Forum White Papers*, 2018 (accessed 15 February 2018)

The OECD considers global megatrends to be important drivers for skills challenges, with **technological innovation, globalisation and an ageing population particularly relevant to Europe**.[535]

The figure below depicts the changes forecasted by Cedefop in job opportunities throughout the EU across job types. **Cedefop forecasts that elementary and manual jobs will decline**, while non-manual and highly skilled jobs will be better off.

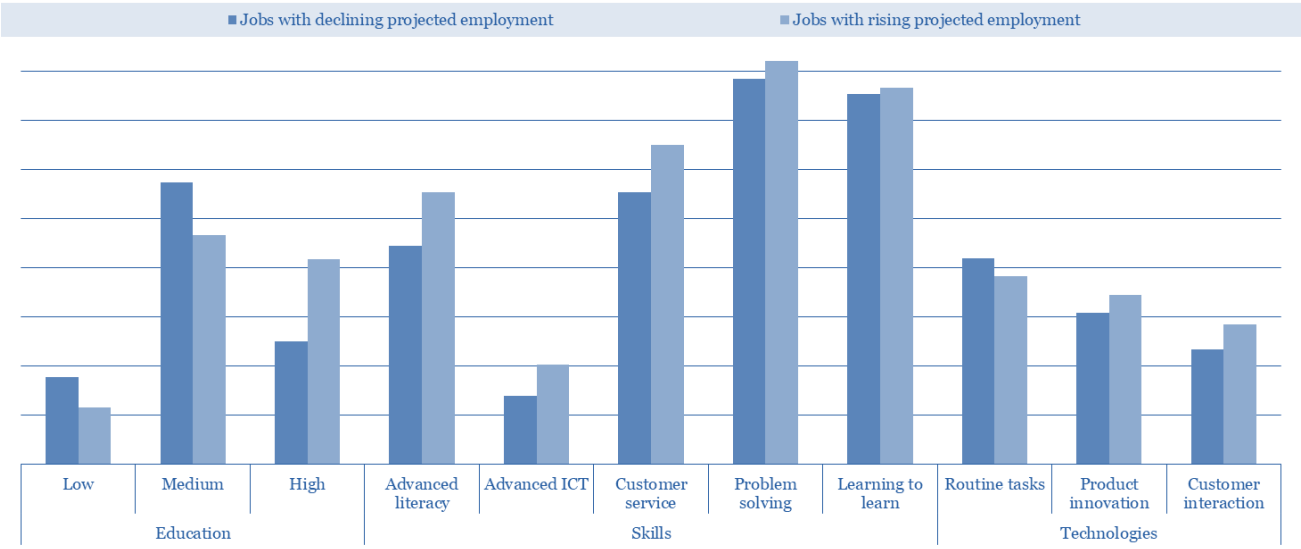
Figure 75: Total future job opportunities, 2016-2030, EU-28[536]



The figure below depicts anticipated employment growth rate across job types, forecasted by Cedefop. This forecast also shows that **low-skilled jobs and those consisting of routine tasks will decline**.

[535] http://www.oecd-ilibrary.org/employment/getting-skills-right_25206125
[536] D. Storrie and A. Zukersteinova (2018). *Role of skills in future employment: Facts & figures*. Presentation, EU Industry Day.

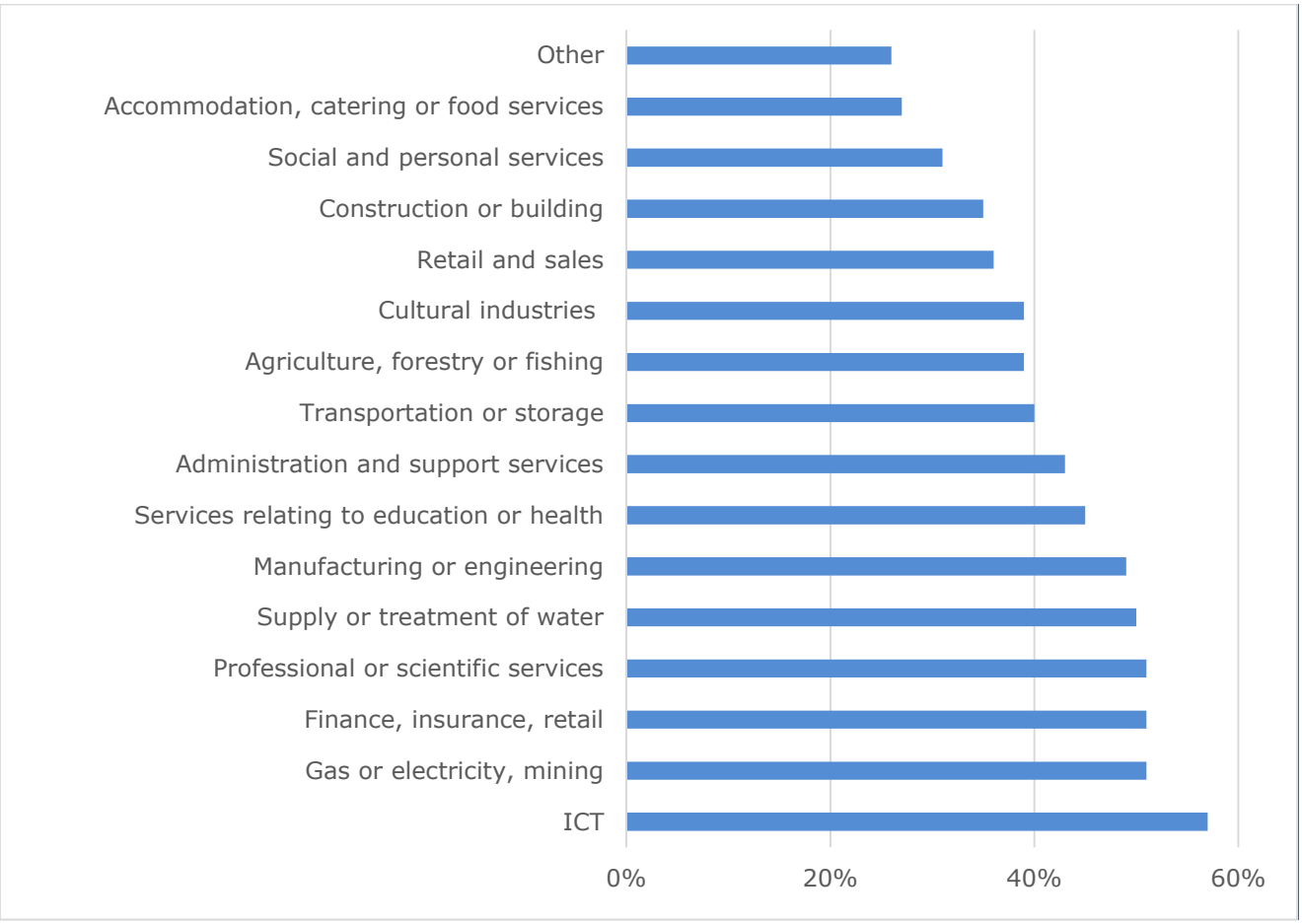
Figure 76: Difference between jobs with positive vs. negative anticipated employment growth rate, 2014-25, EU28[537]



The figure below depicts a Cedefop forecast on the extent of changing technologies in jobs across sectors. It shows that **in catering, food services, and social and personal services the extent of changing technologies is less severe** compared to the ICT sector, gas, electricity and mining, finance, insurance and retail, and professional services.

[537] Cedefo D. Storrie and A. Zukersteinova (2018). *Role of skills in future employment: Facts & figures*. Presentation, EU Industry Day.

Figure 77: Extent of changing technologies (machines, ICT systems) by sector, 2014, EU28[538]



7.1.2. The importance of digital and transversal skills

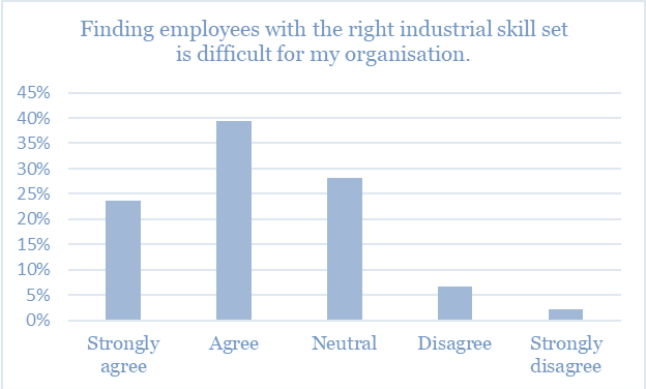
The increasing innovation in technology and the growing digital world stresses the importance of computer code. Research has shown that coding skills are becoming increasingly more important for employees to attain.[539] Being able to program software is a skill that is often required for employees within businesses that work with data. **Jobs that include programming are growing 50% faster than the job market overall**.[540] Furthermore, the job market for programming is growing 12% faster than the average growth of the job market itself. Acquiring programming skills is extremely relevant for the following sectors; IT, data analysis, artists and design, engineers and scientists.

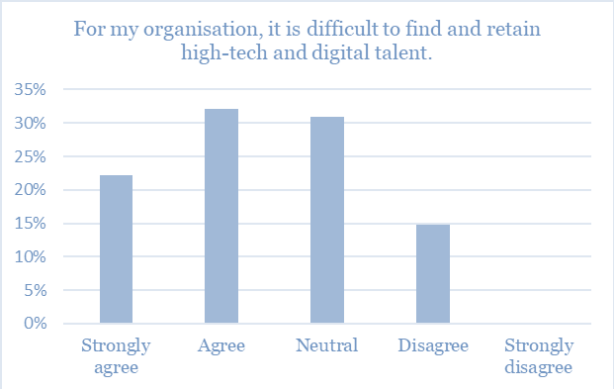
Studies show that **workers suitable for hybrid jobs are in increasing demand**.[541] These hybrid jobs often require employees to possess skills in programming as well as skills in design, marketing and data analysis. Moreover, studies show that the demand for professionals skilled in data, artificial intelligence, analytics and machine learning is increasing.[542] Hybrid jobs are a clear example of jobs

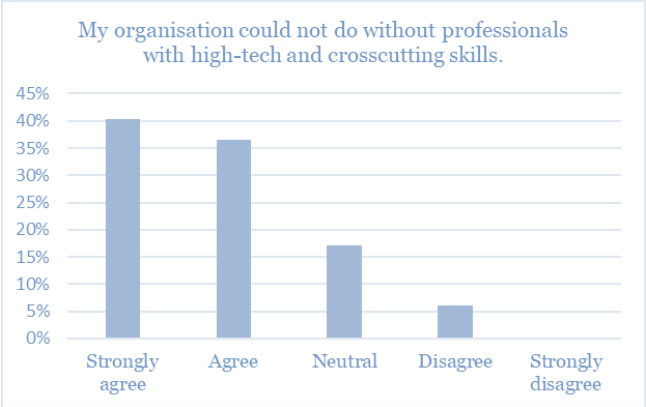
[538] D. Storrie and A. Zukersteinova (2018). *Role of skills in future employment: Facts & figures*. Presentation, EU Industry Day.
[539] *'Beyond Point and Click: The Expanding Demand For Coding Skills', Burning Glass Technologies research-project*, 2016 (accessed 15 February 2018)
[540] *'Beyond Point and Click: The Expanding Demand For Coding Skills', Burning Glass Technologies research-project*, 2016 (accessed 15 February 2018)
[541] 'Blurring Lines: how business and Technology Skills are Merging to Create High Opportunity Hybrid Jobs', *Burning Glass Technologies research-project,* 2015 (accessed 15 February 2018)
[542] http://burning-glass.com/research/quant-crunch-data-science-job-market/

created by technological innovations. While the hybrid jobs are high in demand, the training system to empower students with this variety of skills are often weak and scarce. However, accelerated training programs can often provide entry-level skills needed for a hybrid job since these skills are not hard to access and relatively easy to learn.

Figure 78, Figure 79, Figure 80: PwC survey among high-tech employers and stakeholders in Europe; N=81, 89, 82 resp.







These messages are similarly reflected by high-tech employers in Europe. Our survey results indicate that, while professionals with high-tech and transversal, crosscutting skills are crucial for employers, the majority of them say **it is difficult to find employees with the right skillset, and to find and retaining high-tech and digital talent**.

7.1.3. The importance of connectivity between education and the labour market

Recent research shows that the **current college students do not feel like they will be prepared for the workplace after their education**.[543] Only 35% of the current college student report that they think the skills they learn are sufficient in preparing them for the workplace. Furthermore, 43% of non-traditional students (aged 24 or older) feel confident that the skills they learn are a sufficient preparation for the workplace. Both traditional and non-traditional students indicate they might have more confidence in their readiness for the workplace if they had sufficient information about which skills are in demand on the job market, and how they can achieve those skills.

[543] Burning Glass Technologies [website], https://www.burningglass.com/blog/skills-perception-gap-two-thirds-students-doubt-workplace-skills, (accessed 10 March 2018)

Accordingly, the WEF argues that **simply increasing the number of high-tech graduates will be insufficient** as a forward-looking approach. In their view, putting practice over theory through experiential learning will assist in imparting graduates with strong creative, critical thinking and non-cognitive skills.[544]

On their part, **employers stress the need for the education system to generate prospective employees that are productive from their first day on the job onwards**. The majority of our survey participants think it is important that the education system generates a skillset that allows for this flying start.

Figure 81: PwC survey among high-tech employers and stakeholders in Europe; N=60

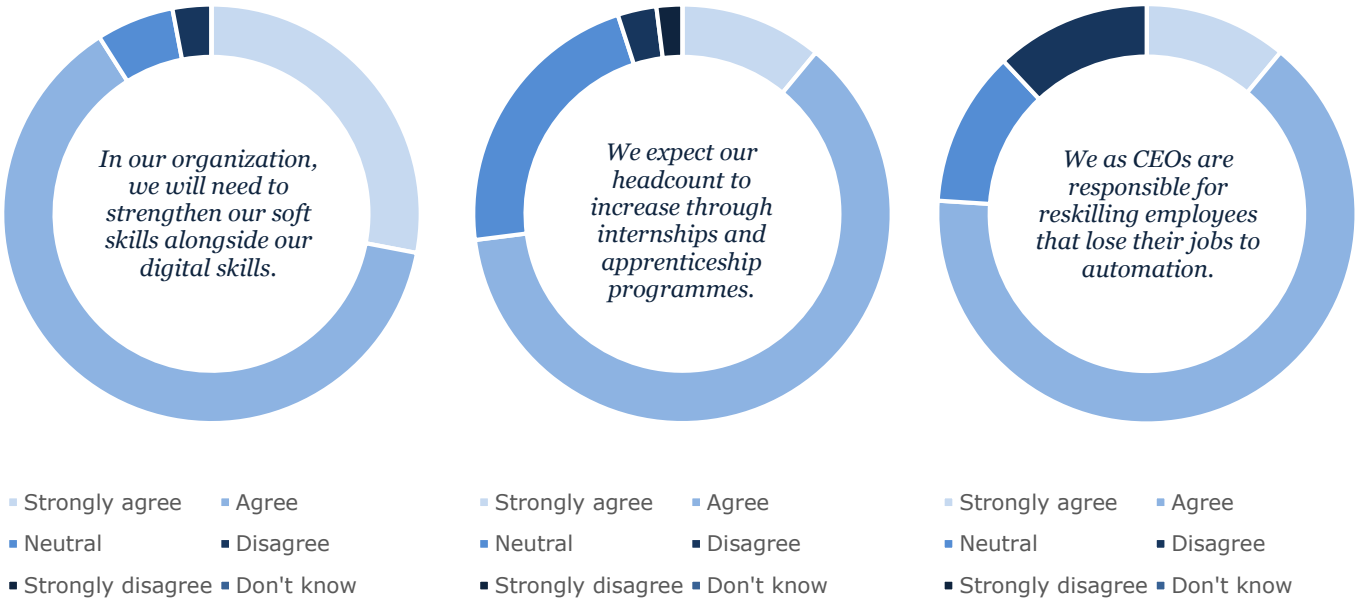
Other research indicates that in Europe, **40% of workers share the belief that their skill levels do not resemble the ones that are required to do their job.**[545] At the same time, research shows age groups passed 25 are significantly less involved in optimizing their talents. The World Economic Forum calculated that in 2017 approximately **85% of the under 25-year-olds are involved in learning activities compared to 45% of those who are 25 and older**. In order to meet changing demands of job roles, the WEF suggests learning and training opportunities should be available through all stages of people's careers.[546]

7.1.4. Employers struggle to find and train transversal skills

A recent survey conducted by PwC among CEOs depicts that ***today's business leaders recognise they will need workers with soft skills to complement their technical prowess***, and that internships and apprenticeship programmes are a good way to bring them in. Moreover, CEOs in the survey indicated they recognise a responsibility on the side of employers for reskilling workers with an out-of-date skill set. This underlines the need for skills development initiatives relevant to high-tech T-shaped skills, and the involvement of industrial partners to implement them.

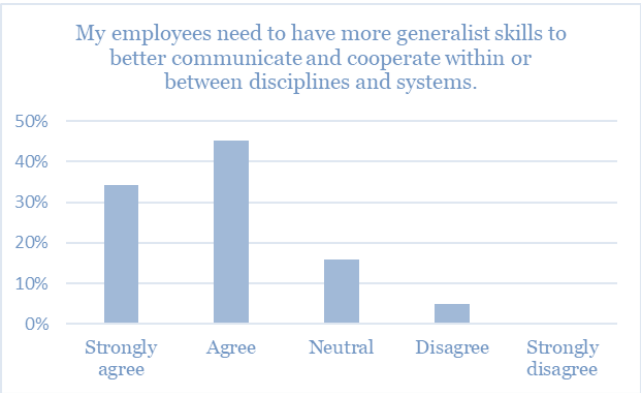
[544] http://www3.weforum.org/docs/WEF_EGW_Whitepaper.pdf
[545] http://www.oecd-ilibrary.org/employment/getting-skills-right_25206125
[546] https://toplink.weforum.org/knowledge/insight/a1Gb0000000LPFfEAO/explore/dimension/a1Gb0000001hNYKEA2/summary

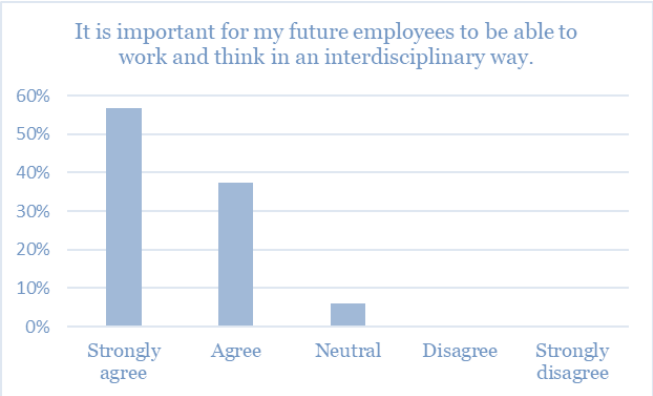
Figure 82: Results from PwC's 21st CEO Survey[547]



Employers underline the importance of these soft skills for current and future workers. In our survey among high-tech employers throughout Europe, employers show a strong positive sentiment towards communication and cooperation skills, skills related management and entrepreneurship, emotional intelligence and the ability to work and think across disciplines and systems.

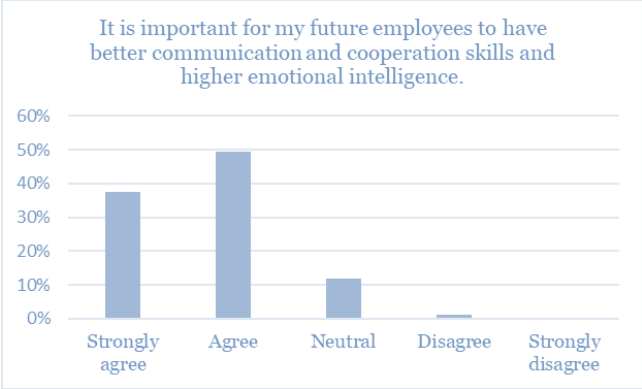
Figure 83, Figure 84: PwC survey among high-tech employers and stakeholders in Europe; N=82, 85 resp.

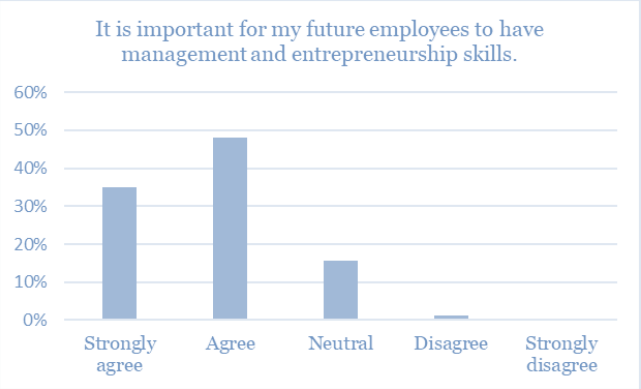




[547] PwC's 21st CEO Survey, 2017 (Data for The Netherlands)

Figure 85, Figure 86: PwC survey among high-tech employers and stakeholders in Europe; N=83, 83 resp.





At the same time, **employers have a hard time finding employees that possess soft skills**. According to research, soft skills are crucial and difficult to find.[548] Also, it is difficult to define what soft skills actually are or should be. A comparison of millions of job offers found that soft skills are not simply people skills; soft skills consist of writing, knowledge of certain software packages, organisational skills and customer service. Although different job offers appear to require different soft skills, communication and organisational skills seem to be scarce everywhere. These gaps often represent skills that are not taught in the traditional training programs.

7.1.5. The relevance of a long-term perspective

Importantly, **skill gaps in high-tech domains require focused attention and a long-term view to address and engage**. This is related to the following characteristics shared by high-tech sectors, including advanced manufacturing:[549]

- They are both capital intensive and knowledge-intensive;
- They require long-term investment decisions to develop processes and buy equipment, which can take over a year to be manufactured;
- They use high levels of technology and R&D and intangible investments (training, improvements to business process) to support innovation;
- They require a flexible workforce with strong specialist skills in the areas of science, technology, engineering and mathematics and design;
- They compete both in international and in domestic markets.

The OECD has developed guiding principles to help policy designers create policies that address skill mismatch problems.[550] Through these guiding principles**, the OECD stresses the need for policy to**:

- Expand opportunities to participate in **adult learning**;
- Link **training for the unemployed** to labour market needs;
- **Recognise informal learning** as well as non-formal learning;
- **Strengthen incentives for employers to invest in training** to meet skill needs, but minimise the administrative burden;
- **Involve social partners** in vocational education;

[548] 'The Human Factor: The Hard Time Employers Have Finding Soft Skills', *Burning Glass Technologies research-project,* 2015 (accessed 15 February 2018)
[549] 2012. Davis, C., Hogarth, T., & Gambin, L. Sector skills insights: advanced manufacturing.
[550] OECD. 2017. *Getting Skills Right: Good Practice in Adapting to Changing Skill Needs: a Perspective on France, Italy, Spain, South Africa and the United Kingdom*. OECD Publishing, Paris.

- Ensure higher and further education provision is **responsive to skill needs** in the labour market;
- **Facilitate labour mobility**, including the inflow of migrants with the skills in high demand;
- **Stimulate demand** for higher-level skills;
- Ensure all relevant **stakeholders are involved** in the production of information on skill needs;
- **Engage in regular monitoring and evaluation**.

A firm body of studies suggests that **technological innovation can positively affect the manner in which educational material is generated**. There is nonetheless a need for strategic allocation of funds for the betterment of hard to reach groups, as new learning tools do not always manage to reach them.[551]

In this context, **this report aims to help successfully shape workforce transformation in the EU** (especially through the upskilling of existing workforce by paying particular attention to social inclusion as well as the preparation of the right framework to train the next generation of the workforce). This project will support the development of new skills that fit labour market needs and that are highly dependent on fast-evolving industries and technological trends.

7.2. Defining high-tech T-shaped skills

In this section, we provide an operationalisation of high-tech T-shaped skills. We describe the concept of high-tech T-shaped skills, introduce the skill types and knowledge areas, and we describe the typical policy challenges that can be expected to be relevant to high-tech T-shaped skills. We will use this operationalisation to describe and analyse initiatives relevant to high-tech T-shaped skills in sections 3 and 4.

7.2.1. Background

In this section we provide a background to our discussion of high-tech T-shaped skills. We first briefly describe the origins of the concept. Then we describe how high-tech T-shaped skills help professionals working across industries, sectors and disciplines, and how high-tech T-shaped skills reflect deep technological and thematic specialisation. In section 2.2, these concepts will be further operationalised.

Throughout this section, we build on the definition of skills formulated in the previous project 'KETs Skills Vision', encompassing the concepts of knowledge and competence.[552]

Skill is usually used to refer to a level of performance, in terms of accuracy and speed of performing particular tasks. Skill can be defined as a goal-directed, well-organised behaviour that is acquired through practice and performed with economy of effort[553].

Knowledge, in turn, includes (1) theory and concepts, as well as (2) tacit knowledge gained as a result of the experience of performing certain tasks. The notion of knowledge is linked to the concept of

[551] World Economic Forum. 2018. Mapping Global Transforations. Accessed last, June 14, 2018. https://toplink.weforum.org/knowledge/insight/a1Gb0000000LPFfEAO/explore/dimension/a1Gb00000015QBuEAM/summary
[552] 'Final Report: Skills for Key Enabling Technologies in Europe: Vision for the Development of Skills for Key Enabling Technologies (KETs)', European Commission Docsroom, 2016
[553] CEDEFOP (2006) "Typology of knowledge, skills and competences: Clarification of the concept and prototype", CEDEFOP reference series; 64

understanding. Understanding refers to more holistic knowledge of processes and contexts and may be distinguished as know-why, as opposed to know-what. Know-how is often associated with tacit knowledge and know-what with propositional knowledge, reflected in the distinction between declarative knowledge (knowing what), and procedural knowledge (knowing how)[554].

Knowledge here thus refers to what one needs to know to be able to carry out the tasks and duties of a certain job, while skills in this respect are what one needs to be able to do in order to carry out the tasks and duties of a certain job.

Competence, in turn, can be defined as one's capability to handle certain situations successfully or complete a job[555]. Competence can thus be considered an umbrella term for being equipped with the relevant knowledge and skills to be able to carry out the tasks and duties of a certain job (using the term 'competence' in this way is also in line with the approach of the e-Competence Framework (e-CF)[556]).

Source: 'Final Report: Skills for Key Enabling Technologies in Europe: Vision for the Development of Skills for Key Enabling Technologies (KETs)', European Commission Docsroom, 2016

In order to drive and coordinate the change involved in digital transformation, technological disruption, increasing consumerisation and servitisation, intelligent automation and social innovation, leadership and entrepreneurship skills will need to be combined with research and innovation skills. This will encompass a range of skills that go from technical and academic skills to softer skills like problem-solving, multicultural openness, leadership, and managerial and interaction skills.[557]

The notion of high-tech T-shaped skills pertains to the versatile combination of generalistic skills across multiple domains and specialised skills within one domain, present within one individual worker. The relevance of high-tech T-shaped skills has been articulated clearly in the T-Summit that was held in Washington DC (USA) in 2016[558], and further defined in the book T-Shaped Professionals: Adaptive Innovators (2018).[559] It underlines:

- **The importance of T-shaped individuals** – Tomorrow's workers will need to process information from multiple and diverse sources, to build, maintain and strengthen professional relationships across organisational boundaries, to drive innovation through organisational practices, and to communicate with impact and empathy across social, cultural, economic and disciplinary divides;
- **The urgency of training T-shaped professionals** – Experts think that T- shaped professionals will be able to increase competitiveness (which in Europe is still under strain) while addressing and engaging huge societal and environmental challenges that become more time-critical with every passing month;
- **The necessity of engaging a broad array of stakeholders** – The training of T-shaped professionals will require the engagement and commitment of actors from industry, academia, governments, foundations, professional bodies, and other stakeholders that can help shape

[554] *Ibid*.
[555] Ellstrom P. E., Kock H. (2009) "Competence development in the workplace: concepts, strategies and effects" in Illeris K. (2009) "International Perspectives on Competence Development. Developing Skills and Capabilities". London: Routledge, cited in Chryssolouris, G., Mavrikios, D., & Mourtzis, D. (2013). Manufacturing Systems: Skills & Competencies for the Future. Procedia CIRP, 7, 17-24.

[556] http://www.ecompetences.eu/
[557] OECD [website], http://www.oecd.org/sti/inno/skillsforinnovationandresearch.htm, (accessed 15 February 2018)
[558] *T-Academy* [website], http://tsummit.org/, (accessed 1 February 2018)
[559] Yassi Moghaddam, Haluk Demirkan, James Spohrer, 2018, T-Shaped Professionals: Adaptive Innovators

and implement the educational models needed to generate T-shaped professionals through formal education and through on-the-job training.

High-tech T-shaped skills help working across industries, sectors and disciplines

Future professionals will need to be more creative and entrepreneurial, to innovate, to build relationships, to advance research and to strengthen their organisations. **The broad development of the future professional reflects the individual's aptitude to collaborate across industries, sectors and disciplines**. This includes the ability to engage and join forces with professionals from other disciplines as well as communication and knowledge sharing with non-experts of their field.

Studies have shown that the source of many unintended social consequences of technological developments in the last century can be traced back to a failure to incorporate "non-technical" dimensions.[560] According to these studies, **there is a need for multidisciplinary teams consisting of members with advanced knowledge in the natural sciences and mathematics alongside synthesizers and integrators**. There has been a lack of attention within the academic field of engineering for traits such as broad thinking, synthesizing, teamwork and consensus building, entrepreneurial mind-set, and creative design. This mind-set endures despite indications that graduating seniors with more well developed professional traits have an employment advantage, and companies with a culture marked by higher levels of professional traits out-perform others that lack those professionals on the long term. [561]

Nearly a decade ago, experts stipulated that globalisation and the rise of interdisciplinary ways of working have transformed high-tech communities into collaboration arenas crossing cultural, national and disciplinary boundaries, resulting in changing requirements in competencies of technology graduates.[562] No longer does it suffice for technology workers and engineers to manage their daily tasks with plain substance expertise. **Technology workers need to be proficient in communication, teamwork, collaboration, networking, lifelong learning and cultural understanding** as well. These experts argued that this requires a coordinated change in university curricula, and they called for the university system to supply graduates that have skills relevant to the transforming high-tech working communities.

Already in 2002, initiatives have been implemented in the United States to prepare best in class technicians to work in emerging and rapidly changing fields.[563] They were considered to **require interdisciplinary skills and a practical academic and technical core on the one hand, and interpersonal skills and critical and creative thinking skills on the other**. A specific example hereof is the Photonic Technician education programme, designed and developed in the USA under a grant from the National Science Foundation.

However, studies also show that **teaching professional traits is not as straightforward as teaching knowledge and skills that may be more easily defined and measured**.[564]

---

[560] K. Miller, 'Why the Hard Science of Engineering is No Longer Enough to Meet the 21st Century Challenges', Olin College of Engineering, 2015, available from: http://undergrad.msu.edu/uploads/RebalancingEngineeringEducationTReadingrec.pdf (accessed 15 February 2018)
[561] K. Miller, 'Why the Hard Science of Engineering is No Longer Enough to Meet the 21st Century Challenges', Olin College of Engineering, 2015, available from: http://undergrad.msu.edu/uploads/RebalancingEngineeringEducationTReadingrec.pdf (accessed 15 February 2018)
[562] 2009. Communication as part of the engineering skills set, Pia Lappalainen
[563] Technician Education and Training: A Plan for Systemic Change, 2002,Daniel M. Hull
[564] K. Miller, 'Why the Hard Science of Engineering is No Longer Enough to Meet the 21st Century Challenges', Olin College of Engineering, 2015, available from: http://undergrad.msu.edu/uploads/RebalancingEngineeringEducationTReadingrec.pdf (accessed 15 February 2018)

Professional traits (e.g. entrepreneurial mind-set, broad thinking) mostly refer to psychological factors such as attitudes, behaviours, and motivations, that more than often require personal experiences and extensive practice in order to be habitual. Even business schools, who often have well-established programs targeting these professional traits, do not necessarily hit the mark. Because an emphasis on psychological factors without a focus on personal behaviours, together with practice in role-playing to build confidence and personal skills, lacks the effectiveness to facilitate the development of well-rounded professional traits. Nonetheless, technology students would highly benefit from business school curriculum being incorporated in the engineering field.

Furthermore, academics argue that these **technology students would benefit from a curriculum build on substantial engagement with industry instead of solely being exposed to faculty members,** albeit experts in their research discipline. The latter hampers the development of the much-needed professional traits that go further than knowledge acquisition in traditional education.[565]

Also, research shows that in biotechnology **it is important for biotechnology students to have the skills to access relevant information for their studies and critically evaluate the vast volume of information and its sources,** as particularly in biotechnology keeping up-to-date with the rapid pace of change and the risk of outdated information is challenging.[566] Consequently, developing information literacy skills, as part of lifelong learning, prepares Biotechnology graduates for their careers. Students also need to understand the issues related to the use of information such as social, political, ethical, and legal implications.

Consequently, education and training that prepares the workforce for the rapid technological developments in the coming decades will require substantive attention to transversal skills relevant to work in high-tech environments and on thematic areas that cut across technology domains. In the following sections, we will operationalise these transversal skills and investigate how they can be trained in an effective and efficient manner.

High-tech T-shaped skills reflect deep technological and thematic specialisation

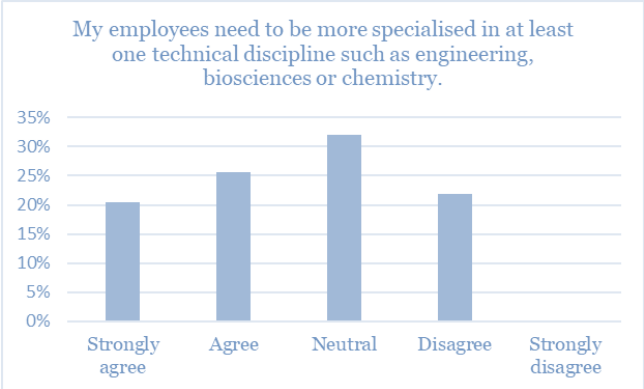
The deep specialisation of future professionals refers to the depth of technological, sectoral and thematic skills and knowledge present in an individual. They are usually leveraged from STEM disciplines (science, technology, engineering and math).

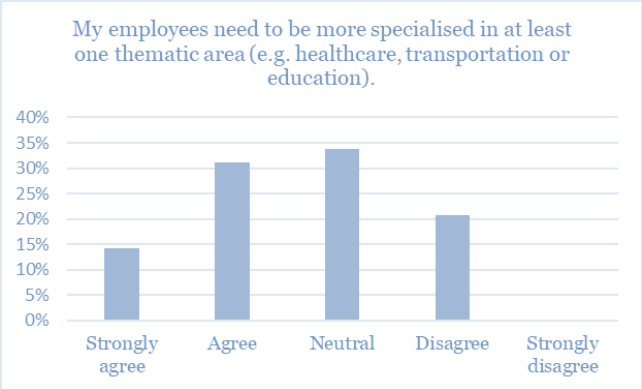
Two conceptualisations of skill depth can be recognised: the depth of disciplinary specialisation and the depth of system knowledge. Here, disciplinary specialisation refers to the skills required to work with Key Enabling Technologies (KETs). Examples of these skills include physics and engineering, but also big data analytics and web development. System, on the other hand, is understood as a major system impacting the quality of life. Systems include all knowledge areas pertaining to top-of-mind societal challenges, such as environment, energy, mobility, health and wellbeing, food and nutrition, security, privacy, and inclusion and equality.

[565] K. Miller, 'Why the Hard Science of Engineering is No Longer Enough to Meet the 21st Century Challenges', Olin College of Engineering, 2015, available from: http://undergrad.msu.edu/uploads/RebalancingEngineeringEducationTReadingrec.pdf (accessed 15 February 2018)
[566] Ward, H., & Hockey, J. (2007). Engaging the learner: Embedding information literacy skills into a biotechnology degree. Biochemistry and molecular biology education, 35(5), 374-380.

These conceptualisations are relevant to high-tech employers in Europe. Employers in our survey show a mostly positive sentiment towards the notion that their current employees need to be more specialised in a specific technical discipline or thematic area.

Figure 87 and Figure 88: PwC survey among high-tech employers and stakeholders in Europe; N=78, 77 resp.





In the following sections, we will detail these technological, sectoral and thematical skills, and investigate how they can be trained in an effective and efficient manner.

7.2.2. Operationalising high-tech T-shaped skills

In this section we operationalise technical skills relevant to smart industrial specialisation, skills specifically relevant to digital transformation, and transversal skills relevant to smart industrial specialisation and digital transformation. During our subsequent analysis in section 3, we will identify for each initiative to which of these skill types they contribute, to determine their role in the breadth of expertise and skills that the future professional should possess.

To further the conceptualisation of high-tech T-shaped skills and future professionals, we propose to include specific skill types to the breadth of the future professional. We opt to build on previous studies that conceptualise skills relevant to high-tech areas and digital transformation, including the study on skills for KETs in Europe and e-skills and e-leadership skills.[567]

The KETs Skills Vision report suggests six categories of competences for Key Enabling Technologies.[568] These six categories were defined based on common patterns in KETs competences, and represent both the need for specialist (technical) skills and crosscutting skills.

These skill categories are:

- Technical skills in an adjacent technology domain;
- Skills related to quality, risk and safety skills;
- Management, leadership and entrepreneurial skills;
- Communication skills;
- Innovations skills;
- Emotional intelligence skills.

[567] 'Final Report: Skills for Key Enabling Technologies in Europe: Vision for the Development of Skills for Key Enabling Technologies (KETs)', *European Commission Docsroom*, 2016
[568] DG Grow. "Vision and Sectoral Pilot on Skills for Key Enabling Technologies: Key outcomes and recommendations." FINAL REPORT v2.0. Service contract nr. SI2.ACPROCE060233200

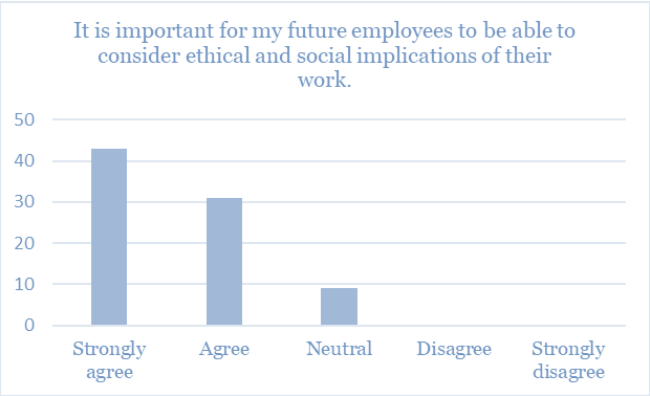
A specific point of attention can be raised regarding ethics. We propose to add this as a seventh category to the notion of high-tech T-shaped skills, especially as recent research indicates the importance of ethical considerations for effective, responsible and sustainable implementation of technological solutions.
An in-depth case study in Australia has shown that **a more prominent sustainability-informed ethics paradigm would allow technology workers to engage with stakeholders in a more effective manner**.[569] High-tech workers could be agents of change, especially when they fully understand and are able to communicate the role and societal impact of technological trends and innovations, especially when interacting with the decision-makers within their stakeholder organisations.

Furthermore, already in 2003 an initiative was implemented that achieved significant improvements in scientific and technological literacy among non-technology majors, by having them analyse moral and environmental conflicts through case studies on that helped them understand biotechnological aspects of these conflicts.[570] Conversely, **it may be interesting to consider exposing technology majors to moral and normative case studies to enhance their ethical and sociological literacy**.

A paper relevant to this topic was published last year. This paper suggests that high-tech T-shaped **expertise should include capacities that allow integration of one's own knowledge with the knowledge carried by someone else**. These capacities encompass trading, interactional expertise, socio-technical integration, and engagement, and can be integrated into STEM education curricula.[571]

High-tech employers in Europe underline the importance of ethical skills and insights. Nine out of ten surveyed high-tech employers think it is important for their future workers to be able to consider the ethical and social implications of their work.

Figure 89: PwC survey among high-tech employers and stakeholders in Europe; N=83



Consequently, we come to propose seven categories of high-tech T-shaped skills. Figure 2.4 below explains each of these types of skills in more detail.

[569] 2010. Practical skills and techniques for the transition to a sustainable future, a case study for engineering education. Dwyer, Brian; Byrne, Edmond P.

[570] Dori, Y. J., Tal, R. T., & Tsaushu, M. (2003). Teaching biotechnology through case studies—can we improve higher order thinking skills of nonscience majors?. Science Education, 87(6), 767-793.

[571] Shannon Nicole Conley, Rider W. Foley, Michael E. Gorman, Jessica Denham & Kevin Coleman (2017) Acquisition of T-shaped expertise: an exploratory study, Social Epistemology, 31:2, 165-183, DOI: 10.1080/02691728.2016.1249435

Figure 90: Adapted from the European Commission's 2016 Final Report: Skills for Key Enabling Technologies in Europe: Vision for the Development of Skills for Key Enabling Technologies (KETs)'

1 Technical	2 Quality, risk & safety	3 Management & entrepreneurship	4 Communication	5 Innovation	6 Emotional intelligence	7 Ethics
competences related to practical subjects based on scientific principles (e.g. characterisation, systems integration, mathematical modelling and simulation, top-down fabrication etc.)	competences related to quality, risk & safety aspects (e.g. quality management, computer-aided quality assurance, emergency management and response, industrial hygiene, risk assessment etc.)	competences related to management, administration, IP and finance (e.g. strategic analysis, marketing, project management, IP management, deal negotiation skills etc.)	competences related to interpersonal communication (e.g. verbal communication, written communication, presentation skills, public communication, virtual collaboration etc.)	competences related to design and creation of new things (e.g. integration skills, complex problem solving, creativity, systems thinking)	ability to operate with own and other people's emotions, and to use emotional information to guide thinking and behaviour (e.g. leadership, cooperation, multi-cultural orientation, stress-tolerance, self-control etc.).	ability to consider the ethical impact of job tasks and new technologies and applications on society.

As figure 2.4 highlights, KETS require a balance between technical and non-technical competencies. These technical competencies are essential and difficult to train, yet to optimally utilise technical skills would appear to require at least a minimum level of skill attainment in the other categories.

The international, multi-stakeholder Dialogue Series organised by the World Economic Forum's System Initiative on Shaping the Future of Education, Gender and Work shows that **the complexity of understanding the skills need among workers presses the need for standardised frameworks to assess the demand**.[572] Therefore, within this project, we build on the analysis of relevant competencies within the non-technical skill types described above performed in the study on skills for KETs in Europe and other reports to propose such a standardised framework.[573] One well-known report used is The Future of Jobs Report 2018 by the World Economic Forum. They provide a comparative overview of the top 10 skills demand between 2018 versus 2022:[574]

Today, 2018	Trending, 2022	Declining, 2022
Analytical thinking and innovation	Analytical thinking and innovation	Manual dexterity, endurance and precision
Complex problem-solving	Active learning and learning strategies	Memory, verbal, auditory and spatial abilities
Critical thinking and analysis	Creativity, originality and initiative	Management of financial, material resources
Active learning and learning strategies	Technology design and programming	Technology installation and maintenance
Creativity, originality and initiative	Critical thinking and analysis	Reading, writing, math and active listening
Attention to detail, trustworthiness	Complex problem-solving	Management of personnel
Emotional intelligence	Leadership and social influence	Quality control and safety awareness
Reasoning, problem-solving and ideation	Emotional intelligence	Coordination and time management
Leadership and social influence	Reasoning, problem-solving and ideation	Visual, auditory and speech abilities
Coordination and time management	Systems analysis and evaluation	Technology use, monitoring and control

Technical skills relevant to smart industrial specialisation

Technical skills related to KETs areas can be categorized into production technologies, digital technologies, cyber technologies and knowledge domains. The knowledge domains refer to having expertise in one or more of the societal challenges facing Europe in the years to come. The majority

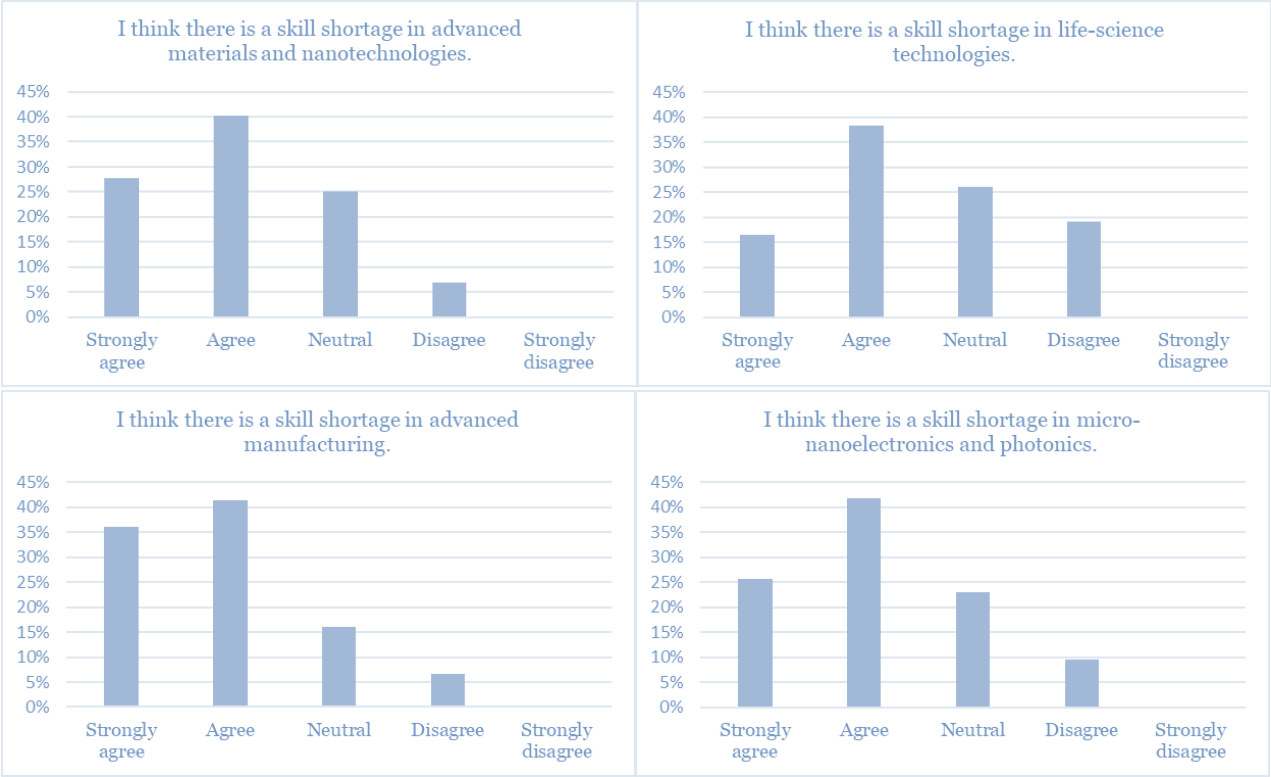
[572] World Economic Forum, 2017, Accelerating Workforce Reskilling for the Fourth Industrial Revolution (White Paper)
[573] See for instance "Skills for Key Enabling Technologies in Europe – European Commission" and "ICT Trends 2020, IDC"
[574] Source: Future of Jobs Survey 2018, World Economic Forum

of jobs in KETS require a technical background, and the kind of technical background depends on the needs of a particular job.

In 2009, the EC has formerly identified six technologies as **Key Enabling Technologies (KETs)**: Advanced manufacturing technologies, Advanced materials, Industrial biotechnology, Micro and nanoelectronics, Nanotechnology and Photonics. In 2018, **the definition of KETs was refined by the High-Level Strategy Group on Industrial Technologies**[575] by confirming the six KETs while separating four of them into two broader categories, **production technologies** and **digital technologies and adding two new main fields: Artificial Intelligence and Digital security and connectivity as cyber technologies**. These technologies enable digital transformation and demand new skills and competencies.

Employers think skills in KETs are important and suffer skill shortages. The employers we surveyed mostly recognise skill shortages in these technology domains, especially in advanced manufacturing. For life-science technologies, this signal is somewhat less strong, although still clearly present.

Figure 91, Figure 92, Figure 93, Figure 94: PwC survey among high-tech employers and stakeholders in Europe; N=75, 72, 73, 74 resp.



Skills specifically relevant to digital transformation

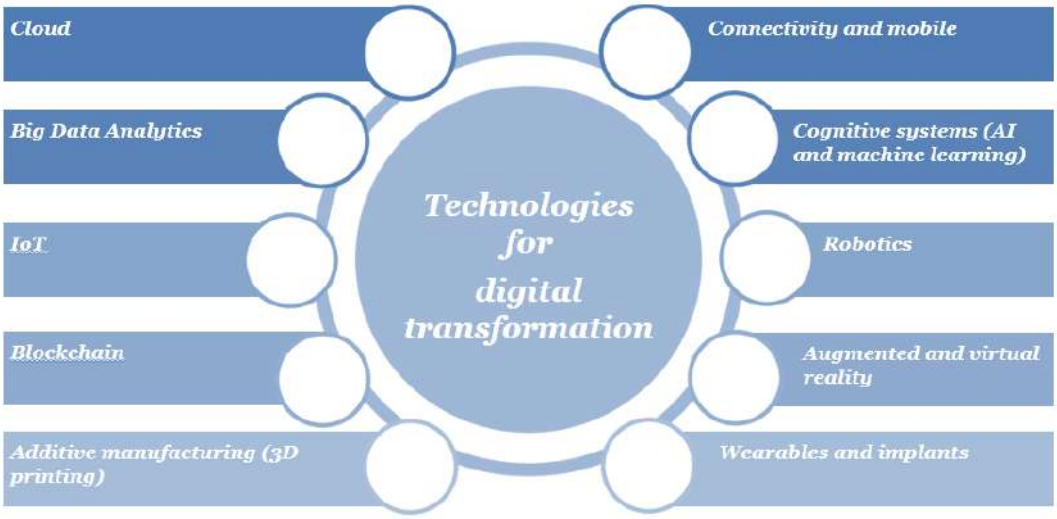
The demand for digital skills derives from technological changes that will be integrated in all areas of business and organisations. **The UNESCO working group on education** describes in its working paper ***Digital skills for life and work*** digital skills as skills existing on a continuum from basic

[575] RE-FINDING INDUSTRY Report from the High-Level Strategy Group on Industrial Technologies, Conference Document, 23 February 2018

functional skills to higher level specialised skills, where **basic skills are skills to access and engage with digital technologies and 'higher level' skills allow to make use of digital technologies in empowering and transformative ways**.[576] Higher-level skills include according to the working group the advanced skills that form the basis of **specialist ICT occupations and professions and computer programming skills** (often referred to as 'coding').

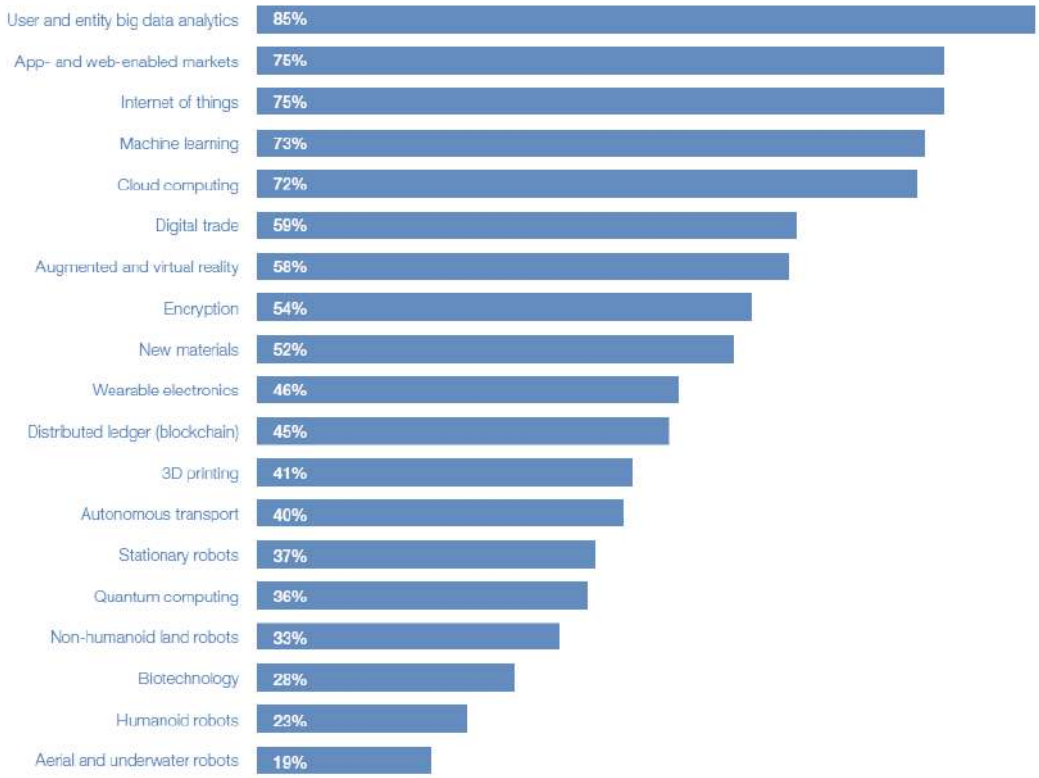
As regards (future) digital technologies, foresight studies[577] predict the biggest technology trends for the coming years are technologies such as the Internet of Things, 5G, cloud computing, 3D printing, data analytics and robotics that are changing the way we design, produce, commercialise and generate value from products and services. These trends are illustrated in figure 2.9 below:

Figure 95: Top technologies for digital transformation mentioned in foresight studies



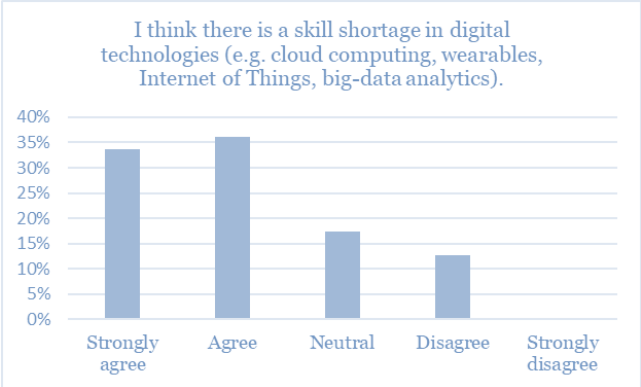
According to a prediction by the WEF, based on a survey among employers, four specific technological advances are set to dominate 2018-2022 as drivers positively affecting business growth. The figure below shows the technologies by proportion of companies likely to adopt them in 2022[578]:

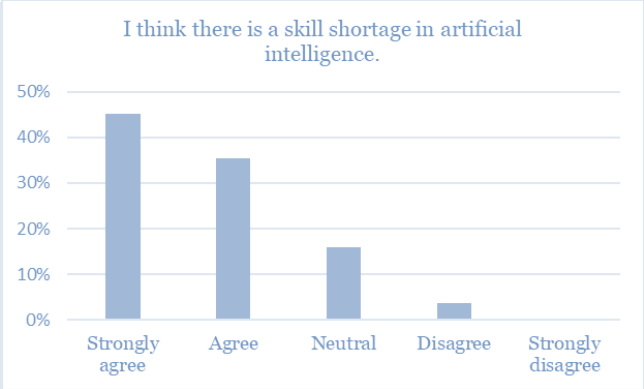
[576] UNESCO Working Group on Education, Digital skills for life and work, September 2017, p.26-28
[577] See for instance "Forbes, Top 10 trends in digital transformation in 2018, 26 September 2017"; "Foresight Services to support strategic programming within Horizon 2020: Foresight report (D3). European Union, 2014"; and "Gartner Top 10 Strategic Technology Trends for 2018 3 October 2017"
[578] Future of jobs survey 2018, World Economic Forum

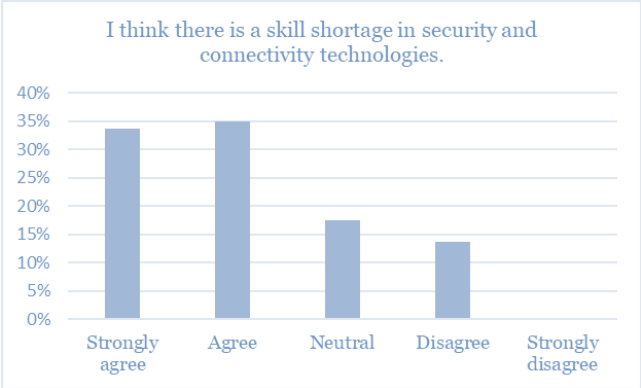


The importance of skill development in technologies for digital transformation is underlined by European employers. Employers in our survey indicate they experience skill shortages in these areas, especially concerning artificial intelligence. They also experience skill shortages in security and connectivity technologies, although this message is less amplified.

Figure 96, Figure 97, Figure 98: PwC survey among high-tech employers and stakeholders in Europe; N=82, 80, 86 resp.







In recent years, studies by Empirica carried out for the European Commission have focused on so-called **e-skills**, **defined in 2004 by the European e-skills Forum** as a wide range of capabilities (knowledge, skills, competences) and issues with an e-skills dimension that span over a number of economic and social dimensions. The studies have focused on 'ICT practitioner skills', 'ICT user skills' and 'e-leadership skills':

- **ICT practitioner skills** are the capabilities required for researching, developing, designing, strategic planning, managing, producing, consulting, marketing, selling, integrating, installing, administering, maintaining, supporting and servicing ICT systems.[579]
- **ICT user skills** are the capabilities required for the effective application of ICT systems and devices by the individual.[580]
- **E-leadership** is a type of **leadership distinguished by the type of goal that needs to be accomplished and what resources a leader must coordinate and align**. E-leadership is defined as 'the accomplishment of a goal that relies on ICT through the direction of human recourses and uses of ICT.'[581] Effective organizations are demanding e-leaders with a portfolio of cross-cutting skills.

According to the e-leadership study, each set of activities demands either strategic understanding (knowing what is possible) or practical understanding (knowing how to do the possible) of a set of skills. The figure below shows the relevant skills for a key set of leadership activities:

[579] Empirica, e-skills for jobs in Europe, measuring progress and moving ahead, 2014, p.20
[580] Idem
[581] Empirica, e-Leadership: e-Skills for Competitiveness and Innovation Vision, Roadmap and Foresight Scenarios, 2013, p.13

Figure 99: Required understanding per activity set and level of expertise[582]

	Literacy & basic skills	Using ICT (Vertical Expertise)				Developing Organizations (Horizontal/Transversal Expertise) Global Knowledge Economy Talents			
Key sets of activities	Reading, writing, math, digital literacy, etc.	ICT expertise	Function expertise	Product expertise	Customer & Sector expertise	Managing change and inventing	Developing a compelling vision	Building and aligning relationships across boundaries	Making sense of a situation
Business development, sales and marketing	+++	+	+	+	+	+++	+++	+++	+++
Business process management	+++	+	+	+	+	+++	+++	+++	+++
Program and project management	+++	+	+	+	+	+++	+++	+++	+++
Global sourcing management	+++	+	+	+	+	+++	+++	+++	+++
Enterprise architecture	+++	+++	+++	+++	+++	+	+	+	+
Solution development and implementation	+++	+++	+++	+++	+++	+	+	+	+
Information management and security	+++	+++	+++	+++	+++	+	+	+	+
IT services management and delivery	+++	+++	+++	+++	+++	+	+	+	+

+ = strategic understanding (knowing what is possible)
+++ = practical understanding (knowing how to do the possible

In addition to the skills an individual needs to possess for tasks in certain jobs for KET's and e-skills, McKinsey states that successful **new ways of working depends on the collective skills and strengths of multi-disciplinary teams**. McKinsey states that the following skills set should be part of any company's 'tech-talent list':[583]

- **Experience designers and engineers**: companies need to invest in tech talent to deliver today's demand for excellent customer experiences. Great experience designers are motivated by customer empathy and can effectively collaborate with product and engineering teams
- **Scrum masters and agility coaches**: 'agile development', where software is rapidly developed in iterative cycles, is a core capability that drives the technology engine. Great scrum masters need to have the ability to be great people leaders, in order to create sustainable change.
- **Product owners**: product owners are often referred to as the mini-CEO of a digital product that needs to define the vision, make decisions and work with developers, engineers, designers and other stakeholders. The product owner needs to influence people and enable teams.
- **Full-stack architects**: full-stack architects need to be fluent across all technology components that include the web/mobile user interface, middleware microservices, and back-end databases and bring deep expertise in one or more areas.

[582] Empirica, e-Leadership: e-Skills for Competitiveness and Innovation Vision
[583] https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-new-tech-talent-you-need-to-succeed-in-digital

- **Next-gen machine-learning engineers**: these engineers are fluent in distributed computing techniques, have experience using different machine-learning algorithms and apply them, understand different parameters that affect learning and understand trade-offs between different approaches. They focus not only on technical solutions but are thought partners to the business.
- **Dev-ops engineers**: these engineers have the experience to navigate a rapidly changing development and cloud-infrastructure computing eco-system and integrate development and operations.

Transversal skills relevant to smart industrial specialisation and digital transformation

Transversal skills relevant to smart industrial specialization and digital transformation can be categorized into quality, risk and safety skills; skills for management and entrepreneurship; communication skills; innovation skills; emotional intelligence; and ethics.

Quality, risk & safety – KETs are envisaged to become widely used and highly impactful, requiring KETs producers to ensure the quality of KETs and to consider risk and safety issues. While companies typically hire dedicated quality assurance specialists, upholding quality and safety is a responsibility of all individuals within a company, necessitating basic quality assurance skills. Furthermore, working with KETs might entail safety risks, making safety skill a prerequisite for future workers.

Management & entrepreneurship – Three distinctive sub-categories of competences can be distinguished within Management & Entrepreneurship category at the individual level, namely, business development-, operational management- and entrepreneurship-related competences. Business development is necessary to capitalize on KETs market potential, and require an individual to have knowledge of strategy, building competitive advantage, the application of state-of-the-art application, and tools and techniques, concepts for the management of new products, and supply chain management when dealing with complex and risky global supply chains.

Communication – As manufacturing processes involve large number of workers from a variety of cultural backgrounds, KET workers need to be able to interact with each other and understand each other's terminologies and goals.

Innovation – The interdisciplinary nature of KETs asks for competences such as having a design mind-set, taking risks with approaches and solutions that have never been applied or attempted before.

Emotional Intelligence – Emotional intelligence is a key ingredient for any successful interdisciplinary team, especially if cultural or other barriers need to be bridged. Emotional intelligence skills include the individual's ability to control own behaviour, and include, among others, persistence, passion and enthusiasm, attention to detail, adaptability, self-discipline etc. Emotional intelligence also includes social skills, including the ability to manage the emotions of others, including friendliness, leadership, integrity, multi-cultural orientation.

Ethics – Given the substantial social and environmental impact that KETs and digital technologies might entail, leaders and professionals need to be aware of the consequences that their actions can have. Skills related to ethics include having basic human values, empathic concern, perspective taking, moral behaviour, moral cognition and moral judgement.

The table below provides a structured overview of these detailed competency areas.

Table 21: Structured overview of detailed competency areas per skills category

1 TECHNICAL	
Production technologies	**Digital technologies**
Chemistry	Physics
Physics	Engineering (incl. Systems Engineering)
Engineering (incl. Systems Engineering)	Electronics
Electronics	Optics
Biology	Photonics
Optics	Computer science
Photonics	Nanoscience
Computer science	Materials Science
Nanoscience	Mathematics
Materials Science	Statistics
Mathematics	Microelectronics
Statistics	Design Methodology
Metrology	Operations Analysis
Big data analytics	Systems Analysis
Business analytics	Computer-Aided Design (CAD)
Microelectronics	Multidisciplinary design optimisation
Design Methodology	Process Layout & Optimisation
Operations Analysis	Life-cycle analysis
Systems Analysis	Scalability analysis
Computer-Aided Design (CAD)	Computer skills
Multidisciplinary design optimisation	Programming
Process Layout & Optimisation	Computational thinking
Life-cycle analysis	Mobile app design and development
Scalability analysis	IT and platform architecture
Computer skills	Enterprise resource planning
Programming	Artificial intelligence
Computational thinking	Complex business systems
Mathematical modelling and simulation	Big data analytics
Computer-Aided Engineering (CAE)	Business analytics
Non-destructive testing	Internet of Things
Real-time modelling and simulations	Systems integration
Process improvement tools	Characterisation and analysis
Computer-Aided Manufacturing (CAM)	
Systems Evaluation	
Standard Operating Procedures (SOP)	
Product labelling and packaging	
Top-down fabrication techniques	
Equipment Selection	
Installation	
Equipment running skills	
Operation Monitoring	
Troubleshooting skills	
Maintenance, Repair and Overhaul (MRO)	
Systems integration	
Characterisation and analysis	
General Lab Skills	
Specific Lab Skills	
Cyber technologies	**Thematic domains**
Engineering (incl. Systems Engineering)	Environment
Computer science	Energy
Design methodology	Mobility
Systems analysis	Health and wellbeing
Cyber technologies	Food and nutrition
Computer skills	Security
Programming	Privacy
Computational thinking	Inclusion and equality

Cloud computing and virtualisation	
Security skills	
IT and platform architecture	
Web development	
Internet of Things	
Social media	
Mathematical modelling and simulation	
Systems evaluation	
Systems integration	
Characterisation and analysis	
2 QUALITY, RISK & SAFETY	
2.1 Quality	**2.2 Risk & safety**
Quality management	Risk Assessment
Computer-Aided Quality Assurance (CAQ)	Working conditions/ Health and safety
Quality Control Analysis	Emergency Management and Response
	Industrial Hygiene
	Equipment Safety
	Ethics
3 MANAGEMENT & ENTREPRENEURSHIP	
3.1 Business development	**3.2 Operational management**
Strategic analysis	Project Management
Technology strategy	Time Management
New Product and Process Development (NPPD)	Teamwork skills
Marketing	Coaching & Developing
Customer Focus	Delegation skills
3.3 Entrepreneurship	Monitoring
Deal negotiation skills	Risk Management
Acquisition of funding	Management of Personnel Resources
Intellectual Property (IP) management	Management of Financial Resources
International regulatory affairs	Supply chain management
	Cost modelling skills
	Generation of shop floor work instructions
	Procurement skills
4 COMMUNICATION	**5 INNOVATION**
Interpersonal skills	Integration skills
Verbal communication	Design mind-set
Written communication	Continuous experimentation
Presentation skills	Complex Problem Solving
Public communication	Creativity
Virtual collaboration	Systems thinking
6 EMOTIONAL INTELLIGENCE	
6.1 Self-management	**6.2 Social skills**
Persistence	Friendliness/Being respectful of others
Passion, enthusiasm and curiosity	Leadership
Sense of responsibility	Integrity
Stress tolerance	Cooperation
Attention to detail	Multi-cultural/global orientation
Adaptability	
Ability to thrive on failures	
Balancing life and work demands	
Self-discipline	
Self-control	
Proactivity	
Continuous improvement orientation	
Active Learning	
Alertness	
Judgment and decision making	
7. Ethics	
Basic human values	
Empathic concern	

Perspective taking
Moral behaviour
Moral cognition
Moral judgement

7.2.3. Challenges related to high-tech T-shaped skills

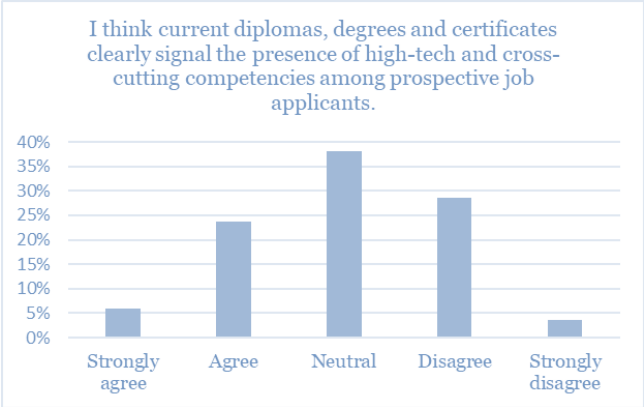
When analysing initiatives, strategies and policies relevant to high-tech T-shaped skills, it is important to understand to which challenges they respond. Previous studies have identified specific types of labour-market challenges related to skills in high-tech areas, including Key Enabling Technologies. Our analysis will build on this typology, pointing out which labour-market challenges identified initiatives specifically address in section 3, and embed this typology in recent literature on the influence that high-tech T-shaped skills have on classroom approaches and curriculum design.

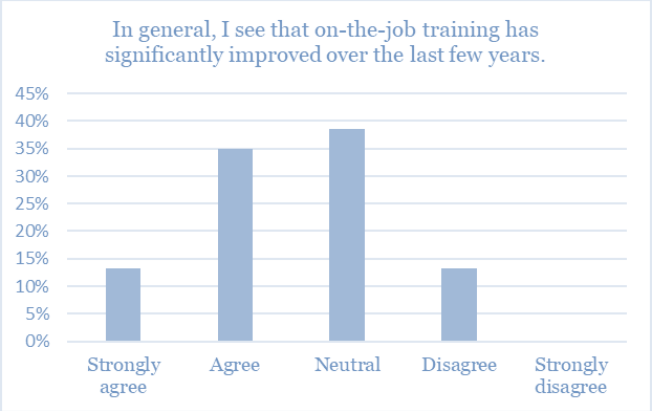
Relevant strategies, policies and initiatives can focus on a number of aspects of high-tech T-shaped skills, including:

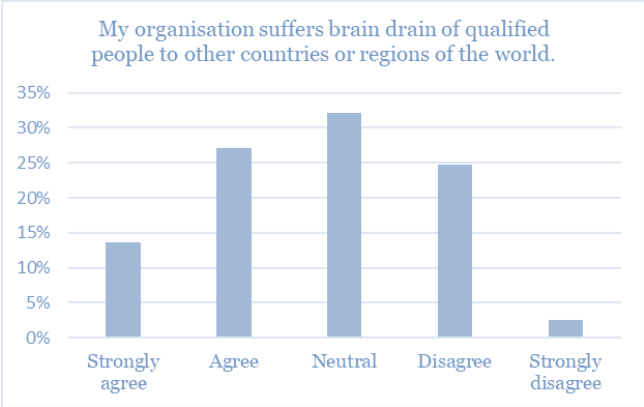
- Policies and initiatives that "sell" **high-tech careers as being attractive** and prestigious, with both personal and financial reward;
- Policies and initiatives that create '**high-tech awareness' already a decade before students enter the workforce**, introducing and attracting students to a wide range of technological disciplines;
- Policies and initiatives that introduce technical education early in a young student's curriculum and that **attract young people to high-tech educational tracks**, and that introduce high-tech topics to children starting from an early age;
- Policies and initiatives that encourage **co-development of educational initiatives and materials** with educators, industry, and policymakers;
- Policies and initiatives that adapt university programmes to the **highly-skilled human capital needs of industry;**
- Policies and initiatives that **prepare a future generation** of researchers, engineers, designers and business leaders to state-of-the-art technology;
- Policies and initiatives that **include training activities aimed at improving high-tech skills** to research, development, and product demonstration projects.

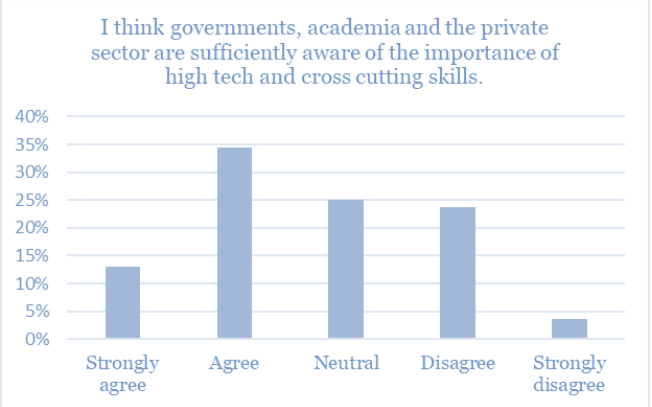
A fair share of surveyed high-tech employers in Europe recognise these challenges. They especially think it is crucial to improve the image and awareness of high-tech and/or digital as a field to work in, so that more high-potential professionals choose these careers, particularly minorities and women.

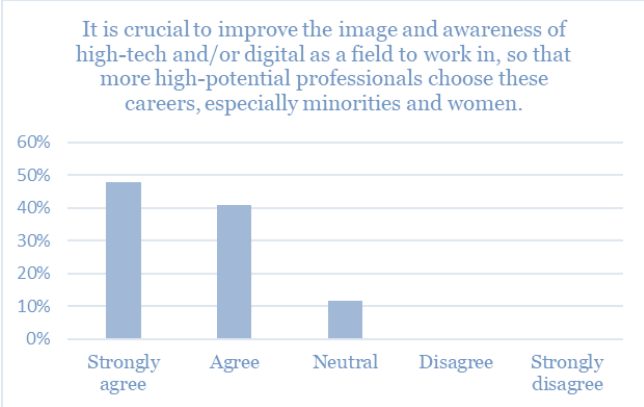
Figure 100, Figure 101, Figure 102, Figure 103, Figure 104: PwC survey among high-tech employers and stakeholders in Europe; N=86, 81, 84, 84, 83 resp.











Classroom approaches to high-tech T-shaped skills may become more interactive and more integrated

Studies have shown that, prior to the 2000s, technical courses were taught through a narrow academic classroom to laboratory experience. However, since the turn of the century, few have shifted towards more **"experiential learning" that consists of pedagogical techniques that are more interactive in nature**, and that include simulations, capstone projects, and leadership training. [584]

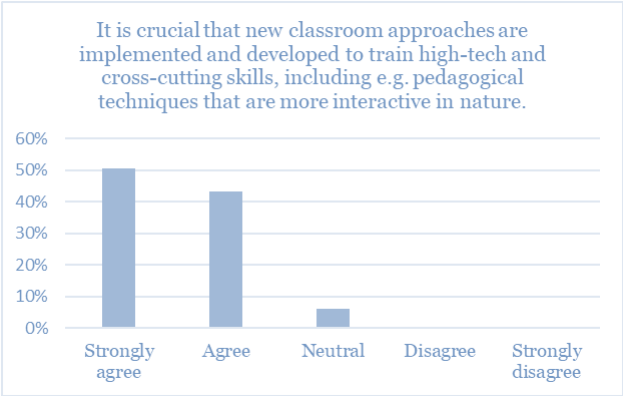
[584] P. Goodhew, 'How they do it elsewhere', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 7-12

Some experts stress the need for a unified experience expressed through the concept of a Centre for Engineering Design that operates as **a platform for innovation and collaboration between school pupils, university and its students, and industry**.[585]

Other experts argue for vertically **integrated projects that break down the barriers between courses, academic years, academic generations, and research/teaching**.[586] This happens through the engagement of 10-25 students from different courses and different years over a period of several academic years in support of nurturing skills in leadership, planning, communication, research, conflict resolution, and fundraising.

Employers also emphasise the importance of innovative classroom approaches. Our survey indicates a clear need for new classroom approaches that train high-tech and crosscutting skills, including pedagogical techniques that encourage and foster interaction in the classroom.

Figure 105 PwC survey among high-tech employers and stakeholders in Europe; N=83



Appropriate curriculum design requires carefully calibrated industry-academia collaboration

Experts on high-tech T-shaped skills also explore different approaches to curriculum design. Some experts argue that due to the limited "shelf-life" of knowledge, any course that puts more emphasis on knowledge instead of capabilities shall result in limited value for students and future employees. By designing a curriculum based on a pull-centric process-based model, **education is approached through a reversed learning programme where the final 'output' capabilities dictate the prior 'input' learning need**.[587] This would increase the coherence of educational modules within a curriculum.

Others argue though that this pull aspect should not dominate the conversation. They stipulate that although there is a necessity for higher education to facilitate a learning environment that is more in tune with industry needs, educators and policymakers both should not lose sight of the fact that **engineering is by its very nature a highly complex and multifaceted discipline**.[588]

[585] M. Cook, 'Accelerating Development of Creative Design', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 13-18
[586] S. Marshall, 'Vertically Integrated Projects: transforming higher education', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 19-22
[587] D.G. Allan and G.D. Rowell, 'Industry-ready Graduates through curriculum design', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 23-34
[588] R. Clarck and J Andrews, 'Engineering or the Engineer', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 51-58

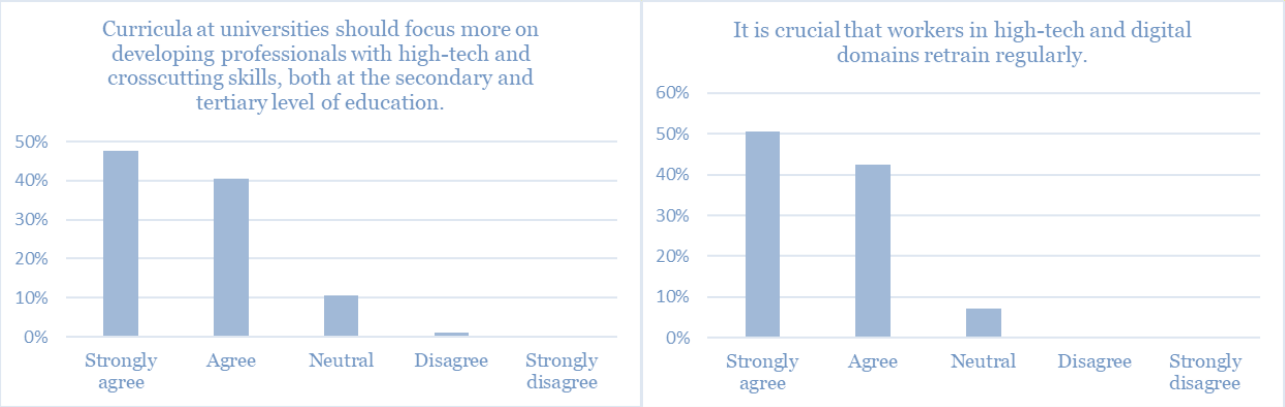
Some experts would worry that industrial actors put too much emphasis on getting new recruits integrated into companies, their working teams and the industry at large. This would contribute to the pressure on academic institutions to deliver ready-made high-tech workers, to the detriment of broad and foundational academic development of students. **They argue that this process should be a joint endeavour characterised by two aspects:**[589]

- Industry involvement throughout the university years;
- Academia's involvement throughout the professional career as part of a life-long learning effort.

Moreover, some experts argue that many technical curricula are construed as applied science, while historically technology and engineering have been about creating new things that address and solve interesting problems, key challenges and pressing needs of society, thereby giving rise to scientific discovery and development. Currently, by arranging courses in a way that engineering follows science and mathematics, these **experts argue that creativity tends to take too much of a backseat to formal analysis**.[590]

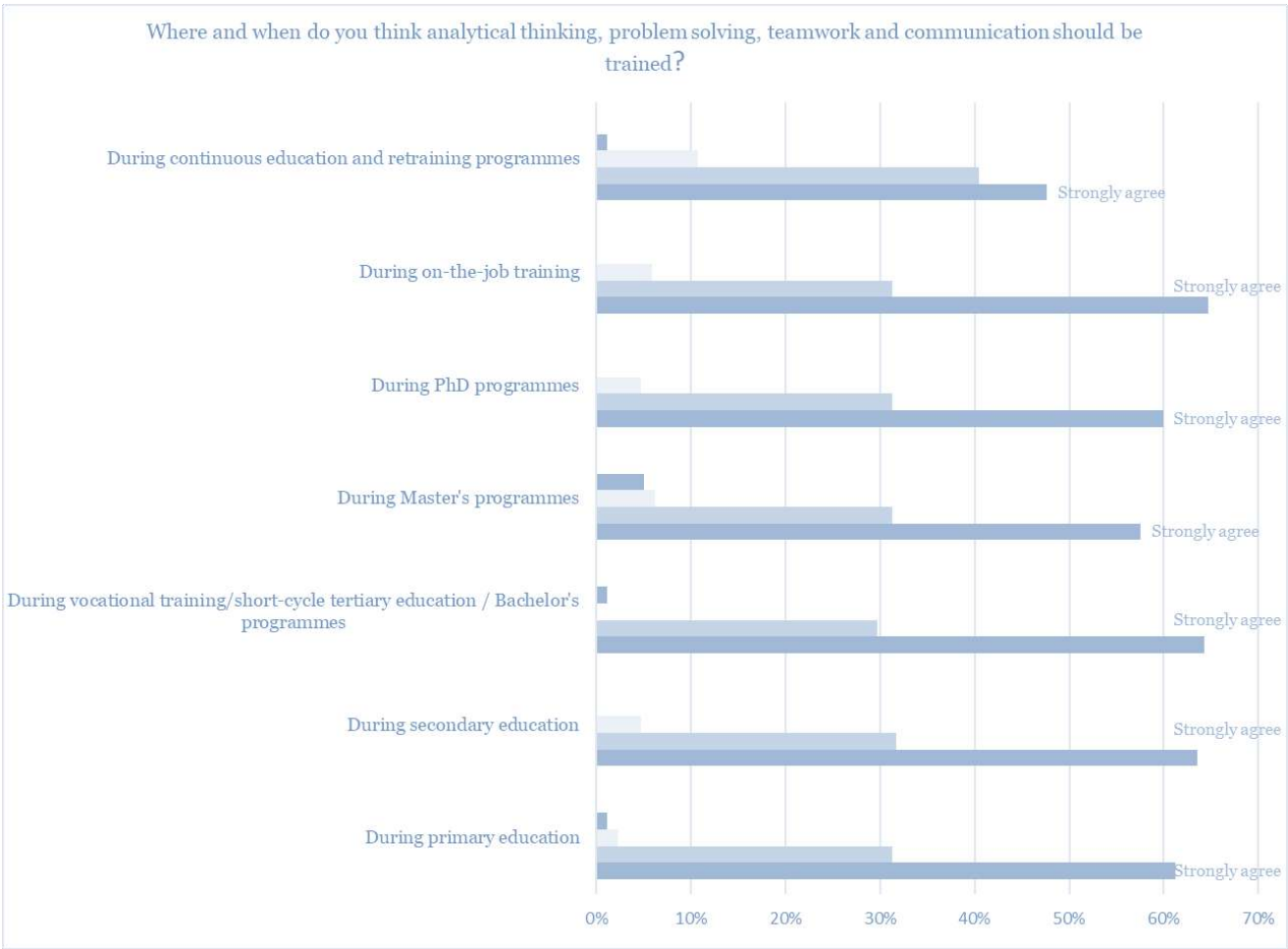
Employers also call for improvements in curriculum design. Surveyed employers think that curricula at universities should focus more on developing professionals with high-tech and crosscutting skills, both at the secondary and tertiary level of education, and that workers in high-tech and digital domains retrain regularly. When asked where and when transversal skills should be trained, such as analytical thinking, problem solving, teamwork and communication, **employers indicate that transversal skills should be trained at all levels, particularly at secondary and bachelor level, as well as on the job**.

Figure 106: PwC survey among high-tech employers and stakeholders in Europe; N=84, 85 resp.



[589] E. Tilley and J.E. Mitchell, 'A view on the engineering curriculum', R. Clarck and J Andrews, 'Engineering or the Engineer', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 59-64
[590] K. Usher and D. Sheppard, 'AIMLED – A new approach to engineering higher education', *New approaches To Engineering in Higher Education*, Institution of Engineering and Technology, 2017, 65-70

Figure 107: PwC survey among high-tech employers and stakeholders in Europe; N=113 resp.



7.3. Strategies, policies and initiatives on high-tech T-shaped skills

In this section we present the initiatives we encountered relevant to high-tech T-shaped skills. We first present industry-led initiatives in section 3.1, secondly we present government-led initiatives in section 3.2, and in section 3.3 we present academic, triple-helix and hybrid initiatives.

For each initiative, we provide some basic information, and briefly describe their objectives, the ways in which they are implemented, their impact and results, the context and regulatory framework within which they achieve these results, considerations on transferability and scalability of the initiatives, and identified success factors and barriers.

In section 3.4, we analyse the leading academic education providers relevant to key enabling technologies and digital transformation. In section 3.5 and 3.6, we describe dual-track education and continuous education, and their relevance to high-tech T-shaped skills. In section 3.7 we describe efforts in the United States for developing transversal skills. In section 3.8 we describe the latest insights in funding programmes for high-tech skills.

7.3.1. Industry-led initiatives

In this section we describe good practices of industry-led initiatives relevant to high-tech T-shaped skills. Specifically, we describe:

- ARM University Program in the UK;
- Codecool in Poland;
- SkillSET, active in the US with an aim to operate world-wide in a later stage;
- The IBM Skills Academy, operating world-wide;
- Schneider Electric's Energy University operating world-wide;
- The Tech Partnership in the UK;
- Soft skills & leadership program for technology professionals in The Netherlands;
- The Stages initiative in the Czech Republic.
- Amazon's career choice in the USA
- Demolia in Latvia

ARM University Program

Company name	ARM
Type of organisation	Company
Contact person	Khaled Benkrid
Sector	Education
Country	UK
Web link	https://www.arm.com/research-education/university

Objectives

The core objective of the ARM University programme is to build a long-term relationship with academia and students.

Description

The programme provides a variety of ARM teaching materials, hardware platforms, software development tools, IP, and other resources for educators, students, and researchers. Central to the ARM University Program's "Lab-in-a-box" offerings are the hardware boards, one-year renewable software licences for the full ARM Keil® MDK-Professional development tool, and Complete teaching materials, including lecture note slides, demonstration codes and hands-on lab manuals with solutions in the source. The strategy is to familiarise individuals with the ARM ecosystem.

Impact and results

ARM has managed to expand on its catalogue with education kits, which is currently used in multiple countries. Furthermore, the organisation has started since 2017 with an Arm Schools Program: a dedicated program for pre-university education to complement the Arm University Program and Arm Education Media.

Context and regulatory framework

The Arm University Programme eco-system consists of partnerships with silicon vendors, OEM publishers, EDA vendors, university professors, students, and developers at large. ARM serves as a connecting body between all these entities that make use of their design. The continuity is largely dependent on the willingness of ARM to seek further embedment of its eco-system. Given that ARM has a considerable pool of contributors to its disposal and students and professors cannot yet make use of alternatives to the ARM catalogue, there is a higher probability that ARM can expand on its initiative rather than phase out the initiative.

Transferability and scalability

The transferability of the ARM university project is subject to some conditions. The most important one is the funding part. ARM itself does not manufacture any hardware, it only designs them, therefore using the partners who develop hardware based on ARM design as vendors for the educational material. Most companies in especially Europe do not have a similar ecosystem and organisational structure as ARM has, making it a challenge to provide a similar service. The logistical capacity will constitute a challenge as well, not in the last place due to the possibility that other industries do not enjoy a hardware offer that is easily shippable.

Due to ARM's worldwide reach it is able to upscale its programme to a large number of countries. Also given the fact that the backbone of the ARM University programme is its e-platform, there should be no limitation to the number of countries the programme could reach.

Success factors and barriers

- Due to providing the development tools, ARM manages to give educators materials to assist them in their courses.
- The Arm University Programme builds upon years of experience with Universities across the UK and the rest of the world.

Codecool

Company name	Codecool
Type of organisation	Private
Contact person	Tamás Tompa
Sector	Education
Country	Hungary, Poland
Web link	https://codecool.com/

Objectives

Codecool seeks to create the best available coding course in the region by teaching those skills that are high in demand, thereby filling the industry need for well-rounded software developers.

Description

Codecool is a for-profit organisation that offers a tailored 18-month learning experience where students train to become cutting edge software developers equipped with soft skills (e.g. communication skills, time management and creative thinking). The first six months of the programme teach the student generalist programming skills, and the second six months focus on developing specialised skills in one or more technical domains. The last six months include on-the-job training. Further noteworthy characteristics are that Codecool is post-paid, meaning a student can pay for the course only after completing the course, and that it offers a job guarantee, meaning students who do not find a job within three months of graduation do not have to pay back their fees. This lowers the barriers for promising students to join Codecool.

Implementation

Codecool started in 2015 in Hungary, and currently has two schools in Hungary (Miskolc and Budapest) and two schools in Poland (Krakow and Warsaw). Each school has a faculty of 10 to 20 people, including both teachers and support staff, and Codecool currently has 53 employees. Teachers are IT professionals with over 10 years of working experience as software developers. The Codecool management ensures that there is a constant retraining of teachers and a sharing of best practices. The schools are self-organised and adapted to fit local needs. Businesses that hire Codecool graduates are diverse, and include start-ups, SMEs and corporates such as Morgan Stanley, UniCredit and Vodafone. The cost of Codecool training are split between students and companies that pay a recruitment fee.

Impact and results

Since its inception, Codecool has delivered 230 graduates. There are 421 students currently in school.

Context and regulatory framework

There is a gap between the skills that universities supply in their IT programmes and what businesses need. Universities tend to deliver IT graduates without interdisciplinary skills or soft skills, whereas this is the type of professionals that industry needs. This creates an unfulfilled market demand to which Codecool's business model responds.

Transferability and scalability

Codecool currently operates in two different countries, and there are plans to open more schools in the years to come. The Codecool formula, where students receive tailored education and technical and soft skills, does seem relevant in other geographies too. However, the transferability of the Codecool business model is likely to differ per country, depending on (local) business needs and local educational offerings.

The scalability of the initiative is currently constrained by the needs for face-to-face interaction between students and teachers and the high faculty-to-student ratio. Codecool is experimenting with online learning, which might increase the scalability of its products.

Success factors and barriers

- Personalised and person-centred learning;
- Balance between hard and soft skills;
- A fail-safe environment where students work on projects in an experimental and self-paced way;
- Ownership of students over their own learning;
- Mentors' and students' interests align in delivering a software developer that is productive from day 1.

What has been more difficult is the fact that Codecool offers no officially recognised diplomas of certificates, meaning that it can take more time to establish trust between Codecool and potential customers. Furthermore, Codecool relies on reliable recruitment needs.

SkillSET	
Company name	SkillSET
Type of organisation	Industry-led
Contact person	On request
Sector	Education
Country	Worldwide (initially only US)
Web link	http://www.theskillset.org/

Objectives
The SkillSET portal's objective is to bring competitive training content together on one platform to meet the global skills gap challenge arising from the Fourth Industrial revolution.

Description
The SkillSET portal, created by leading organizations in the IT sector, is a free platform of online tools that assists in streamlining the process of reskilling adults. The partner companies are sharing their training libraries into the SkillSET portal, where uses then have access to state-of-the-art training materials, ranging from general business skills to advanced topics in big data or cybersecurity. The portal also includes a tailored Skills Assessment to help users determine which courses best fit their current skillset and learning goals.

Implementation
The initiative will first be accessible to the US market, with plans on scaling up and extending the initiative to other geographies.

Impact and results
The SkillSET initiative aims at 1 million people accessing and making use of the SkillSET portal by the end of 2020.

Context and regulatory framework
To meet the global skills challenge as a result of new technologies and a changing economy, the World Economic Forum launched the IT Industry Skills Initiative. This Initiative, conceived by the Forum's IT Governors community, in turn created the SkillSET portal. The founding partners are Accenture, CA Technologies, Cisco, Cognizant, Hewlett Packard Enterprise, Infosys, Pegasystems, PwC, Salesforce, SAP and Tata Consultancy Services.

Transferability and scalability
Transferability and scalability are both high, because the platform is entirely web-based, and therefore the costs for upscaling and making it available in different geographies likely is low.

Success factors and barriers

- Working together with leaders in industry.
- Contribution in partnership based on expertise.
- Easily accessible and free.
- Personalised learning experience.

IBM Skills Academy

Company name	IBM
Type of organisation	Private
Contact person	Mariusz Ochla
Sector	Education
Country	Worldwide
Web link	IBM Skills Academy

Objectives

IBM Skills Academy assists universities in filling the gap between academia and business, improves student learning through hands-on experiences with the latest technologies, and helps connect students to the job market. This is beneficial to IBM's long-term needs for a solid knowledge base.

Description

The Skills Academy Program is IBM's primary training and certification initiative aimed at university students. Through partnerships with universities, students in IT or IT-related fields can participate in different 'career tracks' that range from data scientist to predictive analytics modeller. Each career track has a number of distinct skill-focused learning objectives that are based on market research and in line with high-demand jobs in the IT market. The teaching is through a blended learning module that is partly web-based (roughly 80%) and partly classroom based (roughly 20%). This means that students take self-paced online courses, have instructor-led classroom training, and do hands-on lab exercises through IBM's cloud environment.

Upon successful completion of a career track, a student receives two IBM certificates – Explorer Badge and Master Badge. This certificates are part of the IBM Open Badge programme. It takes 50 hours classes (blended-learning) to achieve the Explorer Badge. It is necessary to pass a corresponding exam to get the Mastery Badge. The IBM Open Badge is a digital recognition of technical skills that can be used across industries, and which the student can share on professional networks. This certificate also help recruiters to find students more easily, and improve students' chances to receive a job interview. Teachers can receive training themselves to optimize the face-to-face learning experience, and receive an IBM certificate to signal their expertise.

Implementation

Students at a university that has a partnership with IBM can participate. Students can choose from a set of twelve career paths that have been built based on market research and input from partner companies. Participation is mostly extracurricular, although some universities are adopting (part of) the IBM Skills Academy into their own curriculum. IBM does not seek to make a profit out of the Skills Academy, but to cover the costs, students or the university have to pay some moderate fees.

The Skills Academy started as a pilot in a number of African countries, but has now expanded to different regions as well, including Asia, the Pacific, and the United States. Last year, the first Skills Academy launched at a European university as well. Aim is to have partnerships with hundreds of universities across Europe.

Impact and results

Since IBM's Skills Academy only started in Europe last year, it might me more informative to focus on the Skill Academy's impact in Africa.

Since 2014, the year of the launch, 35,000 university students participated in the Skills Academy programme, and 9000 students received Open Badges. These students came from 10 different countries and studied at 150 different universities. Of the students that attended a course, 60% now have a job.

Context and regulatory framework

For this initiative, IBM builds on its long-held relationship with universities worldwide. IBM reaches out to the university partners and leverages its business network to engage with universities that might be interested. A third option for cooperation would be when universities contact IBM to join the programme directly.

IBM delivers the online software and learning materials, and the universities decide how to best fit the Skills Academy offerings in its curriculum or as an extracurricular activity.

Transferability and scalability

The transferability of the programme is high, as is illustrated by the fact that the programme is similar for the different world regions. Scalability is high too, but constrained by the requirement to have face-to-face interaction, and by the requirement to have a lab to use the relevant software.

Success factors and barriers

- Through IBM's vast network with universities and because the programme largely uses online-learning, the number of students reached has been very high.
- The set of skills that students learn are directly relevant to them and to their future employers.
- What has been more challenging at times is the fact that engaging universities is resource intense, and the difficulty that official procedures impose in adapting university programmes.

Schneider Electric's Energy University

Company name	Schneider Electric
Type of organisation	Company
Contact person	Belinda Liu (SVP Learning Solutions Global HR)
Sector	Energy
Country	Global
Web link	http://www.schneideruniversities.com/energy-university/

Objectives

Energy University aims to be the leading source of innovative energy education in the world.

Description

Schneider Electric launched Energy University in 2006, a free online educational resource with more than 350 courses on energy efficiency and data centre topics. The initiative is aimed at anyone who wants to launch or enhance their career or company by taking a step towards energy efficiency by using multiple free energy education courses online. This includes clients, potential clients, students and people with limited access to education.

Implementation

- Free vendor-neutral online data centre and energy efficiency courses available 24 hours a day and in 13 languages.
- Two certification exam offers for career advancement: PEM & DCCA
- Courses developed by subject matter experts from around the world.
- Self-paced, less than one-hour modules
- 22+ global industry endorsement for educational credits
- The LMS enables registered users to track which courses they've taken, the results of the quizzes attached to each, print transcripts and certificates of completion, and more.

Ideas for courses come from a number of sources. One is the vast array of white papers written by Schneider Electric's subject matter experts (SMEs). Subsequently, the Energy University team works together with the SMEs to determine whether they would be good candidates for an Energy University course or an update to an existing course. Customers and students a second source of ideas for new courses. As visitors take courses, they fill out surveys that provide feedback on topics and any changes they would like to see. In some instances, organizations come to Schneider Electric looking for a collaboration. The result of these different types of input is an interactive, engaging learning experience that continues to expand with new courses and users.

Impact and results

From the start in 2006 until 2010 there were 100.000 registered users. In 2014 the number of users has increased to 400.00+ registered users from 180+ countries. In total from 2006-2014, there are 670.000+ courses taken online. Furthermore, due to the interactive feedback and input for new course ideas, the online platform keeps expanding.

Context and regulatory framework

The initiatives is funded and launched by a company that has the resources to continue this initiative, including maintaining the online platform, the course offerings and monitoring. The courses are offered vendor-neutral, resulting in a broader use by industry associations and institutes. These partners endorse and give education credits to their members for taking the courses offered by the Energy University.

Transferability and scalability

This initiative can be transferred to other industries when funding and knowledge to create the courses is available. This initiative can be seen as an open sourcing of education readily available for employees now also made available for everyone online. When other companies want to follow this initiative in other sectors this can easily be copied, however when this is not the case substantial funding to create an online platform with the broad offering of courses is needed and will form a barrier to the transferability. Most of the courses are in English, but courses are also available in 12 other languages which are crucial for the transferability to other countries.

Furthermore, expanding the course catalogue in co-creation with students and new research leads to the natural scaling of the initiative. The results have shown that the initiative has grown substantially in registered users, courses taken and amount of courses offered, which provides a good indication for this project's scalability.

Success factors and barriers

- An online platform in English and courses offered in 12 other languages as well.
- All courses are offered free of charge and anyone can follow these courses online at their own convenience.
- Having knowledge in-house and being able to work directly with researchers to create new courses.
- Global industry endorsement for educational credits.
- Using feedback from users and collaboration with institutes to create new courses.

The Tech Partnership

Company name	The Tech Partnership
Type of organisation	Private initiative
Contact person	Bob Clift
Sector	Education
Country	United Kingdom
Web link	https://www.thetechpartnership.com/about/

Objectives

The Tech Partnership is a network of employers that aims to create a pipeline of skills needed for the digital transformation in the UK.

Description

The Tech Partnership is a network comprising over 1000 employers from every sector, and led by a board of chief executives of companies in digital industry and heads of technology from across sectors. The Partnership collaborates with employers, educations and government to achieve its objective. A small team of skilled specialists, coming from industry, academia and other backgrounds, supports The Tech Partnership Company.

Implementation

The Tech Partnership tries to reach it goals in four ways. Firstly, the Partnership tries to inspire young people to pursue digital careers by working in schools, colleges and universities across the UK. Secondly, the Partnership seeks to raise the quality of digital skills training and education by developing degree and apprenticeship programmes and apprenticeship standards that meet industry's needs. Thirdly, the Partnership promotes basic digital skills through the digital skills framework and basic digital skills initiatives. Fourthly, the Partnership seeks to bridge the gap between students and employers.

Impact and results

To inspire young people to digital roles, the Tech Partnership created a network of ambassadors from the sector to talk to pupils directly. 700 of these ambassadors volunteer visited schools to attract pupils to digital careers. Furthermore, the Tech Partnership launched a digital learning platform called TechFuture where pupils can familiarize themselves with the tech sector in a fun and informative way. In the past years, 1600 UK schools and colleges participated in TechFuture. This programme offers 50 courses, ranging from game design to cyber security. Finally, 500,000 girls (aged 10 to 19) were reached through a gender campaign to attract women to digital jobs.

To raise the quality of students' digital skills, the Tech Partnership developed apprenticeships and degree programmes. At the start of the Partnership in 2005, there were many talented young people studying IT, but they were difficult to employ because they lacked the right combination of technical skills, project management skills, business awareness and interpersonal skills. The Partnership helps industry by initiating educational programme (such as the ITMB programme) that raises the employer's role in education and improves the skill set and employability of IT graduates. 45 UK Universities offer accredited Tech Industry Gold degrees and degree apprenticeships. Of these degree

students, 75% graduate with a First or 2:1, compared to 52% for computing overall. Graduates of these programmes also report higher employability than their peers.

To improve basic digital skills among the general population, the Tech Partnership and Lloyds Banking Group are leading a consultation to understand and measure the Basic Digital Skills required for adults to be successful in the workplace.

Within the final category, the Tech Partnership organises two events per year to bridge the gap between students and employers. The first is a competition for first and second years, where students work in teams and present ideas to groups of employers. The second is a networking fair where students become better at networking. The Tech Partnership stimulates students doing internships and being exposed to industry during their studies, and this fair contributes to that. Furthermore, The Tech Partnership also recently published a study on the language of technology, and how terminology and meaning can differ between the worlds of education and industry. This report can help create a common language between education and industry and improve the communication between both.

Termination and Legacy

The Tech Partnership will close in September 2018 because of the UK government deciding to discontinue involving intermediate bodies that represent industry. A new Board and not-for profit will continue the Partnership's work in Higher Education, including the apprenticeships and degrees. Another not-for-profit will continue the TechFuture platform.

Context and regulatory framework

Sector Skills Councils (SSCs) are employer-led organisations in the United Kingdom with the goal of developing and managing apprenticeship standards, reducing skills gaps and shortages, boosting skills, and improving learning supplies. The Tech Partnership is the SSC for the tech sector.

The Tech Partnership has two advisory boards. The Industry Board represents the sector and consists of the most senior company representatives in IT and telecom. The CIO consist of companies not from the IT sector, such as NHS digital. The more practical work is done by employer steering groups, which also work together with schools and universities. These steering groups also approach universities for collaboration, and universities are open to participate.

Transferability and scalability

- Many of the activities could be scaled and replicated elsewhere.
- The method of bringing together different sectors to improve education could be replicated elsewhere.
- The termination of the Tech Partnership demonstrates the need for a supportive government policy environment for a sector-led approach to skills.

Success factors and barriers

- The Partnership creates synergy by working towards shared goals among employers and academics.
- The apprenticeships are popular with business, but less so with students' parents, who would rather see their children go to university if they can.

Soft skills & leadership program for technology professionals

Company name	Settels Savenije & Friedrich
Type of organisation	Engineering Consultant
Interviewee	Jaco Friedrich
Sector	Training technology professionals
Country	Netherlands
Web link	http://www.sttls.nl/soft-skills--leadership-

Objectives

Settels Savenije & Friedrich is a collective of companies that, among other things, provide training to technology professionals with the aim of equipping them with soft skills to deal with an ever-increasing complex working environment. They acknowledged the need from the industry for technology professionals with comprehensive communication and leadership qualities and started circa seven years ago with developing and providing training in this field. Settels Savenije & Friedrich see their technical core activities as a base for the design of soft skills training since this approach aligns with the 'way of thinking' of technology professionals.

Implementation

Settels Savenije & Friedrich provide both technical in-depth courses in soft skills and leadership courses. The content of the courses is developed by Settels Savenije & Friedrich together with the High Tech Institute (HTI), with whom they have a strong and long-term partnership. The team of trainers always consists of a technical expert and a communication specialist.

The training programme is divided up into eleven different courses, with courses ranging in topics from effective communication and time management to improving the power of your speech. The former makes use of the classic classroom set up where trainees spend three consecutive days and one evening to learn to master the communication challenges that Settels Savenije & Friedrich have identified. As part of the training, Settles Saveneije & Friedrich create a personal action plan in order for trainees to apply that what they have learned in the course. It also expects from the trainee that they enquire among their peers at work what they consider to be their strong and weak points in their communication. This forms the point of departure for the personalised experience of the course. Several of the other courses at offer apply this same method. The courses proof to be very multifaceted in nature, with teaching methods varying between action learning, lectures, classroom discussions, and role-playing. Furthermore, the courses are aimed at presenting trainees with direct results through the encouragement of real-world applications of the techniques that were taught.

Impact and results

The turnover generated from training activities are increasing approximately 30% annually. Settels Savenije & Friedrich also indicate a high customer loyalty. Their main customer is HSML and over the years they trained around 700 HSML employees.

Context and regulatory framework

The Soft Skills and Leadership Program for Technology Professionals is a training program offered by Settels Savenije & Friedrich, next to their other activities in designing, manufacturing and assembling high tech products, tools and equipment. They offer both open training and in company training. Participants pay for most open training courses around €500 per day. The in-company training courses have a strategy board, which consists of representatives from the client and Settels Savenije & Friedrich, who give advice on the development of the courses. This same idea will be implemented for the open training courses in the future.

Transferability and scalability

This initiative is reasonably transferable since most courses are offered in English. Furthermore, Settels Savenije & Friedrich is already providing soft skills training in the US. Subsequently, the content and method of the soft skills and leadership courses are independent of the type of technology domain. However, training should possibly be tailored for each country in order to connect to cultural and communicative styles. Since most courses are based on classroom style learning, the scalability of this initiative is limited.

Success factors and barriers

Since Settels Savenije & Friedrich have a strong and deep foundation in technology, they are able to understand the need for a technology professional and the developments within the different technology domains. Furthermore, they choose to focus on a limited amount of topics within the courses, in order to provide a deeper understanding of these topics to the participants. The Soft Skills and Leadership Program is quite visible within the target group. Settels Savenije & Friedrich experienced that advertisement has a limited impact, technology professionals don’t seem to take on advertisement easily. It is estimated that around 80% of the course participants are activated by word-of-mouth communication. In this context, they have a high customer loyalty.

Stages

Company name	Stages
Type of organisation	Private R&D and education centre
Interviewee	Opher Brayer
Sector	Urban development
Country	Czech Republic
Web link	www.stages.global

Objectives

The Stages initiative focuses on urban revitalisation through skills development. Currently taking the city of Prague (Czech Republic) as a starting point, it rolls-out a multi-stage initiative to increase economic activity and prosperity in within the city.

Description

The initiative starts with training innovation skills in young students and intends to proceed to strengthen the technological academic base in the city. This should attract large technology companies to relocate their IP-generating activities to Prague, which will improve local employment opportunities for high-skilled workers. With a strong academic base and a stable presence of technology companies present in the city, the Stages initiative will then aim to build a local community of high-tech start-ups to increase entrepreneurial spirit. Together, this should generate economic growth and lead to more and better paying high-skilled jobs.

Implementation

This skills development initiative is implemented through a teaching method that trains innovation skills in young students, and through train-the-trainer activities that prepare local educators to use the teaching method. The teaching method trains the basic building blocks of innovation skills using a wide variety of minigames. These minigames train pattern recognition and learning-to-learn skills, and how to transverse learnings and insights from one knowledge domain to another. The local teachers that deliver these trainings have been taught the method by its designer, Opher Brayer. He will also train these teachers to instruct other teachers in the method. This is all done in a classroom setting.

In parallel, the initiative focuses on creating a network of local stakeholders and non-domestic stakeholders to expand the initiative and drive it forward. This is done through seminars and workshops held in Prague. Involved stakeholders include local and city government, educators, technology companies, consulting firms, and capital investors from Israel and the United States.

Impact and results

As the implementation of this initiative in Prague is only a few months underway, impact and long-term results are not yet measurable. However, the initiative is already working on dissemination materials to promote 150 success stories achieved with the first training activities in the cities, including case studies on children with severe learning impairments that show significant progress in their development through the Stages training methods.

Context and regulatory framework

This initiative is privately led and supported by a diverse range of private-sector organisations. At the same time, the delivery mechanism of its skills development activities leverages the existing educational system in Prague. Consequently, the initiative requires a close fit with formal educational arrangements and regulations, and with the boundaries of what parent will accept from their schools and from after-school activities.

Transferability and scalability

Because of the train-the-trainers aspect of the stages initiative, it appears to have good scaling-up potential. When upscaling efforts would cause the initiative to expand beyond the Czech Republic, the language in which the training and teacher instructions is delivered have to be adapted. This also holds for the transferability potential of the initiative. Also, transferability of the skills development initiative will depend on the extent to which national and regional education systems will allow it to enter schools and become part of the formal curriculum, and whether parents will accept it as an augmentation of their children's education, either in class or outside of school.

The broader urban developmental aspect of the Stages initiative is designed not to result in a zero-sum game between urban regions, each striving to attract the same companies and organisations. The initiative deliberately intends to work with smart specialisation strategies to encourage cities with specific profiles of expertise, and to encourage international cooperation between cities to engage technological and societal challenges.

Success factors and barriers

The initiative recognises a potential success factor and a potential barrier in the extent to which local actors in Prague can demonstrate an entrepreneurial mind-set. On the one hand, this entrepreneurial mind-set would help to spur along the different facets of the initiative and would aid in networking and coordination activities with international stakeholders and investors. On the other hand, the extent to which an entrepreneurial mind-set is demonstrated by local stakeholders is one of the things this initiative aims to improve.

Amazon's Career choice

Company name	Amazon
Type of organisation	Company
Contact person	Juan Garcia
Sector	Retail
Country	USA
Web link	https://www.amazon.com/p/feature/fsp92a2bhozr3wj

Objectives
The purpose of this programme is to offer employees an opportunity that can lead to technical and vocational certifications or associate's degrees in eligible in-demand fields. Through this, Amazon aims to create an environment where their employees can pursue their aspirations even if these lie outside of the company.

Description
The company recognises that in the current economic climate it can be difficult for people to find the financial resources and the flexibility to acquire new skills through training. They have therefore chosen to offer their hourly associates the possibility to join the Career Choice Program.

Implementation
After associates have been employed by Amazon for as little as one continuous year, the Amazon Career Choice Program will pre-pay 95% of tuition and fees for associates to earn certificates and associate degrees in high-demand occupations such as aircraft mechanics, computer-aided design, machine tool technologies, medical lab technologies, nursing, and many other fields. In addition, Amazon will also reimburse 95% of the cost of all required textbooks. The program will pay up to $12,000 in tuition, textbooks and associated fees over four years.

Amazon exclusively funds education only in areas that are in high demand according to sources like the U.S. Bureau of Labor Statistics, and we fund those areas regardless of whether those skills are relevant to a career at Amazon. Because of the great interest in Career Choice, Amazon has built onsite classrooms so college and technical classes can be taught inside Amazon's fulfilment centres. This will make associates' participation in Career Choice even more seamless.

Impact and results
So far, more than 10,000 employees have participated in Amazon's Career Choice program, from ten different countries. Amazon's first Career Choice graduate is now a nurse in her local community.

Context and regulatory framework
Amazon's CEO Jeff Bezos considers the programme to be an experiment. This does pose questions on whether or not the company will continue this programme for a prolonged period. The offering has been scaled up in order to facilitate employees of Amazon across its many locations in the world. Amazon is the chief bearer of costs for this programme.

Transferability and scalability

The transferability of this initiative is very low, mostly due to the fact that there are very few companies that could afford to offer such an option to their employees. Amazon has managed to upscale its programme to 10 branches across the world, including Germany and the UK. Given the resources that Amazon has to its disposal and the willingness it has shown to expand, the scalability across the branches of Amazon can be considered high.

Success factors and barriers

- Financial resources of Amazon
- The opening of onsite classrooms in order to bring education closer to the workplace

Demola	
Company name	Demola Latvia
Type of organisation	Industry
Contact person	Liene Rubina
Sector	Education
Country	Latvia
Web link	https://latvia.demola.net/about

Objectives

Demola's main objective is connecting students with industry, sharing knowledge and creating innovation that benefits students, universities and companies.

Description

Demola is a concept that encourages collaboration between industry and universities, and that teaches students to engage in team-based creative problem solving. It offers a pre-structured programme that includes open calls for companies and students to participate, and that facilitates the 3.5 months period in which student teams work on cases provided to them by companies. Every project results in a solution, which can be in the form of a concept, demo or prototype. If the company sees potential in the solution, it can license or purchase the outcome and use it as basis for further development.

The tools and methods used in this process are a combination of Demola's and local faculty's. The Demola Concept includes contracts, IP, licensing models and other legal requirements that facilitate the process and are in line with international business standards and practices. Teams are always interdisciplinary in nature, and are supported by staff, company representatives and sometimes by experts outside of the university.

Implementation

While students receive no grade for participation in Demola Latvia, they can receive official university credits. Demola takes place is organized in the evenings as an extracurricular activity. During the 3.5 month project, there is a 3-hour workshop every week, next to meetings with facilitators and individual work. The teams are as open as possible, allowing students of all levels and from different universities to participate. Each team is interdisciplinary, and always has one foreign student and one student from creative industries.

The company behind Demola is Finnish, but the concept has been applied to 23 cities in 15 countries. The two largest universities in Latvia, Riga Technical University and the University of Latvia, organise Demola Latvia, while participation is open to other university students too. Demola Latvia is currently in its third iteration.

Impact and results

Demola Latvia has had iterations and is preparing for the third. In the first round, 17 teams of 5 participated. In the second round, the number of teams was limited to 10 to increase manageability. For the upcoming round, 12 or 13 teams are envisaged to participate.

Context and regulatory framework

Funding comes from the Investment and Development Agency of Latvia. In addition, companies participating in Demola Latvia – mostly SMEs – each pay €500 to participate. In principle, one company engages with one project. After finishing the project, companies have 30 days to make a final decision whether or not to buy the solution (e.g. a prototype) that a team designed. If they buy the solution, they pay either €1000, €2000 or €3000 to the team, which can split it as it sees fit.

Transferability and scalability

Demola as a concept is very transferable, as the quick spread of Demola centres worldwide highlight.

The scalability is limited by the fact that the concept requires face-to-face interaction, and relies on cooperation between universities and (local) companies.

Success factors and barriers

- Each stakeholder receives new and often unexpected insights.
- Demola Latvia helps expectation management and cooperation between students and industry.

What at time has been more challenging is that students find it difficult to meet their obligations. To counter this, Demola Latvia considers working with team leaders in the next season.

7.3.2. Government-led initiatives

In this section we describe good practices of government-led initiatives relevant to high-tech T-shaped skills. Specifically, we describe:

- Technofutur TIC in Belgium;
- The BRIDGE initiative in The Netherlands;
- The UK's Post-16 Skills Plan;
- The Advanced Learning in the United States;
- Mittelstand 4.0 in Germany.

Technofutur TIC

Company name	Technofutur TIC
Type of organisation	Non-profit organisation
Contact person	Yvan Huque
Sector	Education
Country	Belgium
Web link	http://www.technofuturtic.be/

Objectives

The objective of Technofutur TIC is considered to be fourfold when taking into regard the different target groups it caters. The overarching objective of the initiative is nonetheless all-encompassing, as Technofutur TIC aims to instil members of all its target groups with the competencies needed in the contemporary work environment.

Description

Technofutur TIC currently offers to train individuals into the areas of Developers, IT management, and Business IT. These individuals belong to one of four target groups. The first target group is the currently employed, emphasis in these training are on maintaining the employability. The second and third target group is educators and students, whereby the former is provided material that may be absent in the school setting. The fourth target group, that enjoys the most extensive attention, is the group of jobseekers. The objective of providing up to date training to jobseekers is to arm them with the competencies needed to reintegrate into the workforce.

The courses offered are articulated through three levels of technological training: basic, advanced and expert. The latter specifically focuses on cross-functional skills acquirement in order to enable jobseekers to enter the labour market for the medium and long term.

Implementation

The courses offered are articulated through three levels of technological training: basic, advanced and expert. The latter specifically focuses on cross-functional skills acquirement in order to enable job seekers to enter the labour market for the medium and long-term.

Technofutur TIC further divides its target groups based on individual's profiles. In the case of job seekers, the profiles may differ in the area of acquired formal education and IT proficiency.

The trainers, who come from external partners such as University partners or computer service companies, take part in the pedagogical objectives of the programmes and contribute to the implementation of new competencies such as project-based learning. Technofutur TIC has set up several network and development laboratories to assist in the practical applications of the training.

The support for jobseekers is taken beyond acquiring technical skills, as Technofutur TIC provides training in resume writing, digital identity and job interview simulations are held. In addition to this, an internship of 4 to 6 weeks can be part of the closing stage of the overall training. Additionally, those who have no to low formal education are advised to take evening courses in order to acquire

a diploma. This also affects the training period which is normally six months but could be subject to an extension when necessary to obtain additional education.

Impact and results

Technofutur TIC provides training to around 300 jobseekers per year and 70% to 90% of the jobseekers reintegrates into the workforce. These significant successes provided further incentives for Technofutur TIC to create new initiatives such as the launch of the Data Academy in 2017. Furthermore, they are planning to start an Open Learning Lab in 2018. The lab will function as an area where a variety of people are welcomed to work and train on specific skill sets.

Context and regulatory framework

Technofutur TIC has had experience in training as a centre of competence for over 19 years in IT, which makes it responsive to technological developments.

Transferability and scalability

Due to its close cooperation with employment agencies, the Technofutur TIC initiative represents a concept that could be applied to a large number of industries. However, it depends on the target group and the goal whether or not the training period can be finished in 6 months.

With regard to the scalability of the initiative, the specific features of the Wallonia region should not be disregarded. A major factor for the success of this initiative is that those involved are knowledgeable about the region and therefore provide a programme and support that are attuned to the characteristics and human capital demands of the region. In order to achieve similar results on a larger scale, cooperation with entities that have comparable knowledge in their respective regions is needed.

Success factors and barriers

- The interpersonal relationship, especially with the job seekers, contributes to the reintegration process they are involved in.
- Technofutur TIC does not work with in-house trainers. It manages to recruit trainers who have extensive professional experience. They are of the opinion that trainers with current experience as professionals contribute specific knowledge which is essential to the success of the programme.
- The programme is adapted to sociological considerations based on the backgrounds of trainees.

BRIDGE	
Company name	Metropoolregio Rotterdam Den Haag
Type of organisation	Government
Contact person	Cees Stoppelenburg
Sector	Education
Country	The Netherlands
Web link	https://mrdh.nl/project/bridgege

Objectives

The initiative "Building the Right Investments for Delivering a Growing Economy' (BRIDGE) centres on closing the mismatch between regional education and the labour market within the context of a changing economy.

Description

BRIDGE is a project carried out by the city of Rotterdam, educational and healthcare institutions, and in close collaboration with industry. The project revolves around the question of how to prepare students in vocational education for the future labour market, with a focus on the learning pathways engineering, healthcare, maritime, food, construction and logistics.

Implementation

To achieve BRIDGE's objective, the project includes a skills analysis - researching which types of knowledge and skills will be in demand in the years to come – which it translates into a skills agenda and call to action. The skills analysis has identified 10 generalistic skills that each student should possess, ranging from time management to working in a team. In cooperation with industry partners, the project also identifies and promotes sector-specific knowledge and skill requirement to complement these generalistic skills. The research in turn informs interventions that teachers can choose to adopt. These interventions, for example experiential learning, will come into effect in the school year 2018/19. The BRIDGE-project includes studies researching to how these interventions can be made financially sustainable.

Other activities have the aim of motivating students to pursue education in sectors that have promising job prospects but are currently unpopular. BRIDGE does this through career coaching from elementary school onwards with a wide range of different interventions, involving parents with their children's educational choice, and undertaking a communication campaign to ensure that ideas that pupils have about certain sectors and career trajectories corresponds to reality. Finally, BRIDGE industry partners offer guaranteed jobs for pupils after graduation to further boost the number of students choosing relevant tracks.

Impact and results

The initiative runs until 1 November 2019, and has a budget of 4.9 million EUR provided by the European Commission. Next to delivering a skills analysis, skills agenda and call to action, BRIDGE will develop a number of classroom interventions. The aim is that in 2020, half of the pupils in Rotterdam Zuid following vocational education choose for a specialization in technique (35%) and

health (15%), and that those pupils have a guaranteed job after graduating. If the objective would be reached, 600 pupils would have chosen for a specialization in technique or health.

Context and regulatory framework

Many students in Rotterdam Zuid, especially those pursuing vocational training, face a skill mismatch and difficulty entering the labour market after graduation. BRIDGE helps with transforming education within existing educational structures, and with more and better interaction between education, industry and government. In particular, it helps schools to adapt to more innovative forms of education that are resilient to new technologies, lifelong learning, and partnerships with the private sector. The BRIDGE initiative is embedded within a broader regional skills agenda-initiative.

BRIDGE is a collaboration between the municipality of Rotterdam, National Urgency Program South Rotterdam, Extertisecentrum Maatschappelijke Innovaties, Hogeschool Rotterdam, Metropoolregio Rotterdam Den Haag, SEOR bv, Erasmus University and Rebel Group.

Transferability and scalability

The model could be transferred to other countries and contexts, but would require substantive tailoring to local stakeholders and regional comparative advantages. Given its regional embeddedness, upscaling is possible but resource-intense.

Success factors and barriers

- Combining generalistic skills with sector-specific competencies;
- Pursuing transformation within current structures, not changing structures itself;
- Working with partners to create the most relevant result;
- Comprehensive plan with interventions in mutually reinforcing categories;
- Motivating and supporting young people all the way from elementary school until they enter the labour market.

Barriers include that it can be difficult to get access to (larger) companies, and motivate them to contribute and participate. Furthermore, it can be challenging to have all schools participate in the project, since it places an additional burden on schools that already face a high workload, especially those schools in disadvantages neighbourhoods.

UK's Post-16 Skills Plan	
Company name	UK Department for Education
Type of organisation	Government
Contact person	Mike Westlake
Sector	Education
Country	UK
Web link	https://www.gov.uk/government/news/education-secretary-announces-first-new-t-levels

Objectives

The Post-16 Skills Plan aims at delivering young people and adults the type of education that will prepare them to meet the needs of a changing economy. The technical stream contains T-level programmes.

Description

The Post-16 Skills Plan, which was first announced in July 2016 by the UK government, is a framework to support young people and adults in choosing the type of education and work which will meet the need of the rapidly changing and growing economy. The ambition of the implementation of this framework is that young people who completed a broad and diverse curriculum are presented with two options: to follow an academic stream or a technical stream. The quality of the academic stream is already above standards, however, the technical stream still has to be shaped and improved. The different types of study programmes within the technical stream will suit a wide range of students. The technical stream, containing T-level programmes, will combine technical knowledge and practical working skills which are defined with input from the industry. All programmes within the technical stream will also include a high quality work placement so that students can apply their learning in a real workplace environment.

Implementation

Within the technical stream, there are several routes or programmes. Each route groups together according to related occupations which require common knowledge, skills and behaviours. These routes are further broken down into a number of specialisms, clustered together in a straightforward way so that young people can see a clear path to the occupation of their choice. The content of the different T-level programmes is developed by a group of leading industry professionals from companies including Rolls Royce, Fujitsu and EDF, the so-called T-panels. The first programmes will start in 2020 and the full set of T levels is introduced by 2022.

Impact and results

This initiative still has to be implemented, so at this moment there are no impacts and results yet.

Context and regulatory framework

This initiative was first announced in 2016 and the first T-level programmes will be launched in 2020. Every year an amount of £500million will be invested in this plan by the government. The UK government is said to be committed to carrying out the educational reforms to complement the Skills Plan. The level of commitment is a result of two different developments. The UK government wants to educate and reskill their future workforce in order to keep up with the economic trends. Thereafter,

by leaving the EU, the UK has to prepare itself to be more self-depending in the field of education and workforce.

Transferability and scalability

The Skills Plan can possibly be transferred to another EU country, however, due to the unique position of the UK with respect to the EU, it is not likely that other member states feel the same urgency. This is a national policy, which means it has an impact on the entire UK. There no realistic option that this policy will be scaled up over the national UK borders.

Success factors and barriers

- The policy will be implemented in the entire country, this means there is a large target group.
- Leading industry professionals are included in the design of the programmes.
- By implementing such a broad and integrated technical educational policy there is a risk that successful bottom-up initiatives cease due to a lack of funding or other type of support.

Advanced Learning

Company name	The Institute for Advanced Learning and Research
Type of organisation	Government
Contact person	Julie Brown
Sector	Education
Country	United States
Web link	http://www.ialr.org/index.php/advanced-learning

Objectives

The Institute for Advanced Learning and Research (IALR) has the goal of transforming the economy of Southern Virginia. Its Advanced Learning activities facilitate this process through the development of STEM (Science, Technology, Engineering and Math)-capacity and through promoting lifelong learning.

Description

IALR Advanced Learning initiatives and activities centre on preparing young people and acting as an intermediary between local and regional players. Next to educational activities, the Institute has a Research Department that conducts scientific research in the areas of natural products chemistry, plant science, precision agriculture and polymers. IALR works together with public and private educational institutions and with regional industry partners, and is tailored to the competitive advantages of the Southern Virginia region. IALR serves Virginia, but in particular six counties and two cities in Southern Virginia.

Implementation

The Advanced Learning Department offers multiple programs for people of all ages, from PreK-12 to lifelong learners. Two programs for the PreK-12 target audience include a career choice expo and a mobile learning lab, The Inspiration Lab. Activities concerning lifelong learning include the Gene Haas Centre for Integrated Machining, and the Dan River Region Collaborative. The Gene Haas Centre is a progressive precision machining training model that offers experiential learning for advanced professionals. The Dan River Region Collaborative promotes regional partnerships, including employers, educators and workforce developers, to address workforce development.

Impact and results

In 2017, IALR organized the two-day Southern Virginia Career Choice Youth Expo, where 3800 students from six school divisions explored (technical) careers hands-on, including participating in employer-led activities. This expo strengthens the relationship between technical education programs and employers, and improves career choices.

The Inspiration Lab is a mobile lab to advance K-12 STEM education by providing hands-on and high quality activities for students, hence promoting exposure to STEM education. In FY18, the Inspiration Lab visited 80 sites and had over 8,500 participants.

Twenty-nine students have completed the Integrated Machining Capstone program at the Gene Haas Centre. First-year cohort students report a $5/hour average wage increase 12 months after completion.

Dan River Region Collaborative efforts lead to the Commonwealth's first five certified Work Ready Communities.

Context and regulatory framework

IALR's Advanced Learning has a regional workforce commitment, where it helps students and graduates to fulfil current and future workforce needs. IALR is situated in a rural area with a focus on advanced manufacturing. This sector is undergoing a transformation to Industry 4.0, and will need skilled professionals to sustain itself and attract outside investment. IALR plays into the sector strategies and the region's competitive advantage to adopt its educational activities to fit with current and future needs.

IALR is a higher education institution that is not degree awarding. It can and does offer informal workshops and courses, and partners with public and private educational institutions, such as Virginia Tech. IALR is fully state-funded.

Transferability and scalability

The way that the Institute forms partnerships and contributes to STEM capacity and lifelong learning could be replicated in other areas as well. The Institute might be especially interesting for areas that are also rural and focused on the manufacturing sector.

While the IALR could grow in size, the scale will depend on the number of students and potential partner institutions in the region.

Success factors and barriers

- Thinking more regionally ('the region wins') as opposed to thinking merely at the county or city level. This helps create regional ecosystems that are more innovative, competitive, and visible, and facilitates attracting outside business and investments.
- What has been more difficult is expectation management about when investments in education will yield results, which could take decades, and getting support for investing in more specialized (and therefore perceived as riskier) programs.

Mittelstand 4.0 (part of Mittelstand-Digital)

Company name	Federal Ministry for Economic Affairs and Energy
Type of organisation	Government
Contact person	Werner Kohnert
Sector	Industry
Country	Germany
Web link	https://www.mittelstand-digital.de/

Objectives

The initiative "Mittelstand 4.0" has the objective of helping Small and Medium Enterprises (SMEs) capitalise on the opportunities that digital transformation has to offer.

Description

SME's are the backbone of the German economy, but are often later to adapt to digitalization than their multinational counterparts are. Mittelstand 4.0 raises awareness about digitalization for SMEs, provides information and training for business leaders and staff, and offers specific support in designing and implementing digitalization strategies. The initiative achieves this through its Competence Centres and dedicated agencies.

Implementation

Currently twenty-three Mittelstand 4.0 Competence Centres throughout Germany support SMEs with digitalization. Of these Centres up to now, seventeen have a regional focus and six have a national and thematic focus (standards, usability, skilled crafts and trades, IT economy, etc.). Competence Centres are often a consortium of a research- or technology organization or (e.g. a university), an organization with expertise in knowledge transfer, a regional chamber/network association, and sometimes a social partner, or organization with expertise on IT security and/or business.

The Competence Centres work along an 'enabling chain', where centres first raise awareness and provide information about digitalization to all SMEs in the given region. For those companies interested in a more thorough engagement, Centres can provide qualifications and demonstrations of how digitalization can work in practice. With regards to qualifications, Centres address business leaders and IT professionals, as well as other SME staff. Because the Centres are funded by the Ministry of Economic Affairs, the Centres offer their services neutral and free of charge. According to the funding model a deeper consulting of individual companies is not covered.

The Centres focus on providing know-how about digital transformation in the dimensions technology, organization, work and business processes/models to empower and motivate enterprises to take own steps in digitalization projects. A broad range of generic instruments (e.g. digital maturity assessment index) and best practice solutions is developed und evaluated in sample projects and then communicated to the target groups in various formats (publications, workshops, dialogs, roadshow, exhibits and test environments etc.).

Mittelstand 4.0 Agencies support the Competence Centres in fulfilling their tasks. These agencies are experts in generalistic and methodological transfer know-how and provide competence in four areas, namely cloud computing, communication, trade and processes. Agencies also produce publications and provide training and webinar sessions.

Impact and results

Impact has not yet been evaluated, and any information pertaining to results of this initiative is not yet available.

Context and regulatory framework

Mittelstand 4.0 is one of three initiatives under the umbrella of Mittelstand Digital, financed by the German Ministry of Economic Affairs and Energy. The other two initiatives, which are close to being finished, centre on improving the usability of operational software for the SME sector, and introducing e-standards to promote e-businesses, share information and improve SME competitiveness.

In implementing Mittelstand-Digital the Ministry of Economic Affairs and Economy relies on two contractors: DLR providing all project management services, from assessment of the different proposals to exploitation and sustainability and WIK, to provide accompanying research, networking and evaluations.

The initially launched Competence Centres are reaching the end of the first funding phase end of 2018. There are positive signals from government that funding might be continued. Nevertheless, Competence Centres are thinking about ways to become financially sustainable.

Mittelstand-Digital is created by the German Federal Ministry for Economic Affairs and Energy.

Transferability and scalability

The Mittelstand 4.0 initiative could be transferred, but would require substantive (government) funding. Alternatively, Competence Centres could offer their services commercially.

Success factors and barriers

- Addressing SMEs the right way by speaking their language. This includes hands-on methods which are appealing and acceptable to SMEs.
- Perceiving SMEs as a network, where SMEs are part of an ecosystem that also includes start-ups, universities and industry, and makes use of comparative advantages.
- Competence Centres are not in competition with each other, but learn from each other and develop best practices. This way Competence Centres become experts in knowledge transfer, and can be used for disseminating other new technologies as well.
- Using an interdisciplinary approach.

The barrier is the dependence on government funding.

7.3.3. Academic, triple-helix and hybrid initiatives

In this section we describe good practices of initiatives led by academia, by triple-helix cooperation and by hybrid groups, relevant to high-tech T-shaped skills. Specifically, we describe:

- PROMPT in Sweden;
- The BlueHealth Innovation Centre in Belgium;
- Duke Learning Innovation in the United States;
- Advanced Technological Education in the United States;
- Coder Dojo NL in The Netherlands;
- Vertically Integrated Projects in the United Kingdom;
- Minatec's Innovation Campus in France;
- European Schoolnet's Future Classroom Lab in Belgium;
- The BioBusiness and Innovation Platform (BBIP) in Denmark;
- CECIMO's METALS in Belgium;
- Academy Cube in Germany;
- Swiss Nano-Cube in Switzerland;
- Interdisciplinary Design initiative for the Built Environment in the United Kingdom.
- The Fast-track to IT (FIT) initiative in Ireland
- Skillman EU-wide
- OpP-TEC in the USA

PROMPT	
Company name	Prompt
Type of organisation	Tripple helix
Contact person	Stefan Eck
Sector	Education
Country	Sweden
Web link	http://www.promptedu.se/

Objectives

The PROMPT (Professional Master in Software Engineering) initiative aims at ensuring a steady and high-quality supply of advanced software competencies and innovativeness that benefits both Swedish industry and higher education.

Description

PROMPT is an educational initiative created by academic parties and leading industrial companies and organizations. PROMPT develops advanced courses in web-based format tailored to the skill development needs of current professional engineers and software developers. It is an attempt at boosting lifelong learning and improving knowledge transfer between industry and universities. The courses are all on master's level and designed for participants that have a professional and/or academic background in software development and that need to combine work and studies. Successful completion of each course is awarded with officially recognized credits. Since Master's education is free in Sweden for EU-nationals, there are no fees for participating in PROMPT.

Implementation

PROMPT develops web-based learning that provides a flexible learning experience. The course are on an advanced level and therefore require professional experience or proven expertise in software development. Currently, PROMPT offers 22 courses that fit within five subject-related areas and an additional area for project courses. The five subject-related areas are processes and methods for development of software intensive systems, software testing, dependable software, architecture and design, and big data. Each course has a design group where industry provides its input and where the group decides on the course content. The courses are based on existing courses taught at the different universities, and adapted with industry input. Most of the courses within these areas are worth 7.5 credits, which is the equivalent to 200 hours of study.

Impact and results

In the period 2015-2017, 772 students with work experience certificates from 275 different companies and organizations participated in PROMPT courses. In the autumn 2017 semester, there was an average of 23.5 students per course, and the average age of the participants was 39 years. Of the students, 17% were women (compared to 41 years and 21% women for category 'software and system developer' in Sweden). Most participants lived in Sweden, but there are also participants from other EU countries.

On December 1, 2016, PROMPT Initiative has been awarded European Digital Skills Award in the category More and better trained ICT professionals in Europe.

Context and regulatory framework

PROMPT is fully financed by the Knowledge Foundation's programme "Expertkompetens för innovation" (Expert Skills for Innovation). The KK supports mid-sized universities, and aim of this particular programme is to promote cooperation between academia and industry. Funding runs from 2015 until 2020, and there are talks about extending funding. The ultimate goal is to include the courses in the ordinary university curricula.

Mälardalen University leads the PROMPT initiative in cooperation with educational institutions (Blekinge Institute of Technology, Chalmers, the University of Gothenburg, Mälardalen University and SICS) and dozens of industry partners. Industry partners include but are not limited to Ericsson, Fujitsu, Schneider Electric, Bombardier, Scania, and Volvo.

Transferability and scalability

The partnership model underlying PROMPT could be successfully applied in other settings as well. Bringing together needs of industry and expertise of universities could be beneficial to other European countries, and the web-based format and flexible learning experience could be similarly transferable. However, a limiting factor would be that, unlike in Sweden, higher education is not free in most countries in the EU. This means that the barrier to participate might be higher, or that complementary schemes would have to be designed to tackle higher participation costs.

While the courses are web-based, there is an online interaction between the instructor and the course participants. As a result, there is a limit of 100 students per course to allow for a dialogue with teachers and for peer learning. Consequently, the number of available researchers limits the scalability of PROMPT.

Success factors and barriers

- Knowledge transfer between industry and academia.
- Courses are popular because they are free of charge and award official credits upon successful completion.
- PROMPT offers a way to create lifelong learning. This concept is a 'hot topic', but it is often more difficult to put into practice.

What has been more challenging is the relatively high drop-out rate because of the difficulty of combining study with a busy job, and because some participants are more keen on acquiring the knowledge than receiving the credits. Another difficulty has been the fact that university rules and regulations mean that participants have to be treated the same as regular students, including e.g. early official application. Both do not always fit well with the busy schedule of professional engineers and software developers.

BlueHealth Innovation Centre

Company name	BlueHealth Innovation Centre
Type of organisation	Triple Helix
Contact person	Tom Braekeleirs
Sector	Healthcare
Country	Belgium (Flanders)
Web link	https://www.bhic.care/nl

Objectives

BlueHealth Innovation Centre (BHIC) supports IT and technology-driven innovation in healthcare (cure, care & comfort) in Flanders, with a focus on new and existing entrepreneurship (start-ups) and with both social impact and business objectives. This should lead to the digitization of healthcare and care that is more efficient, sustainable, and of higher quality.

Description

BHIC is a virtual start-up incubator that promotes 'young entrepreneurship' by working together with physical incubators, healthcare institutions, academic institutions and the private sector. As such, BHIC has three target audiences, namely students, starters and healthcare professionals. BHIC activities typically revolve around bringing people and ideas together, sharing knowledge and skills in the areas of technology and healthcare, and fostering entrepreneurship. Despite the fact that BHIC only exists in its current form since 2017 (its predecessor Microsoft Innovation Centre Flanders has been operational since 2012), the centre is well connected to the Belgian Chamber of Commerce, (regional) government and other innovation centres.

Implementation

For students, BHIC organizes networking events, an innovation camp, and a hackathon. For start-ups, BHIC provides advice, has an innovation fund, boosts marketing and communication, and provides free software. For healthcare professionals, BHIC offers its network and organizes networking events as well as innovation workshops. Most events are organized in the cities of Genk and Antwerp. Because BHIC is a not-for-profit, it supports start-ups free of charge.

Impact and results

To reach its goals, BHIC aims to have helped 100 start-ups by 2020, of which it will intensively support 30 and will fully finance 10. It will also organize network events (to stimulate synergies, enrich solutions and stimulate collaboration), prepare the healthcare sector for new technologies (AI, big data, etc.) through workshops and other events, and stimulate effective ideation management, helping start-ups and starters from developing a business plan to organizing its funding.

To date, successful start-ups incubated by BHIC include FibriCheck, which allows using smartphones to detect irregular heart rhythms, LynxCare, which monitors quality indicators for a hospital department, and Play it Safe, which improves the effectiveness of health and safety trainings through videogames. A number of BHIC incubated start-ups have acquired sufficient external funding and a sustainable business model to have become independent companies.

In June 2018 BHIC will present its annual report for 2017.

Context and regulatory framework

In Flanders, as in other regions in Europe, the cost of healthcare is growing. Given that healthcare is predominantly publicly financed, this is putting government budgets under severe pressure. This has led the Flanders government to work together with then-Microsoft Innovation Centre Flanders, and Bluehealth Antwerp to create a triple helix organization focused on boosting innovation and improving effectiveness in healthcare, and to guarantee the sustainability and high-quality of healthcare in Flanders. Next to the Flanders government, BHIC has 15 partner organisations coming from all three sectors, including Microsoft, the municipalities of Genk and Antwerp (where most activities take place), University Antwerp and companies. BHIC works within 3-year timeframes, and has secured its funding accordingly.

Bluehealth Innovation Centre is a not-for-profit whose business model is based on input from government, academia and the private sector. It has two main bodies: the executive board and a 'Board of Directors', in which there are representatives from the three sectors. The VZW structure ensures BHIC can support start-ups free of charge, and makes it easier to attract government subsidies. While sponsored by Microsoft, BHIC is an independent entity.

Transferability and scalability

Rising costs of healthcare are not a problem specific to Flanders, but apply to many countries in the EU. The idea of using innovation centres to spur innovation could therefore be suitable for other countries as well, especially for those countries whose healthcare system are predominantly publicly funded. The nature of a triple helix organization does require active cooperation and a willingness to invest from government, cities, academia and businesses.
Healthcare is a topic whose importance is only set to increase in the years to come. Nevertheless, the scalability of BHIC is confined by the extent to which the parties involved are willing to invest. Success stories will likely increase the visibility and the support of BHIC, which could attract more funding and hence increase BHIC's scale. The partial dependence on government funding and the regional embeddedness of BHIC will put a limit on the scale BHIC can reach.

Success factors and barriers

What makes BHIC successful is:

- Having multidisciplinary teams that include people with backgrounds ranging from medicine to business and IT. Having different perspectives and insights create the most innovative and effective results.
- Producing the right creative mindset. Coming up with creative ideas and developing these requires hard work and having the right mindset. BHIC facilitates this process, fostering innovative ideas.
-

Barriers to success include the Belgian education system, which is overly focused on in-depth disciplinary knowledge, and too little on interdisciplinary skills, creativity and innovation.

Duke Learning Innovation

Company name	Duke University
Type of organisation	University
Contact person	Shawn Miller
Sector	Education
Country	United States
Web link	https://learninginnovation.duke.edu/

Objectives

The mission of Duke Learning Innovation is to help Duke students learn more, and enable more people to learn from Duke.

Description

Duke Learning Innovation is a team that helps faculty to improve the teaching of Duke faculty and hence contribute to the learning of Duke and non-Duke students. This teaching is often interdisciplinary in nature, and primarily designed for university students and graduates.

Implementation

Duke Learning Innovation has four key areas of focus. These are teaching innovation, learning technologies, online initiatives, and research and development. Teaching Innovation includes one-on-one sessions with faculty to explore new pedagogical techniques and new teaching practices and to discuss challenges. Learning Technologies is about developing new tools and learning management. Online Initiatives have a more external focus and include the development of MOOCs and the use of online modules in classes. Research and Development activities include improving teaching and learning by upskilling promising and successful experiments.

Impact and results

Teaching Innovation responded to 868 requests for information and/or consults in 2016-17, provided grants for four teaching innovation initiatives, and organized a conference on innovation in teaching attended by 200 Duke faculty and staff.

Learning Technology managed and supported Duke's learning management system (Sakai), supported other enterprise learning technologies, and explored new technologies such as Duke Extend.

Online Initiatives partnered with faculty to create and evaluate MOOCs. A number of these MOOCs are available on Coursera. In the period 2015-2017, 72,000 participants completed Duke Coursera courses.

Context and regulatory framework

Duke Learning Innovation is located in the Duke Library and is positioned directly under the Provost. The Duke Learning Innovation currently has 22 staff that work in one or more of the four focus areas. Duke works together with Coursera to offer its courses to a wide audience.

Transferability and scalability

The transferability is dependent on the willingness of other universities to allocate resources to hire teaching and technology specialists to improve student learning.

The scalability of the online initiatives could be high, given that they are not location dependent and have low marginal costs.

Success factors and barriers

- An important success factor is having institutional backing and support from the Provost and President to create a 'politically perfect storm'.
- Growing steadily and using strategic hires

At times it was difficult to overcome the status-quo bias, hesitance concerning innovation and to be successful in the competition for attention.

Advanced Technological Education

Company name	National Science Foundation
Type of organisation	Government
Contact person	David B. Campbell
Sector	Education
Country	United States
Web link	https://atecentres.org/

Objectives

The National Science Foundation's (NSF) Advanced Technological Education (ATE) program has the objective to improve the education of technicians in advanced technological industries.

Description

ATE is a competitive grant program that supports educators and brings together partners from academic institutions and industry to help improve the education of science and engineering technicians at the undergraduate and secondary school level. The program provides awards for ATE centres, projects and targeted research. ATE centres lead national or regional initiatives in certain fields or serve as support centres.

Initiatives are faculty-driven, and ATE awards lead, among others, to curriculum development, innovative ways of teaching (e.g. through testing new materials), professional development of college faculty and teachers, and to furthering the knowledge base concerning technician education.

Implementation

Each funding proposal is reviewed by a panel consisting of community college faculty who earlier won an award, industry representatives, and occasionally by specialists or evaluators. Different panels each review similar proposals, e.g. one panel reviews a number of projects relating to advanced materials and picks the most promising initiative. The most competitive proposals feature a partnership with industry that contributes in-kind to the project. Proposals include an argumentation for why it relates to advanced technology, and how it responds to local (industry) needs. High-level institutes further contribute to ensuring that proposals are relevant and that they fit local needs.

There are currently 42 ATE centres throughout the United States, focusing on eight technology areas. These areas are advanced manufacturing technologies, agricultural and biotechnologies, energy and environmental technologies, engineering technologies, information technologies, learning, evaluation and research, micro and Nano technologies, and security technologies. These centres are encouraged to form partnerships with industry and secondary school and university educators. Within these eight areas, individual centres focus on technology areas tailored to the region's competitive advantages.

Impact and results

In 2014, ATE centres and projects educated more than 110,000 students, served over 45,000 educators through 2190 professional development activities, developed 2430 materials and educational activities, and collaborated with 3890 businesses and industries. The anticipated funding amount for 2018 is $59 million.

Context and regulatory framework

The Advanced Technological Education (ATE) program is fully funded by the National Science Foundation (NSF), an independent United States federal government agency that promotes research and education in all non-medical fields of science and engineering. The NSF established ATE as a response to the Scientific and Advanced-Technology Act of 1992, and ATE will celebrated its 25th anniversary in 2018.

Transferability and scalability

Because ATE is fully funded by the NSF, directly transferring the program to other settings would therefore require similar government funding. If this is available, then a program including centres, projects and dedicated research could work in other settings as well. Even if no government funding is available, there could still be ATE facets that could be transferable. For example, the way in which proposals are reviewed and partnerships formed could provide many lessons and might be replicated elsewhere.

The scalability of the program would depend on the federal government's willingness to increase funds.

Success factors and barriers

Success factors include:

- ATE enables principal investigators to pursue their often creative ideas for improving student development, hence contributing to better ways of teaching.
- Community colleges serve their communities, and can boost regional economic development. This in turn benefits the colleges.

What has proven more difficult at times is sustaining long-run high-maintenance projects. If a community college faces a shrinking budget, these projects that are relatively expensive and can only include a limited number of students are an easy target for budget cuts.

Coder Dojo NL

Company name	Coderdojo NL
Type of organisation	NGO
Contact person	Christian Vermeulen
Sector	Education
Country	Netherlands
Web link	https://coderdojo.nl/

Objectives

Aim of the initiative is to provide youngsters with the right tools and knowledge to navigate the increasingly digital world successfully and safely, and to introduce them to the exciting opportunities that new technologies have to offer.

Description

CoderDojo NL is a not-for-profit and volunteer-led organisation that organises extracurricular activities for children aged 7-17 in an informal and creative environment. These extracurricular activities centre on teaching children programming, web development, and other 'digital literacy' skills in a fun and engaging way. It is explicitly not a form of classroom-based learning, but learning through teamwork, individual exercises and games. This means that children can choose their own projects to work on, for instance developing a website, and are taught the different steps needed to realise the project through execution ('learning-by-doing'). During a session, kids get support from the volunteer(s) and they get the opportunity to present their progress and acquire feedback/ask questions. This way, CoderDojo helps children develop not only skills such as programming, but also soft skills such as working in a team. Coderdojo has two key principles: volunteers organise the activities and all children aged 7-17 are welcome to participate. Attending a CoderDojo event is therefore free of charge.

Implementation

The concept of Coderdojo originates from Ireland, where it started in 2011. The CoderDojo foundation in Ireland now provides supports to enthusiastic volunteers that want to start their own local Dojo. The foundation provides free open source educational content through its community platform, translates content and acts as a forum for sharing experiences and initiating broader initiatives. Educational material mainly focuses on coding, although soft-skills are also part of the learning outcomes of the coding sessions.

Any enthusiastic volunteer can set up a local Dojo, using the course materials shared through the network. Once somebody in a community decides to initiate a club, he or she needs to find a venue, locate some technical people in the area that want to volunteer as mentors and start promoting the initiative to recruit youngsters. At the moment, there are 90 Dojos in the Netherlands alone, and almost 1.500 Dojos worldwide. Local volunteers can be students, IT professionals or parents with an IT background, and are often motivated by the fact that many young people do not have the opportunity to gain experience with coding and the realisation that the digital skills gap is quickly growing. In addition, most volunteer enjoy running the local Dojo.

CoderDojo NL is the intermediary between the local Dojos and the Coderdojo foundation. CoderDojo NL tailors the educational material to the local contacts, e.g. by providing material in Dutch. They also answer questions of local Dojo's or the CoderDojo foundation. CoderDojo NL organizes a volunteer meet-up every year, and creates partnerships with private sector or other organisations when the opportunity occurs.

Impact and results

CoderDojo started in the Netherlands in 2013 with three Dojos. This has grown to 90 Dojos in 2018. Each Dojo seeks to organise an activity at least ones per month, and the average number of participants per activity is estimated at 25. The estimated number of children participating in CoderDojo events in the Netherlands is then 27,000.

Context and regulatory framework

CoderDojo NL is a foundation (*stichting*), while the local Dojos are informal organisations. Because the initiative is volunteer-led, there are no budgets to cover costs. Children bring their own laptops, and local venues such as libraries offer a space to host Dojo events. If there are drinks or snacks, this is often covered by the parents of the participating children.

Occasionally, CoderDojo NL engages in partnerships, such as currently with CodeStarter. This would mean that another organisation would either provide funding or in-kind contributions to one or more Dojos. Local Dojos can also ask for funding or in-kind contributions at its own initiative.

Transferability and scalability

The initiative is already operating across multiple continents, underlining its potential for scalability. The approach, based on an open source network driven by volunteer mentors, could also work for reskilling adults for the digital domain.

Success factors and barriers

- The CoderDojo formula ensures an open and inclusive environment where all children can learn.
- Because the CoderDojo Foundation and CoderDojo NL provide a platform with readily available educational materials, it is easy to start a Dojo.

The most important barrier is finding and retaining volunteers. This is complicated by the fact that there are no resources for outreach campaigns. Another barrier is that the lack of funding requires students to bring their own laptops, which increases the barrier for children that do not have a laptop.

Vertically Integrated Projects

Company name	Strathclyde Glasgow
Type of organisation	University
Interviewee	Stephen Marshall & Ed Coyle
Sector	Engineering
Country	United Kingdom
Web link	https://www.strath.ac.uk/viprojects/

Objectives

The Vertically Integrated Projects (VIP) at the University of Strathclyde is based on the VIP programme developed by Professor Ed Coyle at Georgia Tech and Purdue Universities. The purpose of VIP at Strathclyde is threefold:

- Provide the time and context necessary for students to learn and practice many different professional skills, make substantial technical contributions to the project and experience many different roles on a large design team.
- Support long-term interaction between the graduate and undergraduate students on the team. PhD students will mentor the undergraduates as they work on the design projects embedded in the research of PhD students.
- Enable the completion of large-scale design projects that are of significant benefit to the research programmes of faculty members.

Description

The University has the VIP Programme set up through 22 departments over 35 undergraduate majors from across the University. These majors vary from Life Science to Engineering. The projects that are part of the VIP program are in general multidisciplinary complemented by highly cross disciplinary projects. The latter combine Languages with Computer Science, Biology with Maths, and Engineering with Business.

Implementation

University students in different academic years and from a variety of disciplines make up the project teams. Each year the project teams are filled with new undergraduate students who replace the graduating students. The continuing students therefore move up in the hierarchy and are subsequently responsible for the training that the new members get. The Students earn academic credit through their participation in VIP projects in which they assist academic staff and postdocs with research and development issues. In some VIP programmes the Business students work together with leading research groups in order to identify market opportunities for emerging technologies.

The Students earn academic credit through their participation in VIP projects in which they assist academic staff and postdocs with research and development issues. In some VIP programmes the Business students work together with leading research groups in order to identify market opportunities for emerging technologies.

Impact and results

The majority of the projects involve local businesses, high schools, and an outreach to international development field. With regard to the latter, VIP projects have been asked to align with one or more of the United Nations' seventeen Sustainable Development Goals launched in 2016.

Context and regulatory framework

The programme runs on funding from student fees, as is custom to programmes within university environments.

Transferability and scalability

The cross disciplinary aspect of VIP increases both the transferability and scalability of the programme. Any university and any field should be able to apply VIP, which is also proven by the fact that more than twenty-eight universities globally have adopted VIP. In Europe only, in Glasgow and Riga, have adopted VIP, with a third one in Malmö planning to adopt it in the second half of 2018.

Success factors and barriers

- Due to the sustainability of the teams, projects can run over a longer period of time.
- In comparison to traditional education systems, students participating in VIP teams enjoy the advantage of building a portfolio and CV that aid their employability.

Minatec's Innovation Campus

Company name	Minatec
Type of organisation	Triple helix
Interviewee	Jean-Charles Guibert
Sector	Micro- and Nanotechnology
Country	France
Web link	https://www.minatec.org

Objectives

At the core of Minatec's Innovation Centre is forging dynamic new links between technological, industrial, societal, cultural and design considerations. Bringing together researchers, students and industry professionals for the purpose of cross-disciplinary collaboration in order to further the innovation in the micro- and nanotechnology sector. Minatec aims to combine technological resources with research know-how and academic programs in engineering that should result in technological breakthroughs.

Description

The innovation campus is a twenty hectare campus that houses 3000 researchers, 1200 students, and 600 industry experts. The campus houses among others the Grenoble-INP school PHELMA, Minatec conference centre, nano-characterization platform, Minatec Ideas Laboratory, and the companies CEA/Leti, PTA, and BHT.

By operating with both industry experts and academia, Minatec offers a win-win for the parties involved. The academic researchers and students get the opportunity to make use of the campus while also getting immediate feedback from those with business interests in the innovation.

Implementation

Every Friday the parties come together at "Minatec @ Noon" to facilitate the transfer of academic research onto actual start-ups.

Minatec is predominantly focused on competitive research, with the industry experts steering the academics towards research that produces feasible results. Input by academics can therefore be considered too academic to follow-up.

Impact and results

Minatec as a whole has an operating budget of around 300 million euros. Furthermore, the concept has led to Minatec's researcher filing approximately 350 patent applications and authoring over 1600 scientific articles per year. In addition to its research success, the cooperation at Minatec has birthed a multitude of businesses in the Micro- and Nanotechnology sector.

Context and regulatory framework

The campus activities are overseen by the campus' permanent staff. They take a leading role in the emergence of new synergies, handling internal campus communications, promoting the activities within the campus, and boosting its international foothold. Additionally, the executive committee represents the campus and coordinates Minatec's operating division.

Transferability and scalability

When considering the transferability of the Innovation Campus one must keep in mind that location is key for the success of such a concept. The innovation campus is very well situated to be able to attract both industry partners and academic institutions such as the University of Grenoble. Outside of the Paris area Grenoble is considered to be the leading research centre in France and hosting one of the largest student bodies in the country.

Next to the need for cooperation with leading research, higher education and industry partners, there is the issue of space. An innovation hub as hosted by Minatec takes up a considerable amount of space, which is a consideration when considering both the transferability and scalability of the campus.

Success factors and barriers

- The campus benefits heavily from the experience of the French Alternative Energies and Atomic Energy Commission CEA. The CEA is a key player in research, development and innovation
- The University of Grenoble is a highly esteemed University partner

European Schoolnet's Future Classroom Lab

Company name	European Schoolnet
Type of organisation	International non-profit association
Contact person	Elina Jokisalo
Sector	Education
Country	Belgium/ EU
Web link	http://fcl.eun.org/

Objectives

The FCL initiative stems from another European Schoolnet project, iTEC, which aimed to aid progressive adoption of innovative learning activities. This goal created a point of departure for the FCL initiative, aiming to create a learning environment that challenges visitor's perceptions of the role pedagogy, technology and design can play in classrooms.

Description

Created by European Schoolnet, with the support of over 30 IT industry partners, the Future Classroom Lab (FCL) provides a visual presentation of how conventional classrooms can be adjusted to contemporary teaching and learning needs. The lab consists of six learning spaces that differentiate from each other by highlighting specific areas of learning and teaching. Furthermore, the labs contribute to rethinking the role that physical space and resources play in classrooms, teacher-student dynamics, and the manner in which learning styles should be offered. The learning spaces display FLC's vision that education should be a unique learning experience.

Implementation

The overarching non-profit organisation European Schoolnet consists of a board of directors made up of 34 ministries from around Europe including Israel. However, FLC works largely autonomous among the local actors, involving policy-makers, teachers, and ICT providers from the European Schoolnet's member states.

The operational costs are covered by contributions from industry partners, who simultaneously commit to a two-year agreement under which they supply equipment and updates. The added value for these partners is the ability to showcase the use of their technology and how it can be pedagogically justified in a 21st-century educational environment. The technologies by the different vendors are then brought together into the classroom experience that FCL offers, presenting the value of these technologies beyond singular use. For example, the use of a digital whiteboard that can be connected to cameras, robotics, or used for simulations in order to enhance the learning experience. These technologies are capsulated within the six learning zones that represent different learning styles and key stages in project work by working in tandem. Each zone represents a stage in a project which will be brought into practice in an interactive manner by the use of technology. This can lead to use of the technology and learning styles in national settings following a visit to the Future Classroom Lab in Brussels, because teachers have been inspired by the FCL concept and have returned home to set up their own version of the Lab within their own schools.
As for the future steps, the focus will be on the expansion of the network in the local country and the creation of a local network of ambassadors. A special focus will also be put on local Future Classrooms (i.e. flexible learning labs). Since so many of the ambassadors are connected to a local 'learning labs', they will be involved with a pedagogical programme that will be built around the network of

learning labs. The idea is to organise dynamic, spatial webinars to share pedagogical content related to a Future Classroom Lab.

Impact and results

The lab is situated in Brussels, however, inspired by FCL, several teachers, schools and organizations have created their own "learning labs" or "learning spaces". These experiences are shared in a webinar series called "building a Future Classroom", where each webinar tells the story of the building of the lab. Past webinars were about labs in Norway, Portugal, France, USA, Israel and Belgium. The FCL has identified roughly two types of learning labs:

- 'Professional' learning labs: These labs have usually an extended target audience, strong management (incl. clear vision and organisation support), and a strong connection with commercial partners. An example of this kind of lab is Mustikas, created by HITSA in Tallinn, Estonia
- School-based learning labs: These labs are embedded in K12 schools, they have a limited target audience (e.g. students and teachers) and usually less commercial partners. An example of this kind of lab is "FC@Campus Zenit" at the Talenten School in Turnhout, Belgium.

In addition to the lab in Belgium and other living labs, there are 10 projects launched, such as the Interactive Classroom Working Group and the Triseum Validation Pilot (game-based learning). Furthermore, there are 35 multiple-day courses given and 10 courses planned for the near future. The courses are aimed at primary and secondary teachers and ICT coordinators, who enthusiastic to enhance their teaching through new ideas, tools and pedagogies.

Context and regulatory framework

The Future Classroom is an ongoing initiative that, besides from an evaluation service, has no monitoring systems in place. The only current monitoring, with regard to progress and results, is done through indicators such as the number of attendance for workshops, the learning labs created, and the partners that wish to contribute to the initiative.

Main funding for the FCL is provided through the contribution of the industry partners. Even though it is recommended that the initiative does not solely rely on governmental support, it is of importance to reach educators and policy-makers though the involvement of the many national ministries of education. Without involvement and funding, travelling costs and general incentive to join the programme might become a hurdle for schools and their teachers.

Transferability and scalability

The programme is less transferable to other industries, as it is specifically aimed to the use of technology that is built around pedagogic manners of teaching young students. It would for example require adaptions in teaching methods to fit an older audience who work in different industries. However, the eventual goal is teaching children. From thereon, they will continue their education towards employment in different industries. This makes the need for transferability less urgent as its success is applicable for multiple industries.

The Future Classrooms are very scalable, as has been shown by the different FLC inspired initiatives and local learning labs that have started throughout Europe. However, the scalability depends on the amount of teachers that possess a certain level of technological competences. As this is required to participate in this initiative and essential for the expansion of the initiative.

Success factors and barriers

- The funding and supply of the equipment by industry partners.
- A factor that makes FLC attractive to policy-makers and teachers is that they get to explore the variety of technologies that are available and how to work with and around them.
- The showrooms offer the possibility for teachers to collaborate and network, leading to innovative ideas to be used in their classrooms.

BioBusiness and Innovation Platform (BBIP)

Company name	CBS (Copenhagen Business School)
Type of organisation	University
Contact person	Dr Keld Laursen
Sector	Education
Country	Denmark
Web link	www.cbs.dk/en/knowledge-society/strategic-areas/biobusiness-and-innovation-platform-bbip

BioBusiness and Innovation Platform (BBIP)

Objectives

The Bio Business and Innovation Platform aims to provide a bridge between business and biotech by imparting students with the skills required to translate life science into entrepreneurship and business. BBIP attempts to enable them to contribute to bio-based entrepreneurship and new business in Denmark and abroad, by focussing on bioscience's specific commercialisation challenges.

Description

The Bio Business and Innovation Platform is a platform that brings forth the cutting-edge research, highly educated graduates and promising biotech ventures. This stems from the understanding that in order to be successful in the knowledge-driven biotech industry, entrepreneurs need to combine business smarts with an in-depth understanding of the underlying science. It is, therefore, necessary to endorse business know-how among those who master technology and science on a very high level.

Implementation

BBIP, in close collaboration with the Danish bio-industry, has managed to target, develop, and carry out its teaching in a faculty that is comprised of academic staff and experts from the bio-industry. The collaboration is complemented by the knowledge bridging of the academic institutions CBS (Copenhagen Business School), DTU (the Technical University of Denmark), and the University of Copenhagen. Learning opportunities offered from this platform include a Master's degree, single courses at master's and PhD levels, and a minor consisting of three key courses from the master's program. As part of the curriculum, BBIP offers the course "Innovation, Entrepreneurship and Strategy in Bio-business" which focusses on the factors that shape opportunities for innovation and entrepreneurship and consequently the business implications thereof. Furthermore, the course "Finance and Account in Bio-Business" deals with issues in forecasting and planning cash flows, the calculation of present and real option values of projects, relationships to venture capital and stock markets and how to secure funding for start-ups. BBIP further distinguishes itself by its approach to entrepreneurial education. The programme requires students to work on real-life biotech ventures with an onset of commercialization and related intermediary steps. Next to the aforementioned offering, BBIP provides PhD projects wherein PhD students collaborate with business students to develop a business plan for an innovation emerging from the research environment of the bio PhD student.

Impact and results

Having started as a cross-disciplinary program in 2010, BBIP has been adapted into a master's degree program co-founded with its partner LEO Pharma in 2012. The initiative is already contributing to business ventures, such as the companies "Immunitrack" and "Cumulus Bio" that was founded by BBIP alumni. The program has also shown fruitful to the partners Novozymes and LEO Pharma, who

were able to recruit students who acquired in-demand skills. This close cooperation with the industry results in students gaining tangible experience and know-how which prepares them for their future career. Furthermore, students who carried out their thesis project at the BBIP's partner firms, as part of a two-month internship, were able to already build their network pre-graduation.

Context and regulatory framework

In 2012, around DKK 2.1 million was granted to the platform by the Novo Nordisk Foundation over a period of three years. This has covered scholarships for PhD candidates and an annual DKK 200.000 for the recruitment of notable international lecturers. The funding through Novo Nordisk Foundation is significant but absence of this funding would not hamper the continuation of the programme. This is not the case for the cooperation with the bio-industry partners who, next to contributing staff and input to the teaching, offer internship positions to all of the BBIP graduating students. The partnership with the bio-industry makes it that students that have completed the degree are equipped with tools that their counterparts at other programmes do not have. Therefore, a large portion of the BBIP success is due to its close cooperation with its bio-industry partners.

Transferability and scalability

The scalability of this initiative is subject to the limitation that Universities generally, besides cross-university cooperations, do not span outside of their respective countries. Nonetheless, the curricula are taught in English and it would be therefore possible to expand the partnering Universities, given that certain conditions are met. For example, part of the master programme is the completion of an internship at one of the industry partners. Besides that the number of available internships will not be exhaustive, the burden for students outside of Denmark to take part would constitute a significant challenge. That would mean that one of the conditions of upscaling the initiative would be to engage in partnership with companies active in the bio-industry outside of Denmark. Making the condition of having a bio-industry, who are also willing, an important one that has a significant effect on the scalability.

Transferability to other countries is subject to similar limitations. However, transferability across industries is highly possible. Bespoke educational offerings in close cooperation with the industry can only benefit industries and this element constitutes a key selling point to other industries.

Success factors and barriers

- Industry experts that form part of the teaching staff.
- Bio-Industry providing input in order to create a bespoke curriculum.
- Partnership with partners to provide internship possibilities

CECIMO's METALS

Company name	CECIMO – European Association of the Machine Tool Industries
Type of organisation	International non-profit association
Contact person	Maitane Olabarria Uzquiano
Sector	Metalworking machine tool industry
Country	Belgium (Brussel)/ EU
Web link	http://www.metalsalliance.eu/

METALS
MachinE Tool ALliance for Skills

Objectives

Erasmus+ Sector Skills Alliances (funder) aim at tackling skills gaps, enhancing the responsiveness of initial and continuing VET (vocational education and training) systems to sector-specific labour market needs and demand for new skills with regard to one or more occupational profiles. See the specific objectives on page 2.

Description

While disruptive technologies provide new business opportunities for machine tool builders, understanding the scope of technological changes occurring on different fronts and integrating them into their own business is a complex task and requires new skills. METALS will help ensure that the upcoming machine tool workforce is trained on new applications, like metal additive manufacturing, to support the global technological leadership of the European machine tool industry.

Implementation

The project leader is CECIMO (European Association of the Machine Tool Industries) and works together with 10 partners from 4 different countries (Belgium, Spain, Germany, Italy) on the 8 objectives. The educational training aspect happens at the local level with diverse partners across Europe. The METALS internal kick-off meeting was held in Brussels on 12-13/01/1016. The project has an advisory board in which high level sector industrialists and educators are involved to advise on the sector-specific approach. The advisory board monitors and provides practical feedback on activities and applicability of results. For example with the MOOCs pilot test in three countries, to strengthen the effectiveness through feedback and monitoring activities. The structure of having a central project leader and local partners with the support of the advisory council was proven to be meaningful and practical at the local level while achieving European wide impact.

Target groups for the project are:

- Machine tool companies offering in-house training programmes in need of new digital learning materials
- VET learners including apprentices studying to acquire relevant skills for the machine tool sector and experienced machine tool workforce in need of up-skilling
- Vocational education and training providers willing to enrich the outdated curriculum in Europe, National and European-level decision makers looking for industry input for the design of education policies

Impact and results

Since the kick-off two years ago multiple objectives have been achieved and a variety of events have been organised. In 2016 there was a CECIMO Additive Manufacturing and 3D Printing European Conference organized ADDIT3D, the first 3D and additive manufacturing fair and a workshop "Additive technologies: new skills and new jobs". In addition, the EU machine tool industry skills panorama, the METALS dissemination strategy and analytical highlights were created. The initiators were most pleased with addressing the concerns regarding the looming skills shortage. The setup has become a blueprint for working with local partners. Furthermore, the bringing together of leaders in the industry in order to present initiatives and discusses processes in motion was regarded to be very fruitful. Other initiatives are coming up with similar approaches.

Cecimo is also invited to speak more in general about skills trajectory in industry 4.0 and asked in advisory boards to discuss skills progressing projects. This is raising necessary awareness what this project can and cannot do.

Context and regulatory framework

The METALS initiative is a temporary funded project but will be ongoing on a local level. It is fully funded by Erasmus+ from November 2015 to October 2018. Before the funding ends a plan needs to be created to ensure continuation. This is currently being worked on. The involvement of local level partners is crucial to carry out this initiative. It was felt that there was a window of opportunity to update relevant curricula and to ensure long-term sustainability.

Transferability and scalability

This is a scalable initiative for specific industries if there are funding opportunities and local actors who want to be involved. Other initiatives are already following this setup.

Success factors and barriers

- Start with the needs of the industry, combine the three actors and leverage local knowledge.
- Before the launch, there was a common concern around the evolution of skills necessary and a common goal to understand this challenge better.
- It is a member-driven network with a bottom-up approach and a central driver.
- Collective expertise and shared experiences to leverage member based knowledge to the consortium.
- Visibility is one of the key factors
- Having three actors who promote this project in their community makes the visibility stronger, however, it gets easier when there is something concrete to show like the MOOCs.

Academy Cube

Company name	Academy Cube
Type of organisation	International non-profit company
Contact person	Dietmar Kilian and Bernd Boeckenhoff
Sector	Education STEM
Country	Germany
Web link	http://www.academy-cube.com/

Objectives

Academy Cube combines e-learning with job-matching in a digital economy. It has been developed by leading global companies to strengthen tomorrow's workforce and to open the door to new opportunities in the international labour market for motivated talents.

Description

Academy Cube offers practical course content with proven relevance for the industry and connects talented people to companies.

Implementation

The initiative was introduced in 2013 at CeBIT by Neelie Kroes, former European Commissioner for the Digital Agenda, and Jim Hagemann Snabe, former Co-CEO of SAP SE. In addition to SAP, companies such as Cisco, Festo, and Software AG are also involved as partners. The Academy Cube offers e-learnings in technical skills to a cross-border audience. The target group is anyone from 16 years old and up, with a wide range of educational levels. Academy Cube representatives build connections and intensify cooperation at the local level. The Academy Cubes holds National Offices in Spain, Portugal, Italy, UK, Malaysia and soon other countries will follow.

Impact and results

In the interim, it has grown to become one of the most successful platforms for digital education with academic partners, foundations and private organizations worldwide. The Academy Cube online platform counts currently around the 40.000 users. A few years ago a high dropout rate of users was observed, which was attributed to the design of the used platform at that time. For two years Academy Cube invested in a more user-friendly online platform and new curricula, which will be launched shortly. Academy Cube expects to tenfold their amount of users to 400.000 in the year 2020. There are several talent stories on the website about how talents found their new job trough Academy Cube. Talents also emphasize that they have learned practical knowledge by following Academy Cube's e-learnings, which isn't taught at university. Partners indicate that the integration of training and recruiting on one platform enables the connection between the different actors and strengthen Europe's competitiveness.

Context and regulatory framework

Since Academy Cube was initiated as a CSR initiative, it was a logical step to formalize it into a non-profit organization. Funding of Academy Cube consists of three elements. Firstly there are funds provided by foundations, who take part in projects and play a role as a strategic partner. An example such of a project in which Academy Cube is involved is the recent IT summit focused on refugee issues. This summit was half funded by the government and half by the industry. The second and

third element of funding is taking up by the private- and public sector. However, academy Cube has noticed a shift in funding possibilities from the private- and public sector and state that it has become increasingly difficult to find financial support in the past ten years.

Transferability and scalability

Academy Cube, as an online platform, is highly transferable within Europe. However, they are already located in several member states, so it's rather the questions whether this is desirable. The scalability of Academy Cube is also high, since an online platform with an adequate architecture is easily scaled up to more users. The ambition of Academy Cube as an organisation also underlines the possibilities regarding scalability, referring to the ambition of 400.000 users in 2020. In addition, Academy Cube started to search for opportunities to expand to new countries and collaborate with new partners.

Success factors and barriers

Academy Cube is keeping a close eye on the demand of the industry in order to stay on top of new developments and innovations. By collaboration with universities, Academy Cube is able to provide high-quality e-learning. Partners are monthly updated by a full report containing all recent developments regarding Academy Cube, which increases the transparency and leads to a higher level of engagement by the partners. In addition, these reports are also publicly available. Users are regularly asked for their feedback regarding the content and the online platform in general. This feedback was, among other things, used as input for the design of the new online platform. Academy Cube expects that the launch and use of the new platform will increase their visibility. Despite Academy Cube's reasonable degree of visibility within Europe, they strive for improvement, particularly their visibility towards companies. Besides the new platform, Academy Cube also uses social media to boost their visibility. An important barrier for Academy Cube is the number of competing initiatives. In contrast to a big part of their competitors, Academy Cube is not willing to sell their users data, which distinguish them from their opponents.

Swiss Nano-Cube

Company name	Swiss Nano-Cube
Type of organisation	E-Learning Platform
Contact person	Dr. Christoph Meili
Sector	Micro- and nanotechnology
Country	Switzerland
Web link	http://www.swissnanocube.ch/en/about-us/

Objectives

The objective of the platform is to stimulate interest in technological and natural science among young students in Switzerland. Eventually, this should contribute to the training of qualified specialists in the area of M&NT and to the strengthening of Switzerland's position as a residence for innovation.

Description

Swiss Nano-Cube offers a modularly structured information and training platform on micro and Nano-technology (M&NT) for polytechnic schools, high-schools, and vocational schools. The "Innovationsgesellschaft mbH" (St. Gallen) and the Swiss government identified a shortage in teaching material on the subject and the lack of familiarity among teachers with Nano-technology. Through the use of an innovative introduction into M&NT it aims to familiarise students with Nano-Technology.

Implementation

The modules by Swiss Nano-Cube provide an interactive learning arrangement that is suited for a young audience. Among its offerings, Swiss Nano-Cube designed the game "Nanorama Loft" which takes place in a virtual loft and requires young players to find a variety of Nano-Products used in everyday life while subsequently provide answers to quiz questions. Additionally, Swiss Nano-Cube offers the "NanoTeachBox", consisting of didactical teaching and learning materials, videos, presentations and more to be used by teachers in their curriculum. Furthermore, Swiss Nano-Cube offers background information on a variety of Nano-technology specific aspects linking basic effects in the Nano industry, economy, social and technological issues in order to practice-relevant information in the Nano-profession.

Impact and results

In 2012 Swiss Nano-Cube was awarded a "Best of 2012" certificate in the category e-learning at the CeBIT exposition for the Innovation Prize IT 2012 awards. Furthermore, the platform has managed to expand its courses by offering, besides German, interactive quizzes in English, Italian and French.

Context and regulatory framework

The "Bundesamt für Berufsbildung und Technologie" (BBT) provides funding to the development and implementation of "Swiss Nano-Cube", while the remaining funds are provided by sponsors and partners. The initiative follows and implements the national strategy for the promotion of junior scientists in the field of natural sciences and emerging technologies. Thus, the initiative contributes to the strengthening of the Swiss education system and is considered to be important to the national interest in technological innovation.

Transferability and scalability

The Swiss Nano-Cube modules are specifically designed with the focus on Nano-technology. However, the interactive gaming feature of the offerings can be adopted by other industries to meet their own specific requirements. Furthermore, the design and modules are adapted to target a younger audience, therefore the audience should be taken into consideration if other industries want to transfer this design and module to their own initiative.

The online availability of the curricula provides for scalability of the initiative. Any individual or organisation across Europe can make use of the training material in the field of Nano-technology.

Success factors and barriers

- The availability of the learning materials, videos and presentations online.
- The entry-level and interactive characteristics of the courses offer a fun and engaging way to introduce young students to M&NT
- The main barrier is the language, even though the course and materials offered are starting to be translated into other languages this is still mainly offered in German.

Interdisciplinary Design for the Built Environment

Company name	Cambridge University
Type of organisation	University
Contact person	Kayla Friedman
Sector	Built Environment
Country	UK
Web link	https://www.idbe.arct.cam.ac.uk/

Objectives

The programme seeks to impart to students broader knowledge than they've gained through their technical backgrounds. By teaching them to apply soft skills and project management processes to multi-disciplinary design and collaborations and how their built environment can benefit from contributions from other technical disciplines. The objective is to allow students to come up with new innovative ideas outside of the ordinary restrictive frameworks of their own day-to-day projects as built professionals. Such an approach should lead to professionals having a more open approach to alternative views and methods. Weighing in non-technical societal and environmental considerations when commencing a project.

Description

The IDBE is a transformative two year, part-time Master's programme by the Institute for Sustainability Leadership at the University of Cambridge. The programme is meant for professionals in the built environment who have at least three years of professional experience in the sector. The programme generally attracts candidates who are keen to expand their understanding of challenges and opportunities in the built environment. IDBE has a curriculum that caters the needs of built environment professionals ranging from structural engineers to transport planners, design managers to architects.

Implementation

The two-year programme is built around seven separate residential weeks that comprise an intensive programme consisting of lectures, workshops, and seminars. These residential weeks are thematic in nature covering issues such as interdisciplinarity; the client, the user and the design team; sustainable construction and climate change; and more. Each week then consist of design projects that are built around the theme of the residential week, in which interdisciplinary teams work together on a design proposal.

Impact and results

The programme is currently developing a certificate that should be rolled out in 2019. The certificate will offer prospective students the possibility to gain an IDBE certificate in 9 months instead of the degree which takes two years to complete.

Context and regulatory framework

The programme runs on funding from student fees, as is custom to programmes within university environments.

Transferability and scalability

As most of the technical projects of now and the future will consist of multidisciplinary teams, the programme as presented by IDBE is very current. It is therefore easily applicable to other industries and can be transferable across countries. However, as with other university programmes, the programme lacks scalability as it is tied to a specific faculty within the University of Cambridge. University programmes, due to the structures within academia, do not lend themselves easily to be scaled up.

Success factors and barriers

- The interdisciplinary aspect provides technical and non-technical viewpoints on built environment approaches. Something that students at purely technical programmes lack.

Fastrack to IT (FIT)

Company name	FIT, Fastrack to IT
Type of organisation	Registered charity, and non-profit organisation
Contact person	Peter Davitt (CEO): peterdavidt@fit.ie
Sector	Triple helix partnership (government, education and industry)
Country	Ireland
Web link	http://fit.ie/

Objectives

The Fastrack to IT platform states that its mission is to promote an inclusive Smart Economy. Fit will accomplish this mission by trying to create a fast track to marketable technical skills. This fast track aims for people that are most vulnerable to sustained long-term unemployment. Eventually the FIT initiative tries to give the unemployed a change to reskill and make them more likely to find a job after they have completed the program.

Description

The FIT initiative is a non-profit organisation founded in 1999. The activities of the initiative are aimed at developing and promoting technology-based programmes for job seekers. These programmes also encourage career opportunities, because they provide job seekers with necessary knowledge in an increasingly knowledge based economy.

Implementation

Fit programmes take part in the following exercises:

- Upskilling job seekers, even if they have not taken part in formal education for many years. FIT programmes were designed to give the unemployed new marketable skills for sustainable jobs. With these skills, the unemployed can compete for these sustainable jobs in the emerging knowledge economy;
- Providing excellent training by the development of training provision, industry collaboration (e.g. internships and work experience placements) and advice, guidance and information on job hunting;
- FIT interacts fully at all levels of the student's education and progression. From developing the courses to recruiting and screening of candidates, regular review meetings for monitoring student's progress and provision of supports for students. The different stakeholders regularly meet to ensure participants get a quality experience.
- FIT develops training programmes are mainly directed at people coming from, or at risk of, long-term unemployment. The training programmes, which cover a large variety of topics, are all created in collaboration with industry and education to ensure skill enrichment in personal and professional skills.
- Putting policy into action by considering various national policies when developing FIT strategies.

Impact and results

Over 18.000 job seekers have participated and completed the skill training programs of the FIT initiative. From those 18.000 job seekers, 13.500 job seekers advanced into employment. The

website currently states that 4.000 job seekers are in the process of completing FIT training programs. Futhermore, the European Commission named FIT to be one of the most successful employability initiatives in Europe.

Context and regulatory framework

The FIT initiative has a close working relationship with different types of organisations such as government departments, national education and training agencies, local development organisations and community based organisations.

Transferability and scalability

- This initiative is highly scalable due to the high demand for employees, which possess the technical skills that are representative for the current and future needs of organisations. The content of the programmes does not seem to be available online at this time, which threatens the scalability.
- The transferability of this initiative can be considered high due to the growing demand for employees with technical skills throughout Europe.

Success factors and barriers

- The programme gives the unemployed new marketable skills for sustainable jobs.
- The programme covers a large variety of topics, that are all created in collaboration with industry and education to ensure skill enrichment in personal and professional skills

Skillman

Company name	Skillman
Type of organisation	Consortium
Contact person	Fabio Croci
Sector	Manufacturing and Transport
Country	EU-Wide
Web link	http://skillman.eu/

Objectives

The Sector Skills Alliance aims to jointly design educational programmes based on the identified demand for specific skills and competencies that are in line with emerging technologies within the industry. Skillman is considered to be a mutually beneficial endeavour resulting from the educational activities that are developed.

Description

With the support of the Executive Agency for Education and Culture for the European Commission under the Erasmus+ Programme, the Sector Skill Alliance for Advanced Manufacturing for the Transport Sector, Skillman, in conjunction with its partners from the industry, research centres, education and awarding bodies, have worked towards curricula that form the basis for future skills needed by technical professionals.

Implementation

In order to detect the skills needed and convert these into an educational programme, the Observatory on Advanced Manufacturing for the Transport Sector commits its research to three domains of interest: energy performance of production processes and of end products; advanced processes, robotics and use of advanced combined materials; infotechment and the use of ICT and wireless technologies. These are separately assigned to a Thematic Commission, who then translate the labour market intelligence and requirements for educational programmes into a knowledge base. The knowledge base built from the key domains and problem areas provide a credible forecast to industry needs and point of departure to the design of the curricula.

The designed educational programmes that follow from the preparatory steps are primarily aimed at tertiary VET level students, re-skilling or up-skilling programmes for workers, and trainers wishing work with available educational materials. The educational programmes are further complemented by allowing external stakeholders to take part in the Open Network of Associated Partners which allows for further input of quality and know-how for the benefits of the educational programmes.

Impact and results

Shortly after the launch of the Skillman curricula, 280 organisations applied to make use of the programme for their training purposes. The number of organisations was welcomed by Skillman but considerably exceeded their expectations. The worldwide response to Skillman shows the need that the sector has for synergy between education and the industry.

Furthermore, the initiative has led to Skillman signing an agreement with LEAN, which is an innovative VET education capacity building project, to cooperate in the field of advanced

manufacturing in the transport sector. The cooperation will lead to an expansion of the available training tools that are part of the Skillman educational programme.

Context and regulatory framework

The initiative's aim to be a step, or several, ahead in technological advancements in the industry, makes its continuation justifiable for a prolonged period. The use of evaluations to monitor the different steps of the process of developing curricula makes it possible to continuously cater to the needs of the industry.

The main funding source is the European Commission (Erasmus+), who launched the initiative. However, Skillman's daily activities run autonomously and in close cooperation with industry partners.

Transferability and scalability

The initiative has considerable transferability aspects due to its foundational principle of cooperation on problems and skill gaps within specific industries. Other industries can benefit from a similar approach by adopting the workflow of Skillman. Its openness to input from external stakeholders forms the basis for a synergetic approach that results in effective educational programmes targeting industry led demands.

Similar observations can be made with regard to the scalability of the project. Solely focused on the needs of the industry, the only limiting factor to scaling the Skillman concept is the primary locations of organisations that are part of the industry. Furthermore, Skillman's curricula are based upon European Qualification Framework and fit within the framework of the ESCO code aiding to the extent to which the program is scalable.

Success factors and barriers

- The collaborative nature of the Skill Sector Alliance contributes to Skillman offering a unique set of curricula that does not exist elsewhere.
- The systematic method of Skill Sector Alliance provides for a continuous and pro-active approach to capacity building in the industry instead of sporadic and reactionary approaches which characterised the industry prior to this initiative.
- The external evaluations ordered by Skillman have proven to be invaluable to the process. A two-step-evaluation was conducted to firstly, halfway through the creation process, get feedback from the partners which served as input for the latter stages. Secondly, the ex-post evaluation was directed at the main beneficiaries of the program, the students and educators, in order to monitor their reception of the programmes.

OP-TEC	
Company name	The National Centre for Optics and Photonics Education (OP-TEC)
Type of organisation	Triple Helix Partnership
Contact person	Mr. Daniel M. Hull (executive director)
Sector	Education
Country	USA
Web link	http://www.op-tec.org/

Objectives

OP-TEC's mission is to increase the supply of well-educated Photonics Technicians by building and strengthening the capacity and quality of photonics education in the U.S. two-year colleges.

Implementation

OP-TEC serves secondary STEM (Science, Technology, Engineering and Math) programs and postsecondary programs devoted to lasers, optics, and photonics technology or technologies enabled by lasers, optics and photonics. In addition, OP-TEC provides curriculum, instructional materials, workforce needs assessments, faculty development, student recruitment strategies/tools, and support for institutional reform. Central to the ARM University Program's "Lab-in-a-box" offerings are the hardware boards, one-year renewable software licences for the full ARM Keil® MDK-Professional development tool, and Complete teaching materials, including lecture note slides, demonstration codes and hands-on lab manuals with solutions in source. Subject to a qualification process and hardware platform availability, the kits are donated free-of-charge to faculty and educators worldwide to use in their courses.

Impact and results

OP-TEC has established a national infrastructure for developing and supporting widely-disseminated educational programs in cutting-edge, high-demand technologies that require photonics. This infrastructure encompasses collaboration with photonics employers across the country, technical societies, and over 30 two-year colleges. Each college partners with local high schools and employers to serve their community through workforce development in this highly emerging technology. OP-TEC is also bridging the gap in the participation of women and minorities in technology, breaking down geographical and socioeconomic barriers, and making the study of technology more widely accessible. By providing career pathways in which students begin the pursuit of technical careers early and transition seamlessly into post-secondary programs, OP-TEC enables students to acquire the skills necessary to compete in the global marketplace. OP-TEC also works with colleges to educate employed technicians working in this field.

OP-TEC serves as a national clearinghouse for photonics teaching materials; encourages more schools and colleges to offer programs, courses, and career information; and helps high school teachers and community/technical college faculty members develop programs and labs to teach lasers, optics, and photonics technology.

Context and regulatory framework

The National Centre for Optics and Photonics Education, OP-TEC, is a consortium of two-year colleges, high schools, universities, national laboratories, industry partners, and professional societies funded

by the National Science Foundation's Advanced Technological Education (ATE) program. The participating entities of OP-TEC have joined forces to create secondary-to-postsecondary as well as returning adult "pipelines" of highly qualified and strongly motivated students and to empower two-year colleges to prepare technicians in optics and photonics.

Transferability and scalability

Other industries can benefit from the approach from the photonics industry. It is highly transferable due to its principle of cooperation, inclusivity and openness to input from external stakeholders.

The programme is highly scalable as it encourages more schools and colleges to offer programs, courses, and career information; and helps high school teachers and community/technical college faculty members develop programs and labs.

Success factors and barriers

- Working together with many stakeholders: photonics employers across the country, technical societies, and over 30 two-year colleges
- Encouraging the participation of women and minorities in technology, breaking down geographical and socioeconomic barriers, and making the study of technology more widely accessible.
- Providing career pathways in which students begin the pursuit of technical careers early and transition seamlessly into post-secondary programs, OP-TEC enables students to acquire the skills necessary to compete in the global marketplace

7.3.4. Leading education providers in KETs and DT

In this section we analyse the leading academic education providers relevant to key enabling technologies and digital transformation. We map KET domains on classification of technology domains used by most relevant university rankings, and analyse which academic institutions dominate academic fields relevant to key enabling technologies and digital transformation. Subsequently, we discuss academic literature on how to explain differences in university performance.

Looking at prominent rankings of university world-wide, it shows that **the top 20 of world university rankings are currently heavily dominated by the UK and USA**, with the top 5 of world university rankings exclusively populated with institutions from these two countries. The Table below depicts the top five universities on overall scores according to the THE, QS and ARWU rankings.

*Table 22: *World university rankings are Times Higher Education World University Ranking (THE), QS World University Ranking (QS) and Academic Ranking of World Universities (ARWU). The THE and QS ranking are from 2018, the ARWU ranking from 2017*

University rankings* overall scores			
Rank	***THE***	***QS***	***ARWU***
1	University of Oxford	Massachusetts Institute of Technology (MIT)	Harvard University
2	University of Cambridge	Stanford University	Stanford University
3	Stanford University = California Institute of Technology (Caltech)	Harvard University	University of Cambridge
4		California Institute of Technology (Caltech)	Massachusetts Institute of Technology (MIT)
5	Massachusetts Institute of Technology (MIT)	University of Cambridge	UC Berkeley

The difference in rankings can be explained by differences in methodology.

THE uses 13 performance indicators, grouped into five categories. Institutions are excluded if they do not teach at undergraduate level, or if their research output is below a certain threshold.

QS assesses universities on six performance indicators, relating to research, teaching, employability and internationalization. To be eligible for inclusion, institutions must teach at both undergraduate and postgraduate level, and conduct work in at least two of five broad faculty areas (arts and humanities; engineering and technology; social sciences and management; natural sciences; life sciences and medicine).

Also widely known as the Shanghai Ranking, the ***Academic Ranking of World Universities*** (ARWU) assesses six performance indicators, all relating to research excellence. The ranking considers all institutions with Nobel Laureates, Fields Medalists, highly cited researchers, papers published in Nature or Science, or a significant number of papers indexed by the Science Citation Index-Expanded (SCIE) or Social Science Citation Index (SSCI).

Top universities play a crucial role in training tomorrow's technology leaders. In order to understand which academic institutions dominate academic fields relevant to key enabling technologies and digital transformation, we have attempted to connect KET-related and digital areas to classification of technology domains used by the THE, QS and ARWU rankings. Subsequently, we have analysed the rankings for these technology domains.

Our analysis shows that **some elite universities score well in all KET-related areas**. These include Oxford, Cambridge, Stanford, Harvard and MIT. The tables below show these institutions consistently rank high life-science technologies, engineering, the natural sciences, and computer science.

Two Swiss universities consistently make the top 20 rankings in engineering, the natural sciences and computer sciences. These are ETH Zurich and the Ecole Polytechnique Fédérale de Lausanne. ETH Zurich is also mentioned in the top 20 for life-science technologies by the THE ranking.

When taking the UK out of our analysis, it shows that **universities from 'continental' EU do not perform well in the top 20 of these rankings**. Institutions that do make the rankings are the Karolinska Institute (Sweden) and Wageningen University (The Netherlands) in life-science technologies, Delft University of Technology (The Netherlands) in engineering, the Sorbonne University (France) in the natural sciences, and the Technical University of Munich (Germany) in computer sciences. Still, their appearance in these rankings is not consistent, never mentioned by more than one of the three ranking providers analysed.

Life-science technologies

Rank	Life science (THE)	Life-science and medicine (QS)	Life and agriculture science (ARWU)
1	Harvard University	Harvard University	Harvard University
2	University of Cambridge	University of Oxford = University of Cambridge	University of Cambridge
3	University of Oxford		Massachusetts Institute of Technology (MIT)
4	Stanford University	Massachusetts Institute of Technology (MIT)	Stanford University
5	Massachusetts Institute of Technology (MIT)	Stanford University = John Hopkins University	University of California, San Francisco
6	John Hopkins University		University of Washington
7	Princeton University	Karolinska Institutet	University of California, Berkeley
8	California Institute of Technology	University College London (UCL)	Yale University
9	Yale University	University of California, Los Angeles (UCLA)	University College London
10	Imperial College London	University of California, San Francisco	University of Oxford

Life-science technologies

Rank	Life science (THE)	Life-science and medicine (QS)	Life and agriculture science (ARWU)
11	University of Chicago	Imperial College London	Rockefeller University
12	University of California, San Diego	Yale University	John Hopkins University
13	ETH Zurich	University of Toronto	Columbia University
14	Cornell University	University of Melbourne	University of California, San Diego
15	Columbia University	University of Sydney	University of California, Los Angeles
16	Duke University	University of Edinburgh	The University of Texas Southwestern Medical Center
17	University of Pennsylvania	King's College London	Cornell University
18	University of California, Berkeley (UCB)	University of California, Berkeley (UCB)	University of Wisconsin- Madison
19	University of California, Los Angeles (UCLA)	University of California, San Diego	University of North Carolina at Chapel Hill
20	Wageningen University	Duke University	University of Queensland

Engineering

Rank	Engineering and technology (THE)	Engineering and Technology (QS)	Engineering and Computer Sciences (ARWU)
1	Stanford University	Massachusetts Institute of Technology (MIT)	Massachusetts Institute of Technology (MIT)
2	California Institute of Technology	Stanford University	Nanyang Technological University
3	University of Oxford	University of Cambridge	Stanford University
4	Massachusetts Institute of Technology (MIT)	ETH Zurich	Tsinghua University
5	University of Cambridge	Nanyang Technological University	King Abdulaziz University
6	Princeton University	Imperial College London	National University of Singapore (NUS)
7	Peking University	National University of Singapore (NUS)	Imperial College London
8	National University of Singapore (NUS)	University of Oxford = University of Tokyo	University of California, Berkeley
9	ETH Zurich		Harbin Institute of Technology
10	Imperial College London	Tsinghua University	The University of Texas at Austin

Engineering

Rank	Engineering and technology (THE)	Engineering and Technology (QS)	Engineering and Computer Sciences (ARWU)
11	Georgia Institute of Technology	University of California, Berkeley (UCB)	ETH Zurich
12	Carnegie Mellon University	Ecole Polytechnique Fédérale de Lausanne	Georgia Institute of Technology
13	University of California, Berkeley (UCB)	Harvard University	University of Illinois at Urbana-Champaign
14	Ecole Polytechnique Fédérale de Lausanne	Tokyo Institute of Technology	Zhejiang University
15	University of Illinois at Urbana-Champaign	Korea Advanced Institute of Science and Technology	University of Michigan-Ann Arbor
16	Nanyang Technological University	Seoul National University	Shanghai Jiao Tong University
17	University of Michigan	Hong Kong University of Science and Technology= Politecno di Milano	Texas A&M University
18	Delft University of Technology = Hong Kong University of Science and Technology		Purdue University - West Lafayette
19		National Taiwan University (NTU)	University of Cambridge
20	Cornell University	Peking University	Southeast University

Natural sciences

Rank	Natural Sciences (QS)	Physical sciences (THE)	Natural Sciences and Mathematics (ARWU)
1	Massachusetts Institute of Technology (MIT)	Princeton University	University of California, Berkeley (UCB)
2	University of Cambridge	Harvard University	Stanford University
3	Stanford University	Stanford University	Princeton University
4	University of Oxford	Massachusetts Institute of Technology (MIT)	Harvard University
5	Harvard University	University of Cambridge	Massachusetts Institute of Technology (MIT)
6	University of California, Berkeley (UCB)	University of Oxford	California Institute of Technology
7	ETH Zurich	California Institute of Technology	University of Cambridge
8	University of Tokyo	ETH Zurich	University of Tokyo
9	California Institute of Technology	Imperial College London	ETH Zurich
10	Imperial College London	University of Chicago	University of California, Los Angeles (UCLA)

Natural sciences

Rank	Natural Sciences (QS)	Physical sciences (THE)	Natural Sciences and Mathematics (ARWU)
11	Princeton University	University of California, Los Angeles (UCLA)	University of Colorado at Boulder
12	National University of Singapore (NUS)	University of California, Berkeley (UCB)	Columbia University
13	Ecole Polytechnique Fédérale de Lausanne	Cornell University	University of Oxford
14	Peking University	Columbia University	Pierre and Marie Curie Université**
15	Kyoto University	Ecole Polytechnique Fédérale de Lausanne	University of California, Santa Barbara
16	Tsinghua University	National University of Singapore (NUS)	Northwestern University
17	University of California, Los Angeles (UCLA)	Peking University	Cornell University
18	Lomonosov Moscow State University	University of Washington	University of Chicago
19	Nanyang Technological University	University of Michigan	University of Michigan-Ann Arbor
20	Technical University of Munich	University of California, Santa Barbara	Yale University

Computer science

Rank	Computer science (QS)	Computer science (THE)	Engineering and Computer Sciences (ARWU)
1	Massachusetts Institute of Technology (MIT)	Stanford University	Massachusetts Institute of Technology (MIT)
2	Stanford University	Massachusetts Institute of Technology (MIT)	Nanyang Technological University
3	Carnegie Mellon University	University of Oxford	Stanford University
4	University of California, Berkeley (UCB)	ETH Zurich	Tsinghua University
5	University of Cambridge	University of Cambridge	King Abdulaziz University
6	Harvard University	California Institute of Technology = Carnegie Mellon University	National University of Singapore (NUS)
7	University of Oxford		Imperial College London
8	Princeton University	Georgia Institute of Technology	University of California, Berkeley
9	ETH Zurich	Imperial College London	Harbin Institute of Technology
10	National University of Singapore (NUS)	Ecole Polytechnique Fédérale de Lausanne	The University of Texas at Austin

Computer science

Rank	Computer science (QS)	Computer science (THE)	Engineering and Computer Sciences (ARWU)
11	= University of Toronto	Harvard University	ETH Zurich
12	Imperial College London	Princeton University	Georgia Institute of Technology
13	University of California, Los Angeles (UCLA)	National University of Singapore (NUS)	University of Illinois at Urbana-Champaign
14	University of Melbourne = Hong Kong University of Science and Technology	University of Edinburgh	Zhejiang University
15		Cornell University	University of Michigan-Ann Arbor
16	Nanyang Technological University	Technical University of Munich	Shanghai Jiao Tong University
17	Peking University	University of Washington	Texas A&M University
18	Ecole Polytechnique Fédérale de Lausanne	University College London (UCL)	Purdue University - West Lafayette
19	University of Washington	Columbia University	University of Cambridge
20	Tsinghua University	Tsinghua University	Southeast University

When taking a broader look at the rankings, the picture shifts somewhat. **Europe is very well represented in the top 500 of universities worldwide**. Our analysis of the top 500 ranking of

universities shows that institutions from the EU27 (excluding the UK) are present far more frequently. The table below shows that 151 institutions from the EU27 (excluding the UK) make the top 500 ranking, compared to 135 from the United States and 38 from the United Kingdom.

Table 23: University ranking by country Based on ARWU 2017*

Country	Top 20	Top 100	Top 500
EU27	-	25	151
United States	16	48	135
United Kingdom	3	9	38
Switzerland	1	5	8

A study in 2012 confirmed that **there is relatively little movement in the top of the rankings**.[591] Universities that are ranked very high typically retain their high-ranking position, and very few institutions manage to enter into the top of the rankings. The few new entrants that do manage to significantly climb the rankings are mostly from Asian societies.

A 2011 study shows that ***differences in university performance are largely explained by four socioeconomic factors***. [592] The following factors for a large part determine cross-country variation:

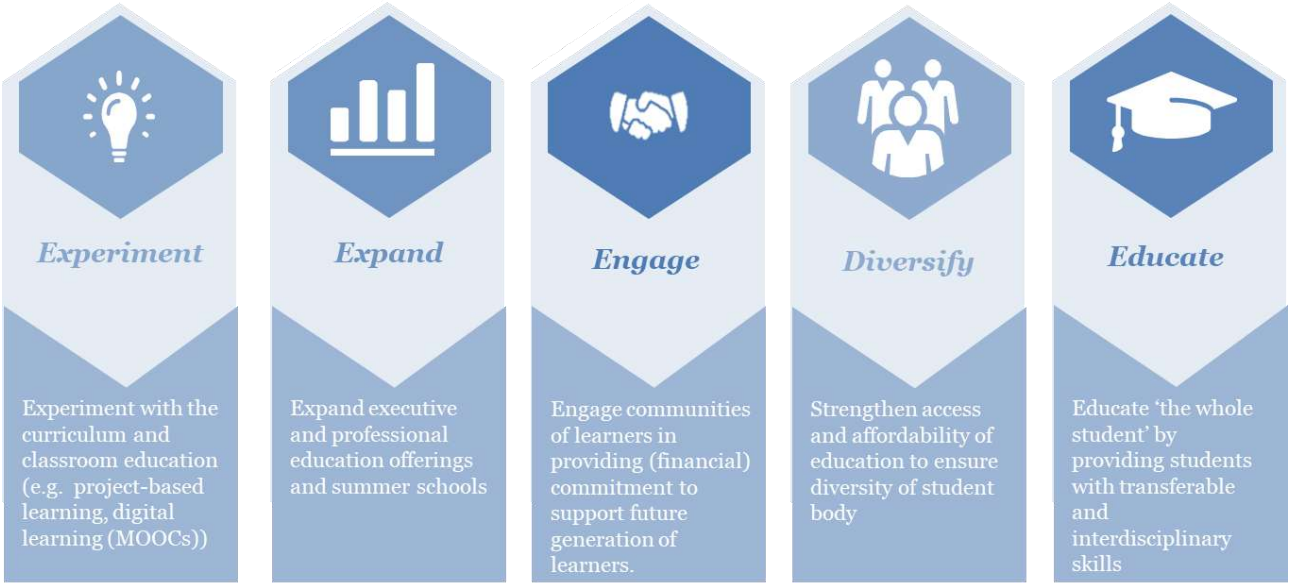
- ***Income***: A general measure of the financial resources available in a country;
- ***R&D spending***: Total expenditure on R&D within a country;
- ***Population size***: The total size of the population within a country;
- ***National language***: The national language within a country; additional research from 2013 concludes that English-language proficiency is a major gatekeeper for the upper echelons of university rankings. [593]

On micro-level, a 2006 study shows that ***university income is one of the most important factors to ranking high***.[594] The study showed that to retain dominance in the academic system, universities require additional sources of income besides tuition fees. The following elements of university income are especially important:

- Student fees;
- Private gifts (typically important for Anglo-Saxon universities);
- Endowments (typically important for Anglo-Saxon universities);
- Revenues from research itself;
- Government funding (important especially for European universities).

[591] Hazelkorn, E. (2012) . *Striving for World Class Excellence: Rankings and Emerging Societies*. In D.Araya & P. Marber (eds) Higher Education in the Global Age: Universities, Interconnections and Emerging Societies.Routledge.
[592] M. Li, S. Shankar, K. Tank, 2011, Why does the USA dominate university league tables?, Studies in Higher Education, 36 (2011), pp. 923-937
[593] Hazelkorn, Ellen. 2015. *Rankings and the Reshaping of Higher Education: the Battle for World-Class Excellence*. 2nd edition. Palgrave Macmillan.
[594] Craig Calhouen, 2006, The University and the Public Good, Thesis Eleven Volume 84 Issue 1

A 2009 paper by the World Bank has sought to uncover how world-class universities apply their funds to retain their high status. Their paper concludes that ***world-class universities are constantly engaged in educational innovation***.[595] Specifically, to entrench their high status they experiment, expand, engage, diversify and educate:



In order to link these insights to key enabling technologies and digital transformation, we have looked in detail at the educational offerings of elite universities. Our analysis shows ***there are shared features among elite university Master's programmes***:

- World-class universities all offer ***distinct programmes in each KET area*** at all levels (Bachelor's, Master's, Doctorate);
- KET-relevant programmes in these universities are ***highly selective, research-oriented***, and with high ***faculty-to-student ratios***;
- Moreover, other universities look at what top-tier universities do, and adapt their curriculum and services accordingly, ***copying best practices***.

Our analysis shows that the top 20 of world university rankings are currently heavily dominated by the UK and USA, with the top 5 of world university rankings exclusively populated with institutions from these two countries. Some elite universities score well in all KET-related areas. These include Oxford, Cambridge, Stanford, Harvard and MIT. Universities from 'continental' EU do not perform well in the top 20 of these rankings, and there is relatively little movement in the top.

English-language proficiency and university income are the most important factors to ranking high, with world-class universities leveraging their wealth to constantly engage in educational innovation. At the same time, it is important to remember that analysis has shown that the ***European higher education landscape is more diverse and complex than US higher education.***[596] This is explained by differences in legislative conditions, cultural and historical frames, and a large diversity of (formal) languages.

[595] The World Bank, 2009, The Challenge of Establishing World-Class Universities
[596] Marijk van der Wende, 2008, Rankings and Classifications in Higher Education, A European Perspective, in John C. Smart, 2008, *Higher Education: Handbook of Theory and* Research, Volume 23

Of course, rankings can be envisioned that use other metrics and indicators than those used by the rankings we describe in this section. An analysis based on number or impact of citations may lead to a different ranking, as may an analysis that explicitly corrects for any implicit language biases in academic achievement. Moreover, considering the expected size of the transformational challenge of upskilling and reskilling current workers as well as upcoming talent, it may very well be that the focus of policymakers should be less on the few universities that dominate the elite rankings, and more on the larger number of good universities that are available to help in the tasks at hand.

7.3.5. Dual-track education for transversal skills

In this section we describe dual-track education and its relevance to the transversal nature of high-tech T-shaped skills. We first describe the importance of the concepts of integration, standardisation and certification for the workings of a dual-track education system. We then describe the popularity and impact of dual-track education in Germany. Subsequently, we pay attention to attempts to adopt the German system in other parts of the world. We discuss the empirical impact that dual-track education can be said to have. Finally, we briefly present the different forms in which dual-track education can be observed in Europe.

Dual-track education: Integration, standardisation and certification

Dual-track education organises formal education in a way that combines in-school classroom-based education with workplace experience and on-the-job learning. The goal is to enhance the development of skills and competence including those difficult to develop in classroom environments, the encourage the development of a professional identity among students, to increase employment opportunities, to facilitate school-to-work transition, and to improve the productivity of young workers starting their careers.[597]

As such, dual-track education is an attempt to train the non-technical skills described in section 2.2 among students, while at the same time attempting to make sure that technical education in schools is and stays relevant to high-tech companies across industries. In this system, non-technical skills (e.g. communication skills and teamwork skills) are trained on-the-job, in real-world working situations where they are directly required. Technical skills are trained both at schools and at the workplace, typically with coordination between educators and employers on the nature and content of education and training curricula.

Dual-track education leans on three concepts that are important for its functioning as a national or regional education system: Integration, standardisation and recognition.[598]

- **Integration** – Dual-track education integrates school-based learning with work-based practice. Students may spend a few days per week at college learning foundation skills and theoretical knowledge on their work. The rest of their time is spent mainly performing tasks at work. Other study programs alternate 50/50 between three-month stints in classrooms and at internships at companies.
- **Standardisation** – Apprenticeships are standardised across a country or region, in terms of learning requirements, nature and quality of supervision, and type of job tasks performed by the apprentice. E.g. every aspiring product designer must study the same textbooks and be familiar with the same design tools. Moreover, subsequent employment prospects do not vary greatly by college or company.
- **Recognition** – Dual-track education certificates (e.g. from schools, from apprenticeships or from workplace training programmes) are widely recognised throughout the national or regional labour market. For example, in Germany's dual-track system, 300+ professional trades have been defined, ranging from aircraft mechanic to chimney sweeper, and certified educational programmes have been developed accordingly.

[597] Directorate-general for internal policies, 2014, Dual education: a bridge over troubled waters?
[598] Deutsche Welle, 2018, What is Germany's dual education system — and why do other countries want it?, Available at: www.dw.com/en/what-is-germanys-dual-education-system-and-why-do-other-countries-want-it

A clear example of a dual-track education system is found in Germany, which for a good extent works as described above. For that reason, we provide some detail on the popularity of the German system, the extent to which it generates desired effects, and the degree to which it is exported to other countries. Of course, the dual-track system has also been present in Austria and Switzerland for decades.

Dual-track education is popular in Germany

Experts estimate that, ***in Germany, over 50% of young people enter into dual-track vocational and educational training programmes*** (VET) before finding a job.[599] Because of this, such VET programmes are highly popular. The number of young people that attend VET programmes is higher than the number of young people that attend German universities. Moreover, experts suggest that a good share of young people in German VET programmes are qualified for university education, but forego a university education in order to participate in dual-track education instead.[600]

Similarly, experts laud the efforts to train soft skills that make responsible young people and the flexibility in a rapidly changing digital economy.[601] They argue that the experience of a real-world working environment together with on-the-job training delivered by experienced staff encourages professionalism and maturity, fosters communication and teamwork skills, and prepares young people for the ever-changing nature of work in high-tech fields.

Dual-track education seems to work for Germany

Experts consider the dual VET system a long-standing, key pillar of Germany's performance as a major industrial power. It can be considered one of the manifestations of coordination between economic stakeholders (e.g. labour unions, employer organisations, government) typical for the German economic model.[602]

This coordination allows for an education system wherein (prospective) workers enjoy sufficient security (in terms of employability) to invest in training and education that for a large part can be company-specific. This is made possible by the wide recognition of resulting certifications and accreditations within the job market. At the same time, as education and training efforts are shared by educators and employers across sectors and throughout the country, employers have less to fear from poaching practices – which often dissuade employers from investing heavily in training and upskilling in other economic settings.[603]
The German economy has one of the lowest youth unemployment rates in the EU, and some experts attribute this in a large part to the coordinated approach to education and training between educators, employers, and labour unions.[604]

[599] Ibid.
[600] Ibid.
[601] Ibid.
[602] For an extensive exploration hereof, see David Soskice, 2001, Varieties of Capitalism: The Institutional Foundations of Comparative Advantage
[603] Ibid.
[604] Deutsche Welle, 2018, What is Germany's dual education system — and why do other countries want it?, Available at: www.dw.com/en/what-is-germanys-dual-education-system-and-why-do-other-countries-want-it

Dual-track education is being adopted elsewhere – with challenges

The perceived success of the German dual-track education system has not gone unnoticed by other governments. Policymakers in several countries around the world work on attempts to emulate the system and its economic results***. The German government even performs capacity building activities*** in countries that want to implement a dual-track education system on national or regional level.[605]

Experts consider the attempts of Slovakia, aided by German policy experts, as an example of successful emulation of the German education system. Private-sector involvement in the Slovakian programme is not as extensive compared to the German situation, but ***attention is placed on the long-term benefits of introducing certificates that are widely recognised*** in the Slovakian labour market.[606]

Policymakers in other countries are interested in adopting the system as well, such as Mexico and Russia. Here the system is less of an export hit however, as dual-track education requires a specific legal and cultural context that in Germany, Austria and Switzerland has historically grown.[607] **Specific path dependencies can hamper the transferability of dual-track education**. An example is the preconceptions that parents can have of dual-track systems, worrying that VET tracks consign their kids to blue-collar jobs with limited prestige. Instances are reported where this challenge has been overcome to some extent at the regional level, through influential local politicians promoting dual-track education initiatives and sponsoring legislation to remove regulatory hurdles.

Dual-track education seems to have empirical impact

Academic interest in the results associated with dual-track education has generated some insights in its impact, although the end of interesting research avenues has not yet been reached. Large-scale quantitative analysis in Spain examined the impact of attempts to implement dual-track education.[608] Researchers concluded the following:

- A longer period of workplace training can indeed foster a quicker transition from school to work;
- Accumulation of relevant job skills, work attitudes and non-cognitive skills can improve the motivation of students;
- Evidence suggests that dual-track education may improve school-to-work transition and reduce youth unemployment.

The latter suggestion, however interesting and promising, would require subsequent impact evaluation in order to substantiate it. So far, no impact evaluations have yet been performed.

Dual-track education comes in flavours across Europe

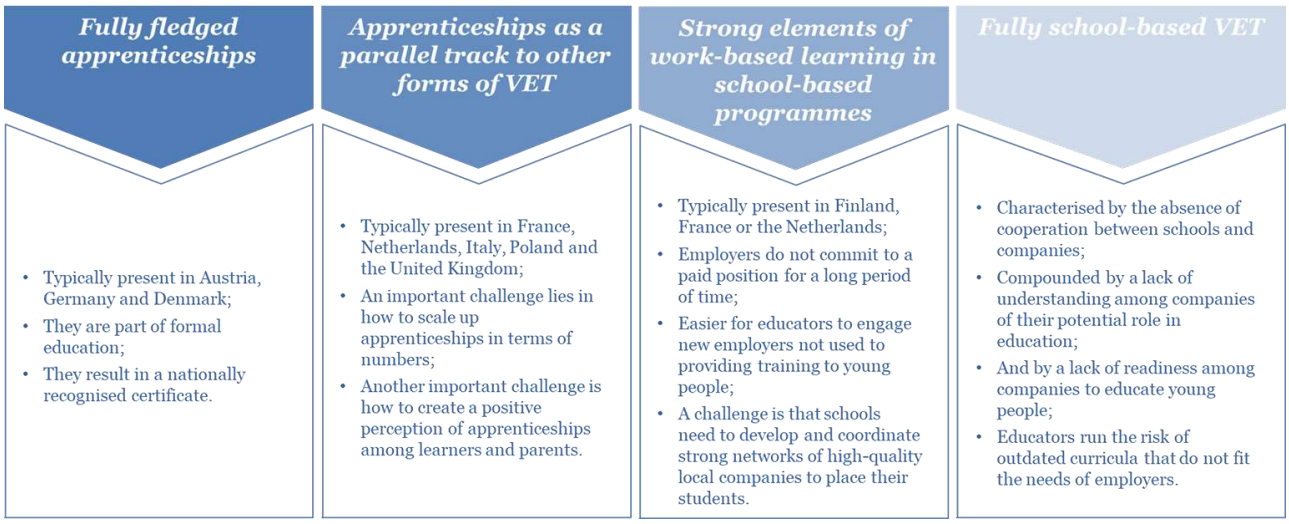
As noted above, **dual-track education in terms of apprenticeships and education-employer coordination is not solely a German affair**. Across Europe, dual-track education can be observed

[605] Deutsche Welle, 2017, Germany exports a secret of its success: vocational education
[606] Deutsche Welle, 2017, Germany exports a secret of its success: vocational education
[607] Deutsche Welle, 2017, Germany exports a secret of its success: vocational education
[608] Presentation from Samuel Bentolila (CEMFI) Antonio Cabrales (UCL) Marcel Jansen (UAM & FEDEA) CVER Conference LSE, September 2017

in different shapes, largely determined by their cultural and legal context. The figure below provides some details on four archetypical manifestations of dual-track education systems in Europe:

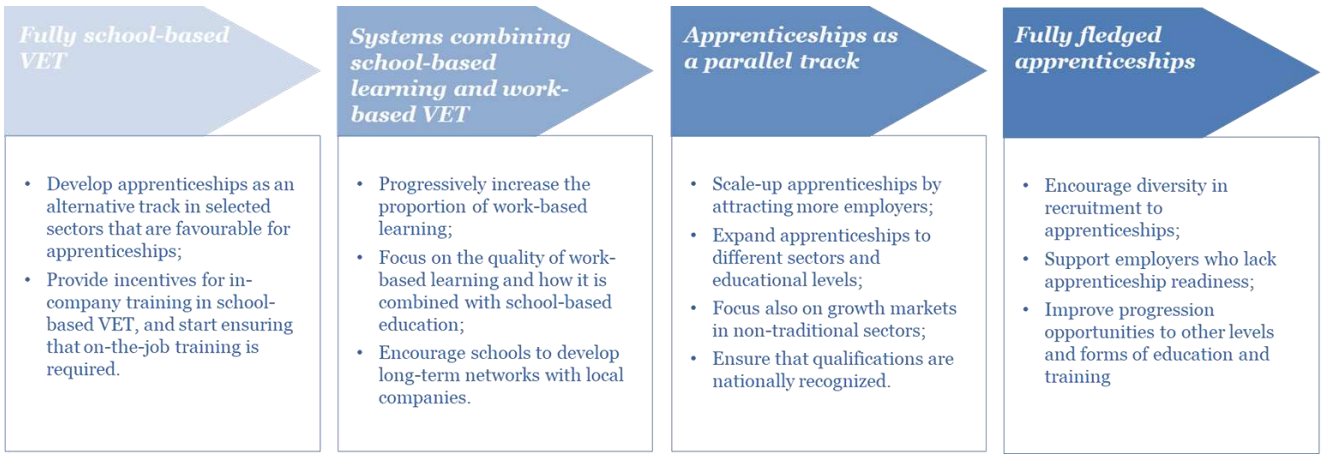
- Fully fledged apprenticeships;
- Apprenticeships as a parallel track to other forms of VET;
- Strong elements of work-based learning in school-based programmes;
- Fully school-based VET.

Figure 108:Archetypical manifestations of dual-track education in Europe[609]



Each of these archetypical forms of dual-track education has ways in which they can be improved. The figure below depicts potential ways to improve dual-track education in Europe.

Figure 109: Potential ways to improve dual-track education in Europe[610]



[609] Adapted from Directorate-general for internal policies, 2014, Dual education: a bridge over troubled waters?

[610] Adapted from Directorate-general for internal policies, 2014, Dual education: a bridge over troubled waters?

7.3.6. Continuous education and retraining the labour force

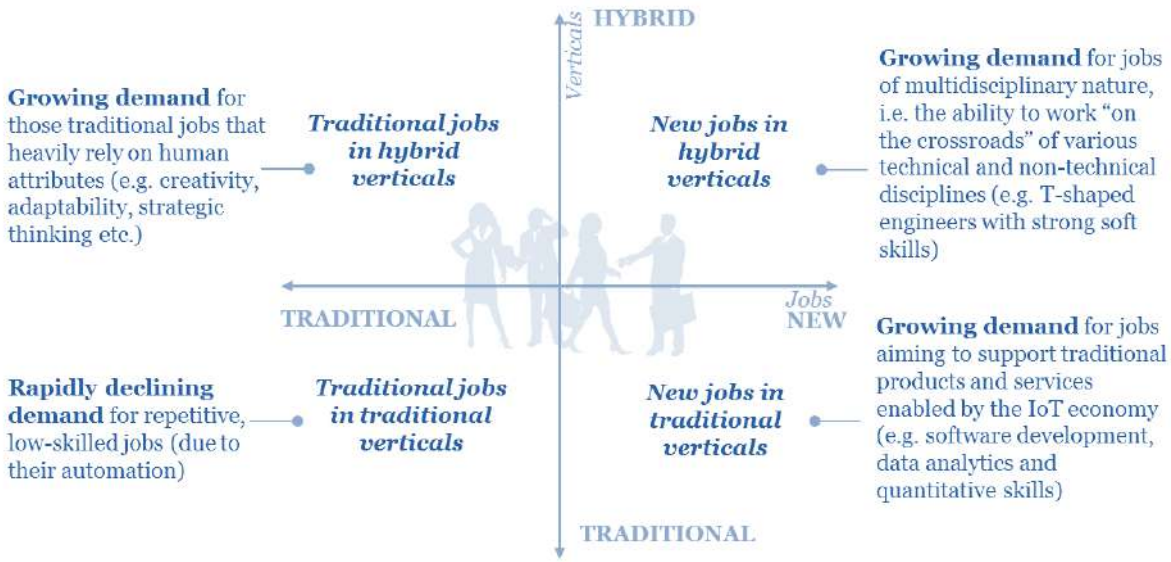
In this section we highlight the importance of continuous education for working adults in an economy undergoing digital transformation, and we pay attention to the empirical impact continuous education can be said to have. We then describe the popularity of continuous education among especially high-skilled workers, and we briefly explore the cost of retraining programmes.

Continuous education is important for working adults

Digital transformation changes professions, occupations and job tasks throughout sectors and markets. Consequently, betting on upcoming graduates and prospective workers to fulfil labour demand in the coming years may not be enough. Considering the sheer numbers involved, retraining current workers may prove vital to prepare enough people for working both in new jobs and in new sectors. Subsequently, ***future-oriented education and training efforts will need to include current workers in the European labour force***.

below provides an overview of the key dynamics of the job market. It splits the job market into four distinctive segments depending on the nature of the jobs (traditional or emerging) and the nature of verticals in which these jobs are used (traditional or hybrid/new). It shows that ***job numbers for new jobs and jobs in new sectors will grow***. Only the number of traditional jobs in traditional sectors will decline, and rapidly.

Figure 110: Impact of IoT business models on employment structure (PwC, 2016)



Few quantitative estimations exist that forecast the number of jobs involved. The most well-known forecasting activity in this area has been performed by the WEF in 2018.[611]

The WEF forecast estimates a significant shift on the frontier between humans and machines when it comes to existing work tasks. In 2018, an average of 71 % of total task hours across the 12

industries covered in the forecast are performed by humans, compared to 29 % by machines. By 2022, this average is expected to have shifted to 58 % task hours performed by humans and 42 % by machines. This finding is tempered by optimistic estimates around emerging jobs. Across all industries, by 2022, growth in emerging professions is set to increase their share of employment from 16 % to 27 % (11 % growth), whereas the employment share of declining roles is set to decrease from currently 31 % to 21 % (10 % decline). These numbers show **that there is a large –scale decline in some roles as tasks within these roles become automated, and a large –scale growth in new products and services and associated new tasks and jobs.** In –demand roles are Data Analysts and Scientists, Software and Application developers and E-commerce and Social Media Specialists and roles that leverage distinctive human skills.

The following figure shows examples of stable, new and redundant roles across all industries:[612]

Stable Roles	New Roles	Redundant Roles
Managing Directors and Chief Executives	Data Analysts and Scientists*	Data Entry Clerks
General and Operations Managers*	AI and Machine Learning Specialists	Accounting, Bookkeeping and Payroll Clerks
Software and Applications Developers and Analysts*	General and Operations Managers*	Administrative and Executive Secretaries
Data Analysts and Scientists*	Big Data Specialists	Assembly and Factory Workers
Sales and Marketing Professionals*	Digital Transformation Specialists	Client Information and Customer Service Workers*
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Sales and Marketing Professionals*	Business Services and Administration Managers
Human Resources Specialists	New Technology Specialists	Accountants and Auditors
Financial and Investment Advisers	Organizational Development Specialists*	Material-Recording and Stock-Keeping Clerks
Database and Network Professionals	Software and Applications Developers and Analysts*	General and Operations Managers*
Supply Chain and Logistics Specialists	Information Technology Services	Postal Service Clerks
Risk Management Specialists	Process Automation Specialists	Financial Analysts
Information Security Analysts*	Innovation Professionals	Cashiers and Ticket Clerks
Management and Organization Analysts	Information Security Analysts*	Mechanics and Machinery Repairers
Electrotechnology Engineers	Ecommerce and Social Media Specialists	Telemarketers
Organizational Development Specialists*	User Experience and Human-Machine Interaction Designers	Electronics and Telecommunications Installers and Repairers
Chemical Processing Plant Operators	Training and Development Specialists	Bank Tellers and Related Clerks
University and Higher Education Teachers	Robotics Specialists and Engineers	Car, Van and Motorcycle Drivers
Compliance Officers	People and Culture Specialists	Sales and Purchasing Agents and Brokers
Energy and Petroleum Engineers	Client Information and Customer Service Workers*	Door-To-Door Sales Workers, News and Street Vendors, and Related Workers
Robotics Specialists and Engineers	Service and Solutions Designers	Statistical, Finance and Insurance Clerks
Petroleum and Natural Gas Refining Plant Operators	Digital Marketing and Strategy Specialists	Lawyers

Next to emerging in demand roles, the WEF estimates that **there will be a large shift in skills required to perform most jobs.** The global average skills stability (the proportion of core skills required to perform a job that will remain the same) is expected to be about 58 %, meaning an average shift of 42 % in required workforce skills over the 2018-2022 period.

These estimations resonate with sentiment across the current workforce. A 2016 survey by the Pew Research Centre found that 87% of workers believe it will be essential for them to get training and develop new skills throughout their work life in order to keep up with changes in the workplace.[613]

[612] Source: Future of jobs survey 2018, World Economic Forum
[613] Pew Research Center, 2017, The Future of Jobs and Jobs Training, available at http://www.pewinternet.org/2017/05/03/the-future-of-jobs-and-jobs-training/

Moreover, thought leaders amplify this message. The Economist declared lifelong learning an economic imperative in 2017,[614] while IBM predicts average human knowledge will double every 13 months, and that digital transformation will double the volume of existing information every eleven hours[615].

Processing, navigating and understanding data, knowledge and insights will be crucial competences across the workforce in the coming years and decades. Experts believe that vocational training is an important aspect into training and disseminating these competences. At the same time, they consider training an individual during just one period in their life no longer sufficient. Instead, they argue, **labour-market systems need to provide training and education throughout an individual's working life**, relevant to her or his career, and available in a modular fashion, accessible in spells that are shorter than current multi-year programmes of formal education.[616] [617]

OECD statistics show that, currently**, training and retraining of workers mostly happens on the job, and most of the time does constitute formal training** (in the sense of organised training outside of the work environment resulting in a certificate or degree). Figure 3.4 below shows the percentage of workers receiving training by type of training across OECD countries.

At the same time, the OECD reports that **business investment in organisational capital and training appears to be very important**, actually as important to companies across the OECD as capital investments in machinery, equipment, software and R&D.[618] Figure 3.5 below shows business investment in fixed and knowledge-based capital across OECD countries.

[614] The Economist, Jan 12th 2017 2017
[615] Forbes, 2017, The Future Of Your Career Depends On Lifelong Learning, available at https://www.forbes.com/sites/schoolboard/2017/10/09/the-future-of-your-career-depends-on-lifelong-learning/#5cbf086e1bd7
[616] Forbes, 2017, The Future Of Your Career Depends On Lifelong Learning, available at https://www.forbes.com/sites/schoolboard/2017/10/09/the-future-of-your-career-depends-on-lifelong-learning/#5cbf086e1bd7
[617] Forbes, 2017, The Future Of Your Career Depends On Lifelong Learning, available at https://www.forbes.com/sites/schoolboard/2017/10/09/the-future-of-your-career-depends-on-lifelong-learning/#5cbf086e1bd7
[618] OECD Science, Technology and Industry Scoreboard 2017, p. 110

Figure 111: Workers receiving training, by type of training, 2012 or 2015 Source: OECD Science, Technology and Industry Scoreboard 2017

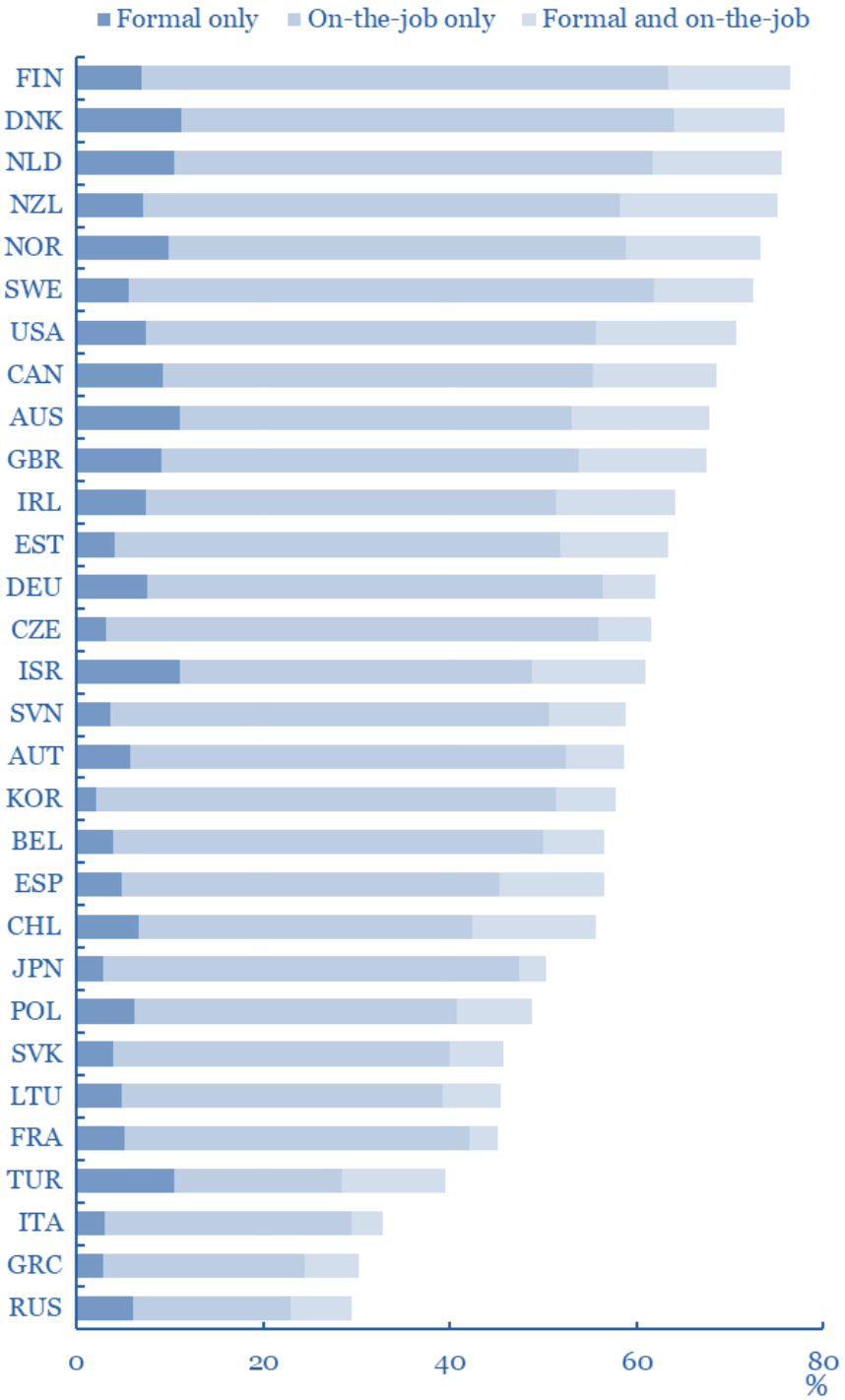
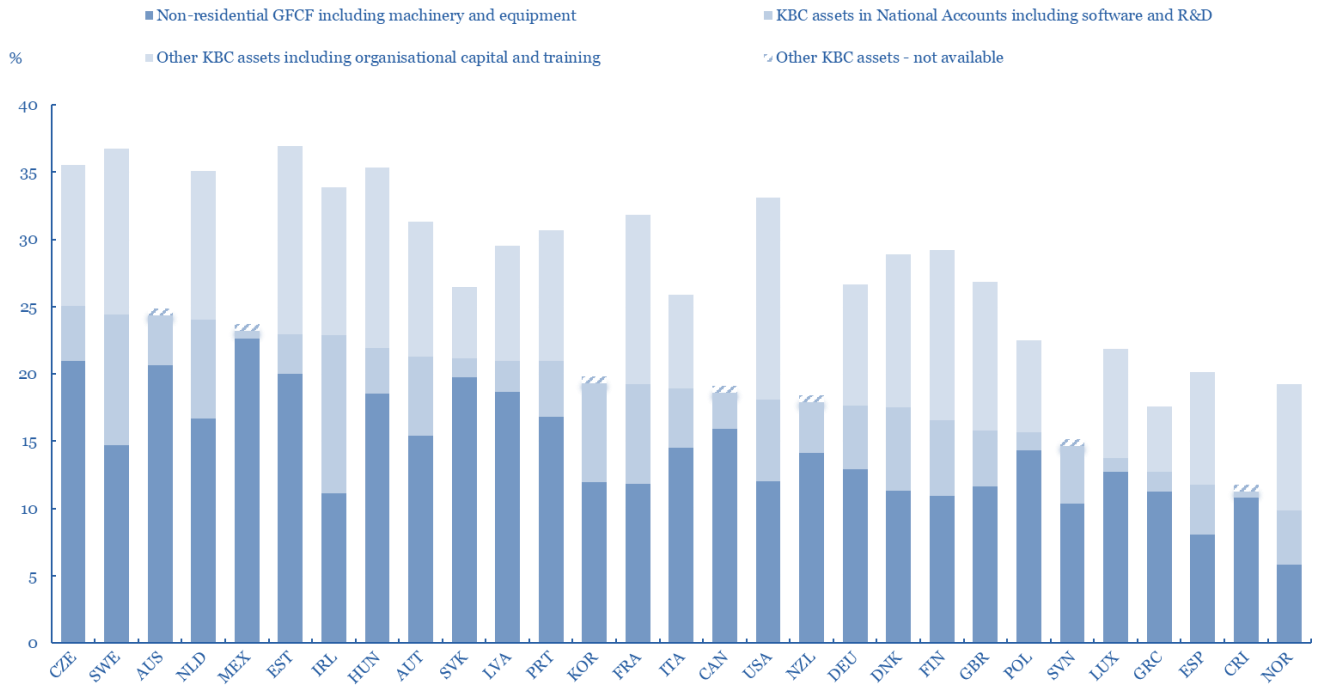


Figure 112: Business investment in fixed and knowledge-based capital, 2015 Source: OECD Science, Technology and Industry Scoreboard 2017



Taken together, this would indicate that while continuous education is considered relevant across stakeholder groups and business investment is training is on par with investments in other areas, **the nature and content of trainings** leave **room for improvement** – especially as quantitative forecasts, worker sentiment and though-leading articles stress the increasing importance of relevant training of workers, with statistics showing most worker training not resulting in certificates or degrees.

Continuous education has empirical impact

Multiple academic studies have been conducted on the effects of continuous education, lifelong learning and adult education. The leading paper that examines the existing evidence for the positive measurable impact of continuous education, delivers two major conclusions: [619]

- **Those who invest in new skills tend to reap a significant return in higher wages**. However, the nearer they are to retirement, the lower the rate of return;
- A minority of findings suggests that learning can have a nil effect on wages, or even a negative effect. This is best explained by many employers seeing this qualification as a negative signal**, as employers appear to think it indicates low ability rather than the reverse**.

[619] John Field, '*Is lifelong learning making a difference? Research-based evidence on the impact of adult learning*', Pages 887-897 in David Aspin, Judith Chapman, Karen Evans and Richard Bagnall (eds.), 2012, Second International Handbook of Lifelong Learning

Consequently, policy development is served well by heading the warnings implicit in these research findings. Care needs to be taken to avoid inefficiency of any policy instruments promoting the retraining of current workers, by considering targeted instruments that include specific arrangements for workers that are close to the retirement age. Also, policy should include measures to promote a positive image around credentials and qualifications obtained by workers years after they have entered the labour market.

Continuous education appears popular among high-skilled workers

The relative popularity of continuous education among workers is subject to little academic attention. In order to gauge worker sentiment towards continuous education we can use the work of governmental policy analysts. Analysis from The Netherlands sheds light on the matter, as The Netherlands ranks 5th in the EU for participation rates in lifelong learning, i.e. enrolment in education or training by people aged 25 to 64.

A large-scale survey among workers in The Netherlands shows that continuous education is popular among specific groups:[620]

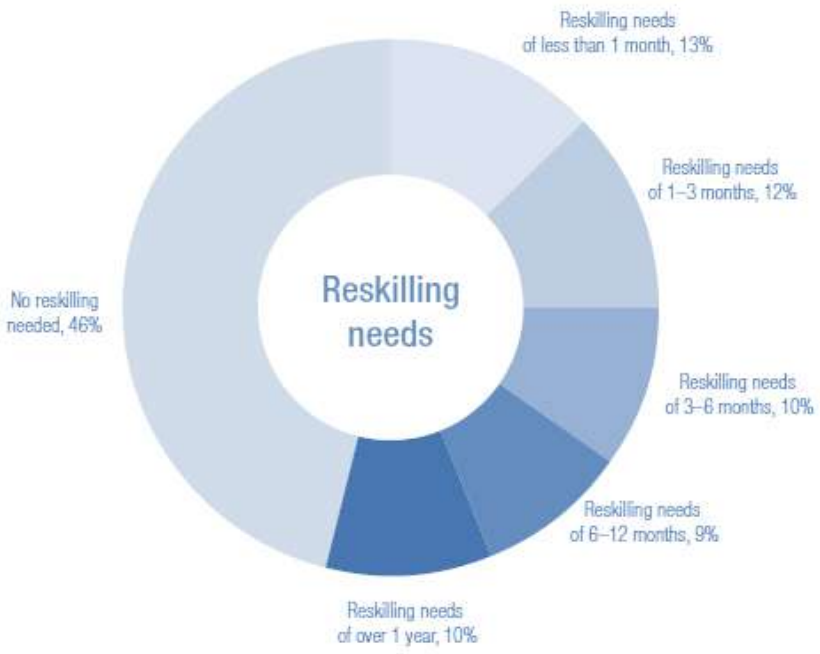
- They are predominantly the **highly educated people in their late twenties** and those working in financial services, health care and education;
- The training they followed might be **a workshop, a Spanish language training or a course in art history**, but might also be a complete course in higher education;
- Those in employment typically acquire additional education to improve work performance.

Consequently, these findings provide valuable input to policy thinking – although we need to consider the limitations associated to one survey in one country. Still, left to its own devices, the market for adult learning might indeed focus on young adults that have completed tertiary education less than a decade ago. Moreover, popular educational content does not always directly relate to the digital transformation of the European economy or regional industrial specialisation in key enabling technologies. **Deliberate policy design may be required to stimulate the development and provision of educational curricula** relevant to digital transformation and smart industrial specialisation, and to workers in their 30's, 40's and 50's.

The cost of reskilling workers

Not much has been researched about the costs associated with reskilling a labour force, neither by academics nor by policy analysts. However, employers surveyed by the World Economic Forum estimate the amount of time the average employee needs for reskilling and upskilling. According to them 54 % of all employees will require significant upskilling and reskilling. Of these, about 35 % are expected to require additional training of up to six months, 9 % will require reskilling lasting six to 12 months, while 10 % will require additional skills training of more than a year. This is illustrated in the figure below[621]:

[620] Dutch Central Bureau of Statistics, 2016
[621] Source: Future of Jobs Survey 2018, World Economic Forum



A brief exploration of real-world examples of reskilling efforts does shed some light on per-worker costs of typical reskilling programmes.

At Airbus, a European aerospace manufacturer, workers are offered a 9-month retraining programme in which they are trained in technological developments and novel job skills for ten hours every week. Combining classroom sessions, MOOCs and digital learning platforms, **the retraining programme costs Airbus about EUR 15,000 per trained worker**.[622]

At General Assembly, a private-sector education provider with twenty campuses around the world, including one in London, participants can participate in twelve-week programmes to learn digital and coding skills. The company has trained more than 35,000 individuals, many of them having quit their jobs and most of them expecting new careers in high-tech and digital jobs. The classroom-based curriculum is developed in close consultation with skill-short employers, and **costs for individual participants are between EUR 9,000 and EUR 11,000**.[623]

As such, these examples imply ball-park figures for the cost of retraining workers that can inform policy thinking. A typical 10-12 week reskilling programme, costing about EUR 12,000 per worker, would imply a EUR 1.2 million investment for a department of 100 technology workers. Assuming the speed with which technology domains change and develop would require a retraining programme every 3-5 years, **the annual expenditure for regularly retraining a department of 100 workers would be EUR 240k-400k**.[624]

[622] Assuming hourly labour costs of EUR 35.00.
[623] The Economist, Jan 12th 2017 2017
[624] This does not take into account any potential revenue loss for time spent by workers away from their jobs.

7.3.7. Efforts in the United States for developing transversal skills

In this section we analyse how transversal skills relevant to KETs and digital transformation are trained in the United States. In the US, as it is in Europe, it is widely acknowledged that new skills and knowledge are needed in order to solve the grand challenges of the 21st century.

STEM disciplines need to connect with other disciplines

In 2015 the U.S. department of Education, in collaboration with American Institutes for Research (AIR) presented STEM 2026: A vision for Innovation in STEM education[625]. The vision acknowledges that complexities of today's world require the workforce to be equipped with a new set of core knowledge and skills to solve difficult problems. The vision stresses the need of STEM skills and knowledge for future jobs, and emphasizes that STEM discipline-specific topics relate to or connect with other STEM and non-STEM disciplines, including art, history, and social studies. The vision promotes life-long learning and fostering skills such as persistence, teamwork, and the application of gained knowledge to new situations. STEM 2026 includes six interconnected components:

- Engaged and networked communities of practice
- Accessible learning activities that invite intentional play and risk
- Educational experiences that include interdisciplinary approaches to solving grand challenges
- Flexible and inclusive learning spaces supported by innovative technologies
- Innovative and accessible measures of learning
- Societal and cultural images and environments that promote diversity and opportunity in STEM

In 2016 the USA had a total government R&D budget of USD 149 billion, of which 60 % is related to defense and space-related R&D. Only Turkey and the UK are other OECD countries that devote 20 % or more of their governments R&D budgets to defence and space R&D. The proportion of funding allocated to industrial production, technology energy and infrastructure is less than 10 % of the budget[626].

In recent years, researchers and university professors emphasized that hard STEM education is not enough to meet the 21st century challenges and that **it is time to rebalance the engineering curriculum by restoring some of the emphasis on professional skills or soft skills,[627] and plead that the United States does not need more STEM majors, but more STEM majors with liberal arts training**. [628]

The T-shaped model was introduced decades ago

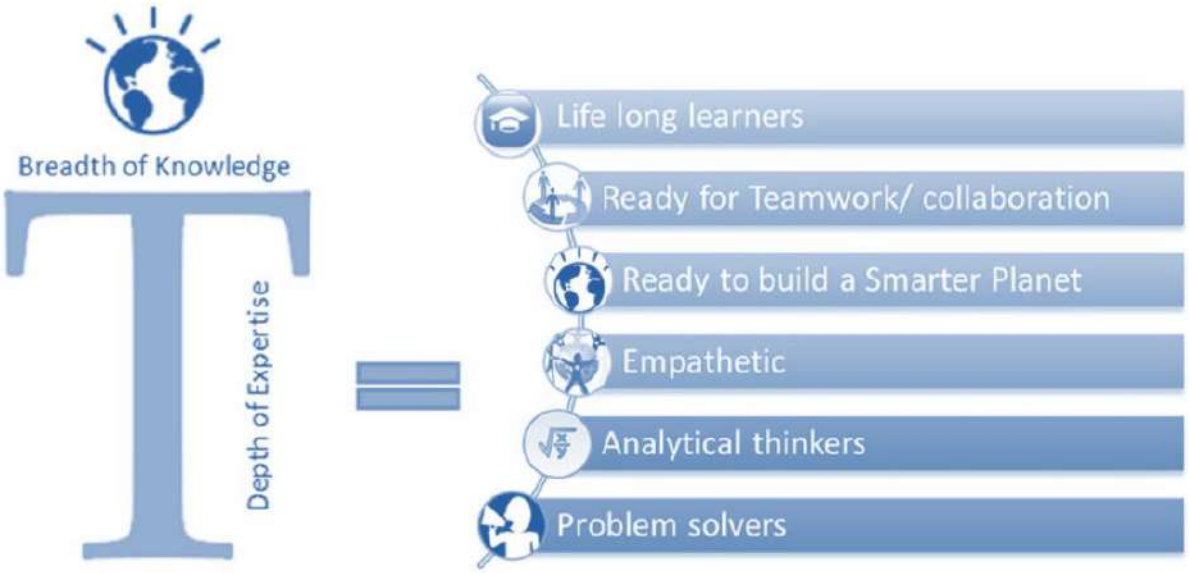
Many organisations in the US have described what (new) skills are needed for today's engineers. Two decades ago already IBM introduced the T-shaped professional where the vertical bar represents depth in a single technical discipline, and the horizontal bar represents the ability to apply knowledge across disciplines and to work with others. As Nicholas Donofrio, retired VP of innovation and technology of IBM stated: "*The revolutionaries who have driven most recent innovation and who will drive nearly all of it in the future are "T-shaped." That is, they have their*

[625] STEM 2026, A vision for Innovation in STEM Education, US department of Education, 2015
[626] OECD Science, technology and industry scoreboard 2017, the digital transformation
[627] R.K. Miller, Why the Hard Science of Engineering is No Longer Enough to Meet the 21st Century Challenges, Olin College of Engineering 2015
[628] WE DON'T NEED MORE STEM MAJORS. WE NEED MORE STEM MAJORS WITH LIBERAL ARTS TRAINING, February 18, 2016, Washington Post article by Loretta Jackson-Hayes

specialties – areas of deep expertise – but on top of that they boast a solid breadth, an umbrella if you will, of wide-ranging knowledge and interests."[629]

The IBM concept of the T-shaped individual is illustrated in the figure below:[630]

Figure 113: The T-shaped model inspired many organisations in the US



After IBM introduced the concept of the T-shaped professional, many organisations have begun developing certification programs as well as assessment tools or organizing conferences to promote T-shaped development**.**

The **International Society of Service Innovation Professionals, ISSIP** is a professional association co-founded by IBM, Cisco, HP and several Universities with a mission to promote Service Innovation. Its purpose is to help institutions and individuals to grow and be successful in the global service economy and to develop the T-shaped workforce of the 21st century.

[629] https://www.informs.org/ORMS-Today/Public-Articles/February-Volume-39-Number-1/The-shape-of-analytics-certification
[630] *Why Do You Need to Become a T-Shaped Person*," Students for a Smarter Planet, blogpost, July 3, 2013. http://asmarterplanet.com/studentsfor/blog/2013/07/why-do-you-need-to-become-t-shaped-person.html

ISSIP training

ISSIP organizes trainings and workshops with various companies inspired by the **lean-start-up concept**. Lean-start up is a methodology to develop businesses and products and aims to shorten product development cycles by adopting a combination of business-hypothesis-driven experimentation, iterative product releases, and validated learning. The concept was further developed by Steve Blank in the *Startup Owner's Manual* that is a practical guide to bring the customer development process to work and by Alexander Osterwalder in his *Business Model Canvas*. The methodology is in the US widely used by innovative start-ups and entrepreneurs and introduced by ISSIP in its trainings because it is an effective method to promote **learning-by-doing**. ISSIP incorporated the T-shaped model in the trainings and makes entrepreneurs aware of their ecosystem. It invites participants to think of solutions from other disciplines and find innovative ways to solve problems. ISSIP organized trainings with CISCO with 500 people participating in 24 hour hackathons. Selected teams from all over the world continue in 10 week trainings through virtual and live collaboration tools. The methodology can easily be incorporated in university programmes as **project-based learning**.

The **INFORMS initiative is developing a certification programme** where analytics professionals can be tested if they are able to bring a core set of analytics skills to a project team. This certification programme covers knowledge that looks like the capital letter T, testing both depth and breadth components[631].

Since March 2014, **leaders from higher education, industry, government, foundations, and professional associations discuss yearly during a T-summit conference** how to design innovative educational models that foster and develop T-shaped characteristics that are in high demand today and in the future workforce.

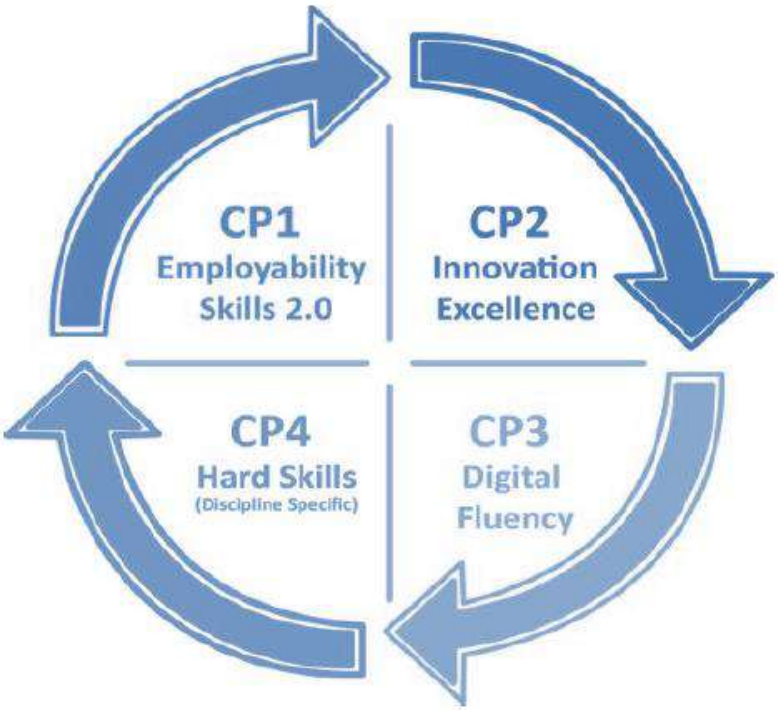
The **Council on Competitiveness** with support from Lockheed Martin Company and others sponsored the **National Engineering Forum** (NEF). According to its website **the NEF brings together leaders concerned about the sustainability of engineering in the United States and the impact on the nation's security and prosperity**. NEF is identifying solutions for challenges facing the U.S. engineering enterprise – capacity, capability, and competitiveness – the 3C's.

The T-shaped model can be recognised implicitly in other models and skills development programmes

The **STEM connector** is another organisation involving a community of more than 3,700 national, state, local, and federal STEM organisations. As described on their website: "STEMconnector is a consortium of companies, non-profit associations and professional societies, STEM-related research & policy organizations, government entities, universities and academic institutions concerned with STEM education and the future of human capital in the United States…" [632] **In a 2014 report, STEM 2.0, they give their view of the professional skills needed for the STEM workforce of the future**. The report recommends that students need exposure to practical applications of their subject matter. Figure 3.7 shows their model, where especially CP1 and CP2 are of particular interest:

[631] https://www.informs.org/ORMS-Today/Public-Articles/February-Volume-39-Number-1/The-shape-of-analytics-certification
[632] https://www.stemconnector.com/

Figure 114: STEMconnector skills development model[633]



Employability Skills 2.0 (CP1) are identified as "the behaviours above and beyond technical skills that enable STEM employees to create stakeholder momentum to commercialize ideas, or in short career skills. It is the ability to present and 'sell' their ideas to others; to function in teams; to develop business acumen; to develop leadership skills; to navigate across a complex matrix of global organizations."[634]

Innovation Excellence (CP2) requires developing the "process of transforming ideas into new and improved systems, services or products that enhance the value of existing resources or create new ones. Innovators identify opportunities and use them to drive change. Innovation excellence requires a 'holistic' multi/trans disciplinary skill set."[635]

Several universities and engineering schools launched innovative interdisciplinary programmes for skills development for engineering students, recognizing the need of T-shaped skills development and encouraging learning by doing. There are no courses called T-shaped development, but **experimental learning is integrated within the curriculum**.

[633] *STEM 2.0: An Imperative For Our Future Workforce*, STEMconnector Innovation Task Force, STEMconnector: Washington, DC, June 2014 . p.13
[634] Ibid.
[635] Ibid.

The Olin College of Engineering was established in 1997, according to their website in order to radically change engineering education with the goal of fuelling the technical innovation needed to solve the world's complex future challenges[636]. **Olin has no departments or tenured faculty, allowing for collaboration and integration of efforts between disciplines**. Olin students complete next to their engineering courses a concentration in either *Arts, Humanities, and Social Sciences* or Entrepreneurship. For example, students discover and analyse the historical context of material science in the course Stuff of History and develop technical solutions in an anthropological context in the course Engineering for Humanity.[637] Olin College has been named by The Princeton Review as one of the nation's top colleges, and recognized among the top institutions in academic rigor and student satisfaction. The results were published in the 2019 edition of The Princeton Review's popular college guide, The Best 384 Colleges.

Another initiative is the KEEN network, a network of engineering schools to educate undergraduate engineers so that they can create personal, economic, and societal value through the entrepreneurial mind-set. The KEEN network has an educational approach involving four cornerstones: business acumen, customer engagement, technical fundamentals, and societal values.[638]

Next to universities innovating their curricula, several programmes were started to stimulate interdisciplinary skills development. The National Academy of Engineering (NAE) funded two interesting programmes:

- A **Grand Challenge Scholars Program** that educates young scholars with the technical expertise, breadth of knowledge and the social, ethical and environmental awareness to find solutions for the 14 "Grand Challenges for Engineering in the 21st Century" that must be addressed in order to achieve a sustainable, economically robust, and a politically stable future for future generations. In 2009, leaders from Duke University's Pratt School of Engineering, the Franklin W. Olin College of Engineering, and the University of Southern California's Viterbi School of Engineering proposed this new education model and got funding for it.[639]
- **Epicentre**, directed by Stanford University and VentureWell. Epicentre's mission was to empower U.S. undergraduate engineering students to bring their ideas to life for the benefit of the economy and society.[640]

Promising models of skills development in the US

Other promising models from the US on skills development are, according to a 2012 OECD research[641], the introduction of career pathways and cluster skills development. In most states and regions in the US the concept of integration of education and training is introduced. Over the past ten years, the United States Department of Labour has increasingly focused on funding regional economic strategies connected to workforce solutions and industry-based sector approaches.[642]

[636] http://www.olin.edu/about/
[637] http://www.olin.edu/academic-life/experience/
[638] https://engineeringunleashed.com/About.aspx
[639] https://www.nae.edu/MediaRoom/20095/177353/186484.aspx
[640] http://epicenter.stanford.edu/
[641] Hamilton, V. (2012), "Career Pathway and Cluster Skill Development: Promising Models from the United States", OECD Local Economic and Employment Development (LEED) Working Papers, 2012/14, OECD Publishing.
[642] Idem p. 8

Career pathway programmes are an articulation of knowledge, skills, and competencies, which connect education with work in an occupation. There are several categories of pathway programmes. The OECD describes these as follows: **Bridge Programmes** are designed to help people at the very front end and provide remedial education and training that help students meet pre-requisite requirements for College and Technical Education programmes. ***Education to* Job Strategies** are programmes designed to help move students all the way along an educational pathway, while keeping focus on the student completing education and getting a job. **Advancement Strategies** are programmes focused on the career progression of students, in and out of work, but with the goal of career advancement along the way.[643]

A career cluster includes broad groupings of occupations and industries based on commonalities. Within each career cluster, there can be several career pathways from secondary school to college, graduate schools, and the workplace. According to the OECD an advantage of this framework is that **it has created a common language and starting point for conversations between the workforce development and education systems**. Adopting a similar language allowed the two systems to talk to each other.[644]

The OECD writes there are some **critical lessons that can be learned from the pathway and cluster models** in the US[645]. Here follows a quotation of a selection of the lessons described by the OECD:

- **Employer involvement:** Some states have established regional groups of employers within an industry, who meet on a regular basis and advise workforce and education agencies. The purpose of these advisory groups is to understand the needs of the industry and marshal resources to meet those needs whether they relate to training or to another aspect of that industry's health. For the purposes of developing a pathway and cluster approach, the expressed needs of employers also need to be balanced with a deep understanding of the whole sector, and the common skills and competencies across different industries and occupations. One employer or a set of employers in a sector may articulate a specific set of skills that they require but it is only by stepping back and looking at related industries that practitioners see patterns and relationships that can be built into curriculum.
- **Balancing Individual and Employer Needs**: Many career pathway and cluster approaches are developed in response to a specific skill shortage or need by an industry or group of employers. However, many of the successful examples highlighted in this report integrate a long-term focus on the development of skills to ensure individuals are equipped for labour force attachment. Employers tend to have a narrower vision of their skill needs, which is more short-term in nature therefore it is necessary to ensure that pathway and cluster approaches balance this priority with the long-term need to equip individuals with a broader set of transferable skills.

Flexibility in programme design: the importance of designing programmes in a business-friendly and flexible manner. Many training providers fail to structure their operations this way - they reach out to firms for input yet design programmes ill-suited for business needs.

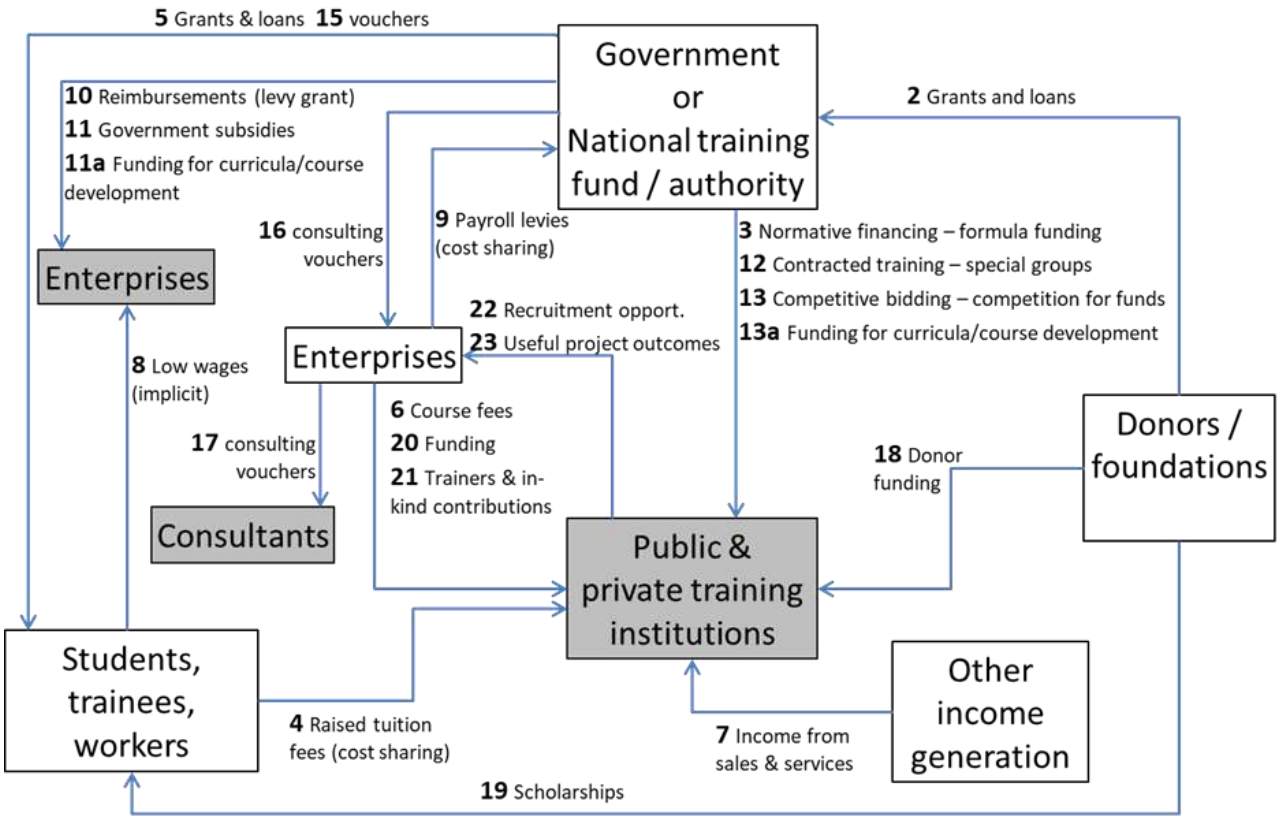
[643] Idem p. 9
[644] Idem p. 10
[645] Idem p. 24-27

7.3.8. Funding programmes for high-tech skills

In this section we describe the most recent insights in funding programmes for high-tech skills development including public-private partnerships. We will present insights and preliminary conclusions from a pending research by Empirica and PwC: **High-Tech Skills for Europe Scaling up Best Practices and Re-focusing Funding Programmes and Incentives[646].**

An integrated framework shows financing flows for high-tech skills development

In the report a framework developed by Ziderman[647] was applied which the author developed after an analysis of the training finance system. His approach covers traditional funding mechanisms as well as new, innovative ones. Ziderman described the diversity of sources of funding – including public, private and donor sources –, financing flows and the diversity of beneficiaries of fund expenditure. Empirica and PwC integrated a few additions to the original framework after their analysis of financing and funding mechanisms. This resulted in the following framework:



In this framework the financing flows are schematically indicated with arrows. Applying the framework 10 different types of funding mechanisms have been distinguished. The 10 types of funding programmes are:

- Funding for industry in building and running **dedicated vocational education centres;**
- Funding for the **co-creation by industry and academia** of new courses and curricula;
- Funding for of new **innovative and alternative teaching/learning systems;**

[646] High-Tech Skills for Europe Scaling up Best Practices and Re-focusing Funding Programmes and Incentives EASME/COSME/2016/033 Interim Report May 2018

[647] Ziderman, Adrian: Funding Mechanisms for Financing Vocational Training: An Analytical Framework. IZA Policy Paper No. 110. Bonn, 2016, p. 29

- Funding **excellence schemes with top universities** to draw top academic talent and students;
- Funding **SME vouchers for consulting contracts and knowledge transfer;**
- Funding **high tech apprenticeships/traineeships** in industry ;
- Funding the **development of open education resources (OER, including MOOCs);**
- Funding (**lifelong) learners through vouchers, fiscal incentives and/or cost sharing;**
- Funding **upskilling/reskilling programmes** for the workforce in particular sectors or regions;
- Other.

Excellence schemes and SME vouchers are highly successful funding mechanisms

Two funding mechanisms have been analysed on relevant criteria such as strengths, weaknesses, opportunities and threats (SWOT), effectiveness, efficiency, impact, scalability (including transferability potential) and sustainability**. Excellence schemes with top universities stimulate to draw top academic talent and students towards industry careers, and SME vouchers for consulting contracts and knowledge transfer allow SMEs to innovate**[648].

Excellence schemes with top universities and high tech industry to draw more academic top talent towards industry careers are funded by government or the national training fund on several ways: by funding students, trainees or workers through grants and loans or funding public and private training institutions for contracted training and special groups. **Supporting mechanisms are enterprises funding public and private training institutions or supporting by own trainers and in-kind contribution, and public and private training institutions offering partnership programmes to enterprises with recruitment opportunities or useful project outcomes.**

These funding schemes are highly effective as they reach target groups and successfully mobilise stakeholders and are highly efficient as they show a high level of satisfaction among stakeholders. The impact on high-tech skills development is high as the scope and focus are on bringing together national leading industrial academic organisations and targeting high-tech skills. The scalability is high as other industrial companies, large SME's and training institutions can be included. The programmes are also sustainable as they integrate practical working experience, mentoring and problem solving. Good examples of these programmes are Software Campus (DE), Industrial PhD 2017 (SE), Industrial Doctorates (NL) and Industrial PhD (DK).

SME vouchers for consulting contracts and knowledge transfer are funded by government or national training fund or enterprises by (partly) financing training and support through consulting vouchers. These SME vouchers are highly effective as they reach target groups and transfer relevant knowledge to SME's. In some cases it has even been carried out fully online and without any bureaucracy. They are also highly efficient as the satisfaction among stakeholders is very high. The programmes require small investment per case and are good value for money. The model is transferable and scalable. Good examples of SME voucher programmes are Go-Inno (DE), Go-Digital (DE), Asesores Digitales (ES) and Industria 4.0 (IT).

[648] High-Tech Skills for Europe Scaling up Best Practices and Re-focusing Funding Programmes and Incentives EASME/COSME/2016/033 Interim Report May 2018, p. 52-55

Some preliminary conclusions of the research are:

- There is a need to **implement innovative, remarkable and disruptive** funding models that have at least **a mid/long term perspective.**
- A **broad spectrum of programmes** is required **and tax incentives** have proven to be suitable in some policy contexts.
- There is **a trend of smaller learning packages** that has resulted in MOOCs and targeted courses of shorter duration. This enables lifelong learners to pick appropriate trainings to enhance their competences.
- It is **recommended that the European Commission supports and funds cross-country implementation of successful (national) programmes and instruments.**
- There is a desire to **create an online one-stop shop for best practises presentations***.*

7.4. Key conclusions on High-tech T-shaped Skills

In this section, we present our preliminary conclusions regarding the first state-of-play analysis of initiatives relevant to high-tech T-shaped skills. We look at key focus areas and common priorities, common features in design and implementation, key attributes of successful in initiatives, and notions on scalability and transferability. In each subsection, we present policy recommendations based on our preliminary conclusions.

7.4.1. Key focus areas and common priorities

In this subsection, we present the key focus areas and common priorities of the analysed initiatives and provide some preliminary policy considerations. Our current research shows the following:

- The most dominant focus is currently on co-development of educational initiatives and materials;
- Initiatives that introduce high-tech topics to children starting from an early age, and initiatives that adapt university programmes to the highly-skilled human capital needs of industry, are common as well;
- These initiatives typically focus on technical aspects of the high-tech T-shaped concept, and combinations between technical skills and managerial and entrepreneurial skills are common, as are combinations with quality, risk and safety skills;
- Emotional intelligence as a skill type is not apparent in the policies and initiatives that have been analysed;
- The systems-thinking aspect of the high-tech T-shaped concept is also not apparent in the initiatives encountered so far.

Skills issues typically addressed

Co-creating and developing educational initiatives and materials – Several of the initiatives we encountered focus on co-creating and developing educational initiatives and materials by educators and industrial partners. These actors have collaborated to jointly create educational materials for online or classroom projects.

Introducing high-tech to youngsters –Initiatives are also encountered that introduce technical education and high-tech topics early on with younger students and initiatives that focus on adapting university programs to meet the highly-skilled human capital needs of industry.

High-tech awareness – Some initiatives focus on creating 'high-tech awareness' already a decade before students enter the workforce, adapt university programmes to fit future industry needs, and focus on preparing a future generation of researchers, engineers, designers and business leaders to state-of-the-art technology.

Reskilling workers – Several initiatives focus on reskilling current workers to prepare them for new jobs or to expand their job function by adding new job tasks. This typically occurs at the middle-skill level and through industry-led initiatives.

None of the encountered initiatives focuses on "selling" high-tech careers as being attractive and prestigious, with both personal and financial reward. The same goes for initiatives that include high-tech T-shaped skills training activities aimed at research, development, and product demonstration projects.

Skill types targeted

Almost all initiatives encountered are aimed at increasing or expanding technical skills. Combinations of technical skills and managerial and entrepreneurial skills are common (for instance the Energy University), as are combinations with quality, risk and safety skills (e.g. ARM's University Programme). Initiatives such as the BioBusiness and Innovation Platform of the Copenhagen Business School specifically focus on combining technical skills with communication and entrepreneurial skills. The Stages initiative in Prague (Czech Republic) focuses on building innovation skills in young children to prepare them for high-tech problem solving and advanced systems thinking.

Strikingly, no initiatives have yet been encountered that include emotional intelligence skills in the skill types that they target.

Policy considerations

Based on the preliminary conclusions presented, several policy considerations become relevant. First, the notion of high-tech T-shaped skills and the future professional can be recognised in current skills initiatives, policies and strategies in Europe. However, they are not labelled, positioned or articulated as such, and their relation to the concept often times needs to be inferred from the outside. Policymakers at the European level could consider promoting the concept more actively, increasing the extent to which it is actively recognised and adopted within the high-tech skills policy domain.

Second, although combinations of skill types relevant to the concept of high-tech T-shaped skills can be recognised in several initiatives, there does not appear to be a clear system to these combinations. Moreover, the focus appears to be predominantly on the combination of technical skills with management and operating skills, and rarely on a combination of communication or innovation skills. Emotional intelligence as a skill type does not yet appear to resonate among the initiatives encountered. Policymakers at the European level could consider to actively promote the importance of these skill types, and encourage their inclusion in skills development initiatives that aim combine different skill types.

Third, while earlier studies have identified EU-funded research, development and product demonstration projects as good opportunities to include broadly focussed skills development actions, we have not encountered initiatives that include high-tech T-shaped training activities within these projects. Policy coordinators and project officers could encourage or require consortia to include such training activities in the projects that they implement.

7.4.2. Common features in design and implementation

In this subsection, we will describe common features in the design and implementation of strategies, policies and initiatives on high-tech T-shaped skills. We will present the most relevant findings and analyse their implications for development and implementation of public policy.
Common features of initiatives relevant to high-tech T-shaped skills are:

- Involving and mobilising industrial partners and local government;
- Targeted delivery methods of specific skills-development initiatives;
- Sectoral coordination of policies and initiatives across Europe.

Below we will describe each of these features in more detail, and provide examples of how they are put into practice.

Involving and mobilising industrial partners and local government

An important factor in the delivery of initiatives on high-tech T-shaped skills concerns the involvement of industrial partners and governmental organisations at the local level. This involvement typically hinges on the extent to which the design of a policy, strategy or initiative allows industrial and local partners to generate a somewhat tangible benefit from their involvement in their individual organisations. We have identified the following mechanisms.

Offering industrial partners the opportunity to pilot specific equipment, hardware and software solutions – Technology companies can offer a valuable contribution to high-tech T-shaped skills development initiatives by providing free access to knowledge assets and technological equipment. Typically, technology companies try to combine this with piloting innovative hardware and software solutions within skills development initiatives, offering access for students and educators to solutions that are close to market release to identify potential user issues before large-scale rollout. This mutually beneficial mechanism can be seen in the University Program of ARM and in European Schoolnet's Future Classroom Lab.

Offering industrial partners the opportunity to spot talents early and cherry-pick their future hires – Private-sector involvement can also be driven by the human capital needs of high-tech employers. This is one of the reasons for industrial partners to be involved in the BioBusiness and Innovation Platform of the Copenhagen Business School. Close collaboration with educators and exposing students to their companies allow them to identify valuable future employees and approach them before competitors do.

Allowing industrial partners to draw individual participants into specific technology and innovation ecosystems – In recent years, large technology companies have adopted the trend towards developing ecosystems of technological solutions, development suites and innovation networks, with ARM as a clear example. Typically, such technology companies try to introduce (future) employees to these ecosystems at an early stage. This is partly driven by the need to hire workers that have been pre-trained, and partly driven by the realisation that technology workers versed in their solutions and suites may end up at potential client companies. Involving themselves in skills development initiatives allows technology companies the opportunity to introduce their solutions and platforms to educators and students early on.

Making skill development initiatives part of a broader investment strategy – Some private-sector organisations recognise upskilling, reskilling and strengthening the education system as an important part of the urban revitalisation and economic value creation. For example, the Stages initiative in Prague (Czech Republic) considers systemic human capital development throughout the city as a first and vital step of a process that includes attracting large, IP-generating technology companies to the city, establishing a vibrant start-up and investment community in their wake, and subsequently raising property value throughout the area. The municipal government is involved to support and encourage this effort towards a smart urban ecosystem design.

Delivery methods of specific skills development initiatives

Specific methods are employed to implement skills development initiatives relevant to high-tech T-shaped skills. These range from online and classroom curricula to educational laboratories and online platforms that connect supply and demand on areas of the labour market that pertain to high-tech innovation.

Creating platforms to connect labour supply and demand – Skills development initiatives can improve their focus when they are in tune with supply and demand of specific skills, and with any potential skill gaps. Interactive online platforms can increase awareness of these gaps and of supply and demand for specific knowledge areas and employee profiles. The platform offered by Academy Cube allows job seekers to post a digital resume, allows employers to post job profiles, and helps the two identify potential matches or potential skill gaps. Identified skill gaps can be remedied through online courses available online on the Academy Cube platform or through third-party training providers.

Online curricula – Making use of increased internet connectivity among young people in Europe, educators can implement skills development initiatives online. This can take the shape of Massive Open Online Courses (MOOCs) or of limited-access digital classrooms, leading up to accredited or otherwise recognised certificates. The online Energy University of Schneider Electric and the Academy Cube platform are examples of initiatives that provide training online. The Swiss Nano Cube initiative offers an example of combining online and offline educational tools.

Classroom curricula – Some initiatives relevant to high-tech T-shaped skills are implemented in classroom environments. The choice for a classroom environment over an online environment is typically deliberate. The rationale behind the choice can be that the target audience has exceptional benefit from face-to-face interaction with their educators, as is the case in the Technofutur TIC initiative that focuses on skills issues of out-of-date workers. The deliberate choice for a classroom environment can also stem from the visibility that an on-site physical classroom brings to company workers, as is in the case of Amazon's Career Choice initiative which is made prominently visible on Amazon locations to encourage workers to sign up for classroom curricula.

Cross-disciplinary curricula and requiring students to work on real-life business ventures – High-tech T-shaped initiatives can also be implemented through cross-disciplinary curricula that combine different academic disciplines and that stimulate intensive collaboration between students from various academic backgrounds. The BioBusiness and Innovation Platform of the Copenhagen Business School offer curricula that brings biology and chemistry students together with business students, to jointly follow courses and work on assignments that focus on both academic breakthrough and the development of a business model that facilitates valorisation. In some educational tracks, biochemistry PhD students are required to join up with MBA colleagues to work on real-life business ventures.

Covering training expenses – As touched upon in Section 1, employers in charge of workers that feature out-of-date or obsolete skill sets consider themselves responsible for reskilling these workers. A clear example is Amazon's Career Choice Program, in which Amazon as an employer offers considerable financial support to programme participants, pre-paying 95% of tuition costs and reimbursing 95% of textbook costs, with a maximum of EUR 9.734 over a four-year period.

Classroom laboratories and retraining teachers – Part of implementing skills development initiatives involve training teachers. Initiatives relevant to high-tech T-shaped skills can involve new teaching methods and approaches to which teachers need to be introduced. European Schoolnet's Future Classroom Lab is an example of an initiative that invites teachers into a futuristic classroom setting that demonstrates innovative, technology-driven educational approaches. The Stages initiative is an example where teachers are trained in new ways of teaching (e.g. involving classroom minigames), and where they are trained to teach this new approach to other educators.

Coordination of policies, initiatives and educational programmes

Implementing skills development initiatives relevant to high-tech T-shaped skills also implies coordination between policymakers, educators, academics and private-sector actors, and across sectors, countries and institutions. Several efforts to generate networks of engaged actors are already underway. The SkillMan initiative provides an example of coordination between triple-helix actors across Europe focused on the transport sector. The METALS initiative does the same, focused on the machine tools sector. In the United Kingdom, the T-level Panels organise skills development coordination across technology sectors in the UK, between educators, high-tech employers, and 3rd-sector representatives.

Policy considerations

These preliminary conclusions lead up to several policy considerations. First, involving industrial partners in skills-development initiatives implies understanding their motivations and ambitions for doing so, and allowing them the opportunity to benefit from their involvement as long as it does not hamper the impact of the initiative itself. This can mean allowing technology companies to use educational initiatives to also pilot specific equipment, cherry-pick their future hires, and promote their solutions, standards and platforms. It also implies researching long-term investment strategies to identify mutually beneficial scenarios that include skills development and analysing their potential economic and social impact.

Second, the different ways through which specific skills-development initiatives are implemented imply the need for increased understanding of which implementation method or delivery mechanism is most useful under what circumstances. This initial analysis suggests that online curricula are very suitable for initiatives relevant to high-tech T-shaped skills, and classroom curricula are especially useful for specific audiences that include workers with obsolete skills. Also, this analysis suggests that interdisciplinary education at tertiary level may be best served by encouraging universities to offer curricula that strictly require students from highly different academic backgrounds to work together on joint assignments.

Third, our analysis appears to underline the importance of cross-sectoral and Europe-wide coordination of policies, strategies and initiatives. This implies a continued effort to encourage both the formation of new coordinating networks and alliances and the entrenchment and expansion of existing networks and alliances to further conceptualise high-tech T-shaped skills and identify ways in which policy makers, educators, academics and technology companies can promote skills development and curricula design.

7.4.3. Key attributes of successful initiatives

In this sub-section the key attributes of successful strategies, policies and initiatives are discussed. These key attributes are identified as most important factors for the implementation, execution and success of the studied initiatives. Subsequently, the possible implications of the identified key attributes on future policy making are discussed.

The findings regarding the identification of the key attributes are bundled into six main findings. The main key attributes of the analysed initiatives are:

- Private and public funding of initiatives;
- Non-financial contributions by private partners and academic partners (e.g. knowledge and materials);
- Industry-led approaches;
- User-friendliness of online platforms;
- Visibility of the initiative within and outside their ecosystem;
- Evaluation of initiative by internal actors, external actors or users.

Key attributes explained

Funding mechanisms and sourcing of materials – Funding of initiatives is crucial both in the initiating phase as in the execution phase. Multiple initiatives indicate that funding from the European Commission is required to establish and maintain international collaboration within Europe. Financial funding from the private sector is also indicated as a key attribute, it is, however, one amongst other key resources which are provided by private companies. Also provided resources in the form of knowledge, education and materials are indicated as highly indispensable by multiple initiatives.

Industry-led approaches – A key attribute for high-tech T-shaped skills initiatives can be found in an industry-led approach, where initiatives originate from an industry need. This approach ensures the actual need for starting an initiative and automatically provides ownerships to the industry initiator. Leveraging local knowledge and involving academic and public partners are indicated as important conditions for the bottom-up approach.

User-friendliness of online platforms – This key attribute relates to the several online platforms which are included in this analysis, including Academy Cube and Energy University. Academy Cube indicates that they experienced themselves how important the user-friendliness is for an online platform. After losing a significant amount of users due to the limited usability of earlier versions, they decided to invest in a new, more intuitive online interaction environment. Academy Cube is convinced that this new platform, in combination with their renewed curricula, will not only maintain their current users but also increase their number users tenfold in the near future.

Visibility of the initiative within and outside their ecosystem – Visibility of the initiative within and outside the ecosystem is also identified as a key attribute of relevant initiatives. Most initiatives indicate that they are quite visible within their own ecosystem. Mentioned success factors for enhancing visibility, besides the efforts of the initiative itself, are the promotion of the initiative by other actors in the ecosystem and when the initiative is able to show a concrete product. An example of this last point is the MOOCs created by the METALS initiative. Multiple initiatives indicate that the visibility outside their own ecosystem is significantly lower than within the ecosystem and they experience that it is difficult to increase the visibility.

Evaluation of initiatives by internal actors, external actors or users – The last identified key attribute is an evaluation of the initiatives. The types of evaluation vary across the initiatives; from monthly to incidental evaluations and from internal to external evaluation. The external two-step evaluations ordered by SkillMan have proven to be invaluable to their process. The first evaluation was conducted halfway through the creation process and consisted of feedback from the partners which served as input for the latter stages. Thereafter the ex-post evaluation was directed at the main beneficiaries of the program, the students and educators, in order to monitor their reception of the programmes. The Academy Cube initiative indicates that it highly values user feedback and include this feedback in upgrades of the content and platform.

Policy considerations

Our analysis allows us to draw attention to several policy considerations. First, funding mechanisms for initiatives show that both public-sector funding and private-sector funding is relevant for high-tech T-shaped skills initiatives. Funding from the public sector at European level appears to be particularly useful to kick-start and fuel initiatives that focus on cooperation and coordination across European countries. Private-sector funding is relevant for capital-intensive initiatives that include advanced online platforms or well-equipped physical locations, especially if industrial partners are willing to make in-kind contributions on these aspects.

Subsequently, the findings also show the industry-led approach of initiatives is a valuable attribute. This implies that governmental bodies could continue to increasingly encourage private-sector involvement and employer-led initiatives, and can try to spur them on by facilitating networking efforts, the sharing and disseminating of best practices, and encouraging Member State governments and local public-sector organisations to work together with industrial partners to scale-up promising initiatives.

Initiatives that have evaluated themselves or that have been evaluated by a 3rd party have indicated that these evaluations have helped them to improve their processes, products and services. This may indicate that it can be useful for policymakers at European or Member State-level to include evaluation requirements for initiatives that they support (financially or otherwise).

7.4.4. Scalability and transferability

In this subsection, we present notions of scalability and transferability of initiatives relevant to high-tech T-shaped skills.

When taking into consideration the future outlook of the discussed initiatives, the extent to which these initiatives are scalable and transferable becomes important for determining their significance within a Europe-wide policy context. In this context, scalability refers to the extent to which an initiative has the potential to enlarge. Transferability refers to the extent to which initiatives could be implemented in a similar way in other industries or within a different policy context. The following section will cover the most important findings regarding the scalability and transferability of successful strategies followed by a brief exploration of relevant policy considerations.

Online platforms and physical classrooms

Regarding scalability and transferability, two key aspects appear to stand out:

- E-platforms show a high scalability and transferability potential;
- Classroom programmes show a lower level of scalability but show a medium to high level of transferability if contextual conditions are taken into account.

Highly scalable online platforms – On the surface most of the initiatives seem highly scalable throughout Europe. Especially initiatives that make use of online platforms offer the possibility to be provided to people across the continent. However, as shown by the Swiss Nano-Cube initiative, language may still constitute a challenge within Europe. Initially, Swiss Nano-Cube offered their curricula in German and expanded to Italian, French and English. Caution should be taken when presuming that English, often the lingua franca in Europe, will be sufficient for offering learning materials to young students. Therefore, translating material to make it available across Europe does represent significant costs that should be taken into account when considering to broaden the scale of online initiatives. Contrary, when analysing the highly successful e-platform initiatives such as Academy Cube and Energy University, who target higher age groups, language does show to be less of a factor when taking into account the high number of users across a large number of countries. Nonetheless, the use of English-only curriculum still has a high probability of excluding a large group of people for whom the English language constitutes a challenge.

Limited scalability for classroom programmes – The scalability of classroom programmes is subject to a wider variety of challenges. It would be necessary to choose whether to upscale the number of trainers (i.e. training domestic trainers locally) or to allocate funds to have existing and experienced trainers travel abroad. Furthermore, for the few classroom programmes that use a specific classroom design, it would mean that, given the spaces aren't used continuously, the cost for occupying multiple spaces could outweigh the benefits of expanding the geographical reach of an initiative. With regard to the scalability of classroom programmes such as Technofutur TIC, which specifically rely on individual attention and face-to-face contact, other elements form a challenge. The pillarization of funding through local unions and the specific attention for regional backgrounds in the offering of the programme and the support that is given pose a significant challenge to broadening the scope of a programme.

High transferability potential for online platforms – There are also specific features to be taken into account when considering the transferability of initiatives. As with the possible scalability of an initiative, online platforms show the highest potential to be transferable across countries and industries. Despite initiatives such as the Swiss Nano-Cube, whose courses are very specifically built for Micro- and Nanotechnological purposes, most online platforms are not too sector specific for them to be applicable in a wide array of industries.

Limited transferability for classroom programmes – The transferability of classroom programmes is subject to more limitations, as for instance the cost of education that differ per country (e.g. location, trainers, and materials). In some cases, the involved organisations leverage knowledge specific to their region that might not be applicable to or available in other regions. These issues form less of a challenge for transferability across industries, as initiatives such as METAL show that certain successful formula are welcomed in other industries. It can even be said that the likelihood of other industries adopting a certain initiative becomes more likely when a specific industry can demonstrate proof of concept.

Policy considerations

Based on these preliminary conclusions, we would offer the following policy aspects for consideration. First, the aforementioned limitations do not appear to constitute severe obstacles to the scalability and transferability of initiatives. In cases where up-front costs would appear high despite clear future upsides, costs could be shared among different stakeholders. Policymakers at the European level could endorse the adaption of good-practice initiatives by the Member States. An analysis could be performed of which the Member States, cities and regions would be best served by what type of good-practice initiative.

Second, policymakers at the EU level can continue their support of initiatives such as METALS, who are working towards providing an online platform resulting from their extensive cooperation with industrial partners to come to relevant content for their curriculum. Initiatives that combine continuous industry input to state-of-the-art curricula show high potential, such as SkillMan and METALS, provided that they are able to acquire the financial resources needed to continue to develop their platforms. The language barrier that has been noted as a potential challenge to the transferability and scalability of initiatives can be overcome. The main obstacle to providing multilingual services is in financial resources.

Third, classroom initiatives could benefit from a different approach to their current strategies. Using METALS as a proof of concept, the classroom initiatives can work from a central base who work together with different actors on a local level to gather the information that serves as input to the curricula strategy. These same actors also serve as the implementers of policies. An initiative such as Future Classroom Lab could benefit from such an approach as they already work with ministries and actors across Europe, yet they are limited to their fixed location in Brussels. Their concept has been emulated several times, showing that there is need for local variations to the concept. Currently, these emulations do not enjoy extensive cooperation with Future Classroom Lab and this is mostly due to the lack of capacity to offer support and share strategies. An overarching coordinating effort could make these currently separate entities benefit from an increased knowledge pool and more efficient setup.

7.4.5. Key insights in mechanisms for high-tech T-shaped skills development

In this subsection, we present key insights in the relevance of dual-track education for high-tech T-shaped skills in Europe, the relevance of life-long learning, the key insights from efforts in the United States, and the latest insights in funding mechanisms for high-tech skills development.

Key insights in the relevance of dual-track education

Our analysis on the workings of a dual-track education system provides additional insight in the importance of integrating school-based learning with work-based practise, standardising apprenticeships across a country or region and recognising certificates widely throughout the national or regional labour market.

The popularity of the dual-track system in Germany prepares young students for the ever-changing nature of work in high-tech fields and, according to experts, contributes to Germany's successful performance as a major industrial power and its low unemployment ratings. **Effective coordination between stakeholders is crucial**. Coordination between labour unions, employer organisations and government in Germany allows for an education system wherein (prospective) workers enjoy sufficient security (in terms of employability) to invest in training and education.
Dual track education is adopted elsewhere in the world, but in different flavours and with challenges. Specific legal and cultural contexts may hinder the success and private sector involvement is not always extensive enough. Academic research on the impact of the dual-track system shows that **workplace training can indeed foster a quicker transition from school to work**, motivate students and reduce unemployment. However, the research would require subsequent impact evaluation in order to substantiate it.

Key insights in the relevance of life-long learning

Our analysis shows that retraining current workers is vital to prepare enough people for working both in new jobs and in new sectors. There is a growing demand for jobs of multidisciplinary nature and jobs aiming to support traditional products and services enabled by the IoT economy. Forecast predicts that the Fourth Industrial Revolution, together with social, economic and demographic developments, will destroy more than seven million existing jobs in 15 major economies, create more than two million new jobs and over one third of key job skills is expected to be disrupted within the coming few years. Training an individual during just one period in their life is therefore no longer sufficient. Instead, **labour-market systems need to provide training and education throughout an individual's working life**, available in a modular fashion and accessible in spells that are shorter than current multi-year programmes of formal education.

Policies should include targeted instruments that include specific arrangements for workers that are close to the retirement age and measures to promote a positive image around credentials and qualifications obtained by workers years after they have entered the labour market. **Deliberate policy design may be required to stimulate the development and provision of educational curricula** relevant to digital transformation and smart industrial specialisation, and to workers in their 30's, 40's and 50's.

Key insights from efforts in the United States

The notion of transversal skills to complement high-tech skills has garnered attention in the United States for some decades already. It has been most clearly articulated in the conceptualisation of T-shaped skills, which has inspired organisations for years and now has found connection and overlap with the organisational learning concept of lean start-up. The synthesis of these two concepts has led to the introduction of **certifications and credentials that workers can use to signal their aptitude** throughout large areas of the American labour market.

Moreover, while the concept of T-shaped is not made explicit everywhere, it can be recognised in numerous interdisciplinary programmes in universities and non-academic educational institutions. **These programmes aim to prepare their students for high-tech jobs through noticeable employer involvement**, and by finding a balance between broad and foundational academic development on the one end, and the needs of employers on the other. Also, educators in these programmes try to adopt sufficient flexibility in their curriculum design to respond to industrial and labour market developments.

Latest insights in funding mechanisms for high-tech skills development

Recent, on-going policy analysis of funding mechanisms for high-tech skills development has uncovered four dominant mechanisms:

- **Funding the construction of dedicated centres** for (vocational) education;
- **Funding targeted projects** that can focus on co-creation of educational curricula, excellence schemed for academic talent, apprenticeship programmes that combine academic education with high-tech work, or continuous upskilling or reskilling activities;
- **Funding design activities** for new learning systems, structural embedding MOOCs, and the development and implementation of open education resources;
- **Funding voucher systems and fiscal incentives,** for instance for SME participation in corporate academies, for knowledge transfer initiatives, and for life-long learning activities.

On-going analysis thus far indicates that especially funding mechanisms through excellence schemes for universities and voucher systems targeting SMEs are highly effective instruments. Analysis also indicates that tax incentives can work in specific policy contexts, and that funding MOOCs may go some way to developing modular educational packages that enable the realisation of life-long learning ambitions throughout the high-tech workforce in Europe.