

EUA STUDY

The Role of Universities in Regional Innovation Ecosystems

The background of the lower half of the cover is a solid blue color. Overlaid on this are several overlapping circles of various colors (green, orange, yellow, light blue, dark blue). Each circle has a small arrowhead pointing in a clockwise direction, suggesting a cycle or a continuous process. The circles are of different sizes and are positioned in a way that they appear to be interconnected.

By Dr Sybille Reichert

March 2019

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Graphic Design: Pitch Black Graphic Design,
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Universities participating in the study

- I Aalto University, Finland**
- I Masaryk University, Czech Republic**
- I Sorbonne University, France**
- I TU/e – Eindhoven University of Technology, the Netherlands**
- I TUM – Technical University of Munich, Germany**
- I University of Manchester, UK**
- I University of Minho, Portugal**
- I University of Warsaw, Poland**
- I UPC – Universitat Politècnica de Catalunya, Spain**

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Foreword



Innovation is the keyword of our times. Europe is facing great challenges, socially, environmentally, and economically, and all sides require innovative solutions to meet these challenges. Universities provide the education, research, and innovation to help create the solutions. What does it actually mean in practice?

This report provides part of the answer by looking at how universities work in their regional environment, based on an impressive number of interviews done in nine different regions. By going deep into a small number of regional innovation ecosystems, it reveals the mechanisms that universities and their partners use to promote innovation. We see how universities have been instrumental in regenerating their regions in the aftermath of the financial crisis, moving beyond transferring technologies and towards the co-creation of knowledge and driving strategic development. The report provides a look into a world of innovation in which the coordination and orchestration of knowledge creation are at the centre of a dialogue that stretches from the students all the way to the management of global companies.

From EUA's perspective, the outcomes here gather strands of work that have been developed over the past few years: It shows how learning and teaching reform has contributed to innovation, especially through problem-based learning, echoing the messages of the TRENDS 2018 Report and the work on learning and teaching. The report also closely relates to the work that EUA has done on smart specialisation strategies and regional innovation, and the numerous events on this topic. Importantly, the report shows how institutional autonomy helps universities to fulfil their potential for adapting to and guiding societal change, pointing to the findings of the EUA Autonomy Scorecard.

The report also opens new perspectives on the importance of open innovation and transversal technologies to meet the challenges of society. It shows how student initiatives can drive regional development, as well as how long-term strategic partnerships between universities and multi-national companies can further research at all levels. The common references to the Sustainable Development Goals in many cases show how a shared agenda can mobilise and give direction to innovation.

It is, in sum, a report that presents concrete examples and good practices. Not least, it promotes the spirit of cooperation. I hope that you will enjoy it.

LESLEY WILSON
Secretary General

Acknowledgements

This study has clearly been a collective effort – and a tour de force for many. First and foremost, I would like to thank EUA Secretary General Lesley Wilson for initiating the project and the EUA core team – Thomas Ekman Jørgensen, Lidia Borrell-Damian, Anna-Lena Claeys-Kulik, Kamila Kozirog, Rita Morais – for their invaluable support of this study by critically reflecting on its design, progress and results, and helping with the interviews at the universities. Conducting more than 130 interviews in nine regions in less than five months for three days each was only possible as teams of two; without such exchange of impressions and assessments of the interviews and the regional contexts, the exploration would not have been such a rich stimulating experience. Thomas Ekman Jørgensen, in particular, I would like to thank for his untiring continuous engagement, thoughtful comments and reflective depth throughout this project, as well as for his careful editing, both of which have enriched my own analysis tremendously and have served as most helpful encouragement, when one visit and case study report chased the other.

Of course, the whole case study design would have collapsed without the logistical wizardry and charming but relentless communication of Bakhodir Gosset who coordinated the case study arrangements. The project's Advisory Board members – Markku Markkula, President of the European Committee of the Regions, Prof. Ray O'Neill, Vice President for Research and Innovation of Maynooth University, Prof. Peter Haring Bolivar, Vice-Rector for Research of the University of Siegen – have been most helpful in reviewing the design, intermediate and final results and analysis of the study. I would also like to thank the leadership in the nine universities that allocated resources and opened the doors for us.

Last not least, we are all most indebted to the contact persons at the universities who suggested and contacted the right interviewees in accordance with the interview roles and design, and put together the relevant background documents which helped us understand the regional settings, institutions and strategy processes. After all, universities have better things to do than organise interviews for a study on innovation processes! Our fervent thanks for this substantial extra effort, on top of their usually already overcharged agendas, thus go to, in order of appearance, Lisa Gledhill of the University of Manchester, Dr E. (Lisette) Appelo of TU Eindhoven, Prof. Guilherme Pereira, Prof. Filipe Vaz and Heliana Silva of the University of Minho, Dr Agnieszka Pugacewicz of the University of Warsaw, Dr Roman Badik of Masaryk University, Taru Henriksson of Aalto University, Mireia de la Rubia of Universitat Politècnica de Catalunya, Dr Sieglinde Amelia Walter of the Technical University of Munich, and Nathalie Wierre of Sorbonne Université. Without your engagement in putting the interview programmes together, and without the readiness of more than 170 university, business and governmental representatives of the nine case study regions to share their experiences and reflections on their innovation environments with us, this study would not have been possible! For all it is worth, let me share with you all, that tracing the spirit and dynamics of innovation in these nine regions has practically restored my shaken optimism regarding Europe's future.

DR SYBILLE REICHERT

Executive Summary

“The Role of the University in Regional Innovation Ecosystems” offers an in-depth qualitative analysis of innovation processes in nine European regions. The study focuses on the nature and changing quality of the interactions between universities, companies, governmental agencies and other public organisations. It focuses on the multi-actor orchestration of innovation, its new interfaces and organisational forms, changing collaborative formats and spaces, as well as the transformation of the key actors’ roles.

The central role of knowledge creation in post-industrial economies and societies has given universities a pivotal role in society. In the regional quest for increased connectivity to fuel innovation dynamics, the **university’s new centrality** becomes inextricably intertwined with its role of orchestrating multi-actor innovation networks. Businesses and governments see the university and its members as ideally suited to “connect the dots” because they are impartial, driven by curiosity and long-term perspectives, rather than by commercial interests and short-term goals. To connect the dots effectively, the university has to be highly responsive, adaptable, strategically directed, autonomously governed, and densely interlinked with its regional partners as well as an international network.

Thus, the key functions of the university of conducting research and educating future academics and professionals, leaders and innovators, are increasingly enacted in densely networked processes of knowledge creation. The case studies provide rich evidence of the ways in which the new formats of producing and sharing knowledge, and of orchestrating multi-actor knowledge creation processes, are integrated with traditional roles of educating students and developing research. This is the result of profound, systematic institutional transformations.

The case studies show how this transformation is linked to the emergence of innovation-collaborative cultures, in which common values, historical narratives, and strategies connect leaders and innovators from universities, companies and public agencies. From collaborative networks to strategic partnerships and joint institutes, actors from different sectors develop interdependent innovation processes. In many cases they even develop everyday co-creation habits, thereby enabling themselves and each other to address problems, from long-term and possibly highly disruptive innovation challenges, markets and societal practices, to current company or public problems.

A new connectivity emerges in regional innovation contexts among actors in the triple helix between universities, governments, and businesses, and their roles are transforming. A fourth

less institutionalised type of actor may be added to the system, namely the public, citizen groups, users, or students, which participate as partners rather than just addressees of innovation processes, making it a quadruple helix in the eyes of some observers.

The qualitative case-study method allows a presentation of all facets of regional innovation processes and the interactions of its triple helix actors in their multi-dimensional complexity. It also uncovers emerging forms and cultures of innovation. The choice of the case studies reflects successful innovation systems in **diverse regional situations** across Europe, including some of the 10% most competitive regions in the EU. Also included are cases from regions with GDP below EU average, benefitting from substantial European Structural Funds.

In order to take account of a wide range of regional differences, the case studies were selected from different regional situations with respect to centrality within the country: capital regions, regions with a large metropolitan city, but also regions that are situated away from the immediate orbit of a metropolitan area. Each case study explored a wide range of institutional activities and actors, to reflect a **multi-actor view of innovation** and of the university’s role in it, using quantitative data on regional performance as well as background documents on regional and university strategies. First and foremost, the results come from the 136 interviews done at the nine universities in the different regions.

The study finds that the roles and mutual expectations of the actors have transformed in recent years, and that these transformations result in seven profound changes, perhaps even paradigm shifts, in the conception and organisation of innovation:

1. From linear to reiterative innovation: Universities and companies no longer conceive of innovation as a linear process that leads from basic via applied research to commercialisation along a continuous line of ‘technological readiness levels’. Rather, they recognise and engage in innovation as a reiterative process in which basic research, applied research and prototype development can stimulate and enhance each other mutually and multiple times in a cooperative process. Universities’ ability to continuously bring new perspectives from different and unforeseeable angles make them crucial partners in the search for trend-setting and sustainable innovation.

Universities’ access to international research is a key source of innovation potential and authority in the eyes of businesses

and governmental agencies. Leading researchers coordinating major strategic cluster initiatives in thematic strengths of the university and the region help to acquire national and international funds for the region. Moreover, the old juxtaposition of basic and applied research is seen as becoming obsolete as the two are generally seen as part of a mutually reinforcing whole. University researchers and businesses, however, do distinguish between short-term solution-oriented research and incremental research with long-term, high-risk open-ended research, both of which are seen as equally needed for a dynamic and sustainable innovation environment.

In all case studies, universities have seen an increase of industry-funded research, but not in public funding for curiosity-driven research. This was seen as a potential problem for future innovation, also by businesses. There are fears that increasing dependence on industry-funded research will lead to a higher risk of biased results as well as potential of scientific breakthroughs driven by curiosity-based research being undermined, which in turn would prevent more radical forms of innovation.

2. From closed to open innovation: Open innovation enhances the role of universities. Given the increasing complexity of technology development and acceleration of innovation cycles, companies have adopted new models of open innovation which include external partners even in core development processes. These open innovation approaches diversify and intensify partnerships between companies as well as between companies and universities or research institutes. This, in turn, leads to dense interactions with external partners as part of businesses' core innovation processes.

Such open innovation reinforces the role of regional assets in effective innovation processes, of which universities provide the most important kinds: talents and research. They also provide the fertile ground for start-ups and spin-offs which are eager to work with established companies. Universities also proactively facilitate the co-creation of knowledge between partners through interface services, joint organisational structures and access to researchers and research infrastructures.

Open innovation networks have developed new forms of connectivity that can leverage regional proximity since they can rely on networks of mutual trust and common interests. They also share values, aims, and narratives, and sustain a common belief in the possibility of progress. Universities are considered well placed to orchestrate such connectivity, due to their independence and the knowledge they produce.

3. From technological to systemic challenge-driven innovation: Innovation approaches are broadening to include technological, social and economic innovation in common agendas. Universities have a central role to play here due to the breadth and depth of their research and education agendas. Businesses, governmental agencies and universities are looking for systemic approaches to pressing challenges, often linked to topics like digitalisation and sustainable development, that can only be addressed with multiple actors' perspectives. Triple helix partners jointly pursue innovation in common spaces and institutional frameworks in order to address challenges that are prioritised by all partners. Universities respond to such urgency in their own research priorities and teaching approaches. Students are strongly motivated by challenge-driven approaches, in learning and teaching as well as in their entrepreneurial initiatives.

Regional development and innovation strategies are broadening their focus to areas of environmental and social innovation and sustainability, embedding technological development in their social contexts. By linking the regional with the global, the social with the economic, the innovation agenda with concerns of social and ecological sustainability, regions – and especially densely populated city-regions – become hubs for systemic innovation. Often, businesses voice their own vital interest in systemic innovation, appealing to universities to help them in such efforts in new open-ended forms of collaboration.

4. From individual to collaborative and interdisciplinary innovation: With increasing specialisation, digitalisation and technological hybridisation, collaborative interdisciplinary research and development become a necessity. External stakeholders find the university's most important role in innovation to be its ability "to incubate interdisciplinary research" and to educate interdisciplinary thinking and competences that are based on deep command of disciplinary methods. Universities have developed a wide array of strategic measures in research and education to foster such interdisciplinary collaborative approaches.

5. From spontaneous to systematic innovation: Our case studies find all actors of the triple helix developing innovation in a systematic and strategic manner. At the regional level, governmental agencies are involving universities, businesses and other stakeholders in structured dialogues to identify, analyse and exploit regional strengths and potentials. At times, this is facilitated through smart specialisation strategies. At most universities, there are close alignments between university and regional development strategies.

Businesses are seeking strategic partnerships with carefully selected universities that offer international strengths in key scientific and technological areas with high potential and unclear perspectives. At universities, strategic approaches to innovation are clearly linked to deep and long-term transformation agendas. Based on the accumulated experience and traditions of collaboration between universities and businesses or governmental agencies, universities' commitment to innovation is seen in reforms in learning and teaching, for example through emphasis on problem-based learning in cooperation with external partners. This commitment is also clear in institutional research strategies that set incentives to collaborate internationally and regionally, and to seek societal and economic impact as well as academic excellence and international visibility. Systematic attention is paid to the most effective interfaces and organisational formats for collaboration between academics. Learning and teaching reforms as well as the increased attention of the last decades to autonomy and strategic steering capacity, but also national and EU funding schemes, have made such orientations possible.

Thus, the third mission of universities becomes more clearly strategically interlinked with research and educational projects as part of a deeper cultural project of creating entrepreneurial awareness, collaborative openness, challenge-driven inquiry, and multi-actor networks. Traditional strengths of scientists and scholars, such as critical thinking, relentless curiosity, questioning of received expectations, and a taste for tough challenges, re-emerge as key competences of innovators.

6. From exchange-based innovation to co-creation in innovation spaces: With increasing density, experience and trust developing in long-standing cooperation frameworks, innovation may move beyond the exchange between independent actors with separate agendas and institutional cultures. Now innovation becomes interdependent co-creation among actors from different sectors and institutions. Researchers, innovators, and leadership from universities, businesses or public agencies are developing a common sense of regional strengths, potentials and challenges. Their collaboration transforms into commonly designed, adapted and implemented processes, with joint decision-making, priority setting, and resource allocation. The dense fabric of collaboration projects becomes a common innovation space, geographically, socially and culturally. Here, universities play the key roles of providing the core research infrastructures around which such innovation spaces are organised.

7. From innovation projects to common innovation cultures:

In pursuit of co-creation through co-location, universities, intermediary agencies such as cluster organisations or science park managers, and business partners, orchestrate relevant events to convert spaces into cultural hubs of innovation. In these contexts, the term “innovation space” or “innovation hub” usually refers to a cultural environment that helps to create a loose sense of belonging to a larger entrepreneurial agenda. Innovation becomes a cultural practice, which feeds on narratives and even celebrates new forms of heroism. University and other innovation directors stage innovation in events, stories and theatrical performances (as in staged venture competitions) that celebrate new ideas, collaboration, and radical innovation. As universities choose to become the nurturing grounds of “game-changers”, innovation is staged as a new form of 21st-century heroism in which the entrepreneur, with unmitigated energy and faith in his – or more rarely her – success, meets a near-impossible challenge and, with the help of loyal supporters, defies all adversities to win success. The breakthrough innovation sets a new trend, disrupts social habits and technological developments, opens new markets, or solves a pressing social or environmental problem.

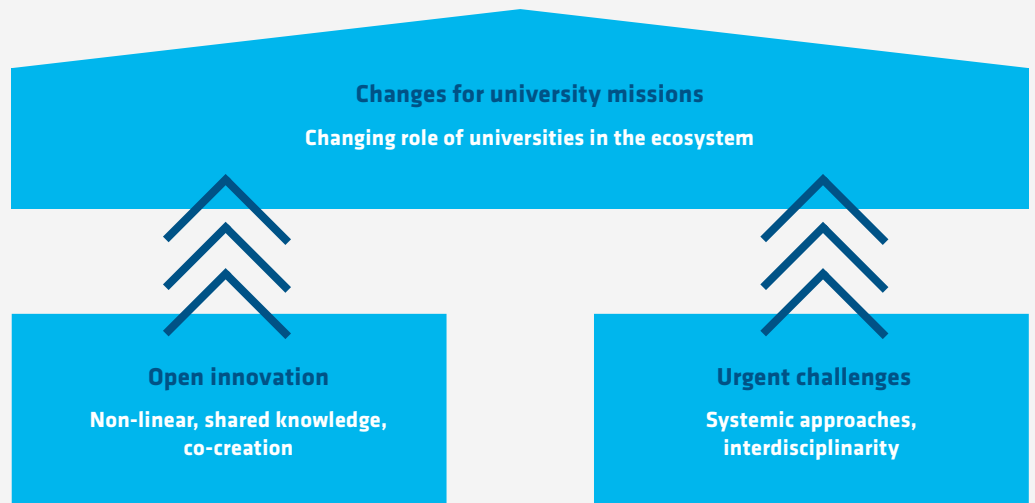
The study shows how the paradigm shifts in innovation reflect a common quest of the triple helix partners for new forms and practices of connectivity. Innovation potential is mobilised through the diversity of perspectives and competences of the different partners. These new forms of connectivity seek coherence in three dimensions: social, organisational and spatial. These three dimensions are most easily aligned through the geographical proximity of regions. While universities, businesses and governmental agencies all need global pipelines to fuel their innovation processes, they exploit their potential most effectively (though not only) in their respective regions. They seek social, organisational and spatial coherence amongst regional partners that share cultural identity, history, vision, challenges and strategic priorities, and that can thus more easily benefit from each other's complementary expertise.

This coherence is found in concrete connections between the various actors. Some of the connections are visible and well known, particularly when it comes to company managers and political and university leaders developing common visions and official strategies, or to researchers and company innovators conducting joint research centres. Other forms of connectivity unfold informally through personal networks at all levels that coordinate and align their ideas – from individual researchers to regional leaders. Moreover, the explicit and implicit cultures, norms, and narratives of a particular ecosystem provide the glue

that makes its parts connect. Joint organisational forms and physical spaces, be it the joint lab, the innovation space or the student start-up hub, are the outcome.

In all case studies, changes are described as deeply transformational. These changes are a response to a new era in which having a wider impact and addressing global challenges have become a core motivation of students and young academics alike. The sense of multiple radical transformations, which make even the immediate future unforeseeable, creates a quest for ownership and for value-driven communities. Collaborative research, challenge-based learning projects and impact-oriented start-ups thus become the most important ingredients in the university's role in regional innovation, and the very fabric of innovation ecosystems.

Figure 1 Innovation and the changing role of universities



Innovation and the changing role of universities

Focus and aims of the study

in an age of radical transformations that touch upon all dimensions of civilisational development, we have lost most of our traditional certainties. Our future holds as many promises of scientific and technological progress as it does threats. With fast-paced globalisation, inexorable digital transformations, unsure economic growth, precarious labour markets, increasing social inequality in most industrialised countries, and environmental consequences that may soon be beyond our control, we are left with one certitude alone: no pressing question – social, economic, technological or scientific – can be answered from a single perspective or discipline or by a single type of institution.

Never did it seem more obvious that we depend on scientific, technological and social innovation to tackle current and future challenges and that such innovation and sustainable solutions will most likely emerge from building bridges across countries, cultures, disciplines, and institutions. **This study shows how universities and their partners in regional innovation systems join forces to build such bridges across institutional and disciplinary boundaries, look for new collaborative formats and spaces in order to address shared challenges, and shape their own changing roles in the process.**

Against the backdrop of increasing demand for innovation, the university finds itself in a new and challenging central position. Its role as a primary knowledge producer comes with demands and expectations that presuppose new modes of developing institutional identity and profiles. Indeed, its **new centrality depends on the university being highly responsive, adaptable, densely interlinked** not only with its academic partners, but also with external stakeholders, globally and locally.

The university is now expected to combine responsiveness to current problems with the ability to engage in long-term research. It is expected to address incremental as well as disruptive innovation challenges, in networks that combine academic perspectives with innovation needs of businesses and public agencies. Such intertwined knowledge creation, called “triple helix”, a term coined by Etzkowitz (2000, 2003),¹ brings academic knowledge together with that of users, markets, social partners, citizens and governmental agencies, not only in research but also in education.

In addition to developing knowledge, know-how and mastery in a wide range of disciplines, the university strives to convey entrepreneurial attitudes and thinking, and to educate and train those who would become the next “game-changers”. Some universities in our study have emphasised this aspect of the university’s role.

The university that is called upon to interact, co-create and achieve a far-reaching impact on regional, national and global development, has been called the “Fourth Generation University” (Pawlowski 2009).² In addition to its traditional educational role (first generation), its second mission of conducting scientific research (and basing its education on such research), and the expanding third mission of creating value by helping start-ups and initiating market innovations, **the Fourth Generation University pursues a less explicitly linear view of innovation. Here, innovation is pursued jointly by triple helix partners in common spaces and institutional frameworks**, to address challenges that are prioritised by all partners. Such innovation is enabled by preceding institutional changes: increased autonomy, interdisciplinary organisation, collaborative structures, teaching and learning reforms, expanded services, as well as governmental incentives and an increased openness of businesses to interact with external partners in open innovation.³

Open innovation approaches of businesses, which form the backbone of recent regional development processes, are closely interlinked with the expanded role of the university and of governmental agencies, as the study shows. In knowledge-based industries, internal centralised approaches to R&D become less important with the increasingly wide-spread realisation that useful knowledge is distributed across different industries (Chesbrough 2003). Using external innovation is a key factor of competitiveness since not all relevant parts of a business’ value chain can be developed internally.

In addition to internal R&D, companies use external research projects, corporate venture capital, spin-offs, licensing, and IP in the innovation process, as Chesbrough (2003) explains in his seminal study of open innovation. “The external knowledge landscape is a vital resource for discovering and recognizing new business opportunities not currently reflected in your roadmap (...) [and] help exploit converging trends that will one day transform the industry.”⁴ Hence, for businesses, cooperating with external researchers and innovators becomes an important method of developing their own business model. They do this by collaborating with universities, buying and selling IP, or looking at the “more visionary start-ups that are challenging the boundary of the industry.”⁵

Wherever universities have developed a dense collaboration with businesses and other external stakeholders, universities become important, often primary partners in such open innovation networks. In this study, we take an in-depth look at how universities become key partners of such networks, both through traditional forms of research cooperation as well as, increasingly, through their own business creation efforts and other new types of impact-driven innovation initiatives. The old juxtapositions of fundamental research and applied research or research-based entrepreneurial initiatives dissolve and transform into complementary formats of research development. This confirms Etzkowitz’ (2000, 2003) observation of the American university research landscape in which he identified the emergence of an entrepreneurial ethos that combines an interest in fundamental discovery with application and technology-based business creation.⁶

These open innovation networks, which have expanded rapidly in recent years, have developed **new forms of connectivity** which – even though they may not be geographically bound per se – greatly **benefit from regional proximity, if they are sustained by social and cultural cohesion**. While universities and many of its partners need global knowledge and partners to be innovative, they explicitly use each other as global pipelines. Regional proximity helps to build such connectivity. Networks of mutual trust, common interests, shared values, aims, and narratives, help sustain a common belief in the possibility of progress.

Hence, new models of **open innovation** emphasise the role of regional assets in effective innovation processes. As knowledge production has shifted away from traditional linear processes of innovation to “iterative chain-link models based on the interaction between knowledge actors” (Huggins 2014)⁷, the **region becomes an important focus of policy attention**. With favourable

framework conditions, and the right potential partners, local interactions can help a firm's competitive profile and global market position.

The **point of departure** of the new emphasis on connectivity, and on the importance of the region as its privileged unit, is an alliance of policy and academic focus on factors that determine **economic competitiveness**. Phenomena such as the rise of Silicon Valley and in-depth studies of regional thematic cluster developments and policies have suggested that the focus on the region offers a more decisive spatial unit for studying or promoting economic competitiveness than the nation as a whole.⁸

Competitiveness has been defined as “the inclination and skills to compete, to win and retain a position in the market, to increase market share and profitability, and eventually to consolidate commercially successful activities” (EU, Regional Competitiveness Index, 2013). Its key attributes have a strong regional dimension, in the EU as much as globally. As research on economic competitiveness and regional innovation processes shows, regional factors have proven to contribute strongly to attracting firms, qualified human capital and investments.⁹ Accordingly, regional performance varies widely within any given national context as well as between national contexts. The variance of competitiveness within a given country reveals disparities that are often as large as the ones between the countries of the EU (EU, Regional Competitiveness Index, 2016 and 2013).

While competitiveness has been the main focus of attention to regional policy in the past, the focus on **regional development and its innovation strategies is broadening to include environmental and social innovation and sustainability**. The examples from this study show clearly that cities and regions are increasingly designing measures that balance economic growth with social wellbeing and environmental sustainability and are relying on universities to help analyse problems and develop solutions. Hence, innovation is understood multi-dimensionally. Regions and cities are pursuing a holistic approach to the main responsibilities of regional authorities. Regional innovation agendas take account of globally recognised challenges and respond to them with concrete regional measures.

By linking the regional with the global, the social with the economic, the innovation agenda with concerns of social and ecological sustainability, regions – and especially densely populated city-regions – become hubs for systemic innovation. Universities, in close alliance with the regions, proactively promote this wider angle on innovation integrating technological, economic and social development in education and research. Moreover, businesses are voicing their own vital interest in systemic innovation, appealing to universities to help them in such efforts, in new open-ended forms of collaboration.

Thus, **the university becomes recognised in a double role: as a central regional actor** in terms of its **role of knowledge production for competitiveness** (Goldstein and Drucker 2006), and **as a cultural actor that facilitates regional interaction**. By bringing a wide range of disciplinary expertise together, it spearheads a search for systemic sustainable solutions to societal challenges. The university provides three key pillars of regional development: knowledge, skills, and the ability to connect multiple disciplines, and institutional or sectoral perspectives. Universities become orchestrators of regional connectivity in all knowledge-intensive sectors.

The concept of the **regional innovation system** which underpins this study shows regional organisations interacting with each other to optimise access to and absorption of relevant knowledge. As the evidence of our case studies will show, innovation systems are systems by virtue of the interdependence and dense interaction of their actors. The concept of a regional innovation system refers to the total sum of organisations in a region that contribute to the creation, dissemination, absorption and application of economically relevant knowledge as well as their inter-linkages (Cooke 2004).¹⁰

This study of regional innovation systems also shares this **focus on endogenous factors** (rather than external factors such as national fiscal regimes). **Going beyond the focus on economic growth, it includes social innovation and the flow of knowledge across organisations as vital factors for effective social and cultural innovation.** Knowledge is transmitted both formally and – importantly – informally through complex sets of social networks. Here, regional proximity is used as an asset in promoting such knowledge flows.

As knowledge is created and shared by individuals in social settings, knowledge flows are dependent not only on the availability of qualified people, “human capital” with a relevant breadth and set of skills and knowledge, but also on a sufficient density of networks, with common norms and narratives, in which knowledge can be created and shared. Knowledge transfer and cooperative structures are vital ingredients of regional success, as are common cultural values, norms and narratives that create a common sense of purpose between people. In such open innovation environments, physical proximity is transformed into collaborative spaces, and Co-location initiates carefully staged formats of interaction.

Universities thus become central players in a region: first, as a key source of knowledge and graduates that are able to contribute to the region; second, in terms of the cooperative structures and engagement it offers. The university builds and conveys “cultural capital” in the sense of common values and norms, and “social capital” in the sense of the quality of the networks that allow resources to circulate and accumulate (Bourdieu 1986). As this study will explore, the effectiveness of a university’s connectivity also depends on its recognition that it is not the sole source of knowledge. Rather, it develops knowledge together with other knowledge actors in a common interlinked ecosystem.

This report focuses on such **interlinkages or “relational assets”** (Storper, 1997) by zooming in on the **role that universities play in their development:**¹¹ How exactly do universities facilitate knowledge flow and innovation in inter-organisational networks? While many of the channels of interaction have been identified (Drucker/Goldstein 2007, Benneworth et al. 2009), there is no **transnational overview of the varying quality and forms of these interactions** and the changes they have undergone in recent years. We may know enough about the tangible and measurable outputs of a university, such as its publications, spin-offs, patents and number of graduates. Indeed, empirical studies on universities’ impact have found evidence of strong regional spill-over effects, through university inputs such as investment, employment, student-population, or outputs such as scientific knowledge, and graduates,¹² and even of the economic impact of a university on the region,¹³ but we know little about the contribution of the university as a part and orchestrator of a network, and how it influences its local milieu as an institution.

As a part of this networking role of the university, the report traces how universities and other regional actors develop new forms of cooperation that go beyond the short-term project-based knowledge transfer of already established knowledge. Instead, different actors in the region, companies, regional authorities, funding organisations and citizens themselves, develop new approaches to technological, economic or societal challenges together by articulating their problems and solutions together, combining hitherto separate sets of competences into an explorative new agenda and conceptual framework which makes use of the complementary perspectives of the partners. Such mutually shared approaches and agendas address more long-term problems than a typical project collaboration and develop more unusual approaches. One might call such forms of collaboration processes of co-creation, since the concepts and methods of such collaboration develop in the process of collaboration itself rather than being set beforehand and partners simply exchanging already existing sets of knowledge. This report traces the emergence of such local **knowledge cultures of co-creation** to see how such cultures are formed and what formats are used to establish them.¹⁴ One important aspect is to show how co-creation can be systematically developed by universities and their partners into local cultures of co-creation.

The new methods of interaction which universities develop to enhance regional innovation, have evolved as part of universities lending greater emphasis to their “third mission”. But while the agenda of the third mission has often been dominated by a focus on commercialisation and IP, this focus to have been integrated into a larger central pre-occupation with social and economic impact. These considerations of impact are integrated into university research, curriculum development and teaching and learning processes, and how synergies between these dimensions are sought systematically.

Figure 2 Elements of an innovation ecosystem



On the basis of diverse perspectives of different regional actors inside and outside the university, the analysis identifies different kinds of challenges, approaches, processes, communication cultures and services, which are seen to contribute to innovation in the regions and the role the universities play in these. In particular, the analysis focuses on the role of the university with respect to six areas:

1. **Culture of the ecosystem:** What are the common narratives and values that help to create trust and a sense of common purpose in the region? How do actors describe the system, and what concrete practices do they identify with, being part of the ecosystem.
2. **Human “capital”:** How has the need for human resources and qualifications changed over recent years, and how has the university contributed to meeting these needs? How have universities adapted their own teaching and continuing education offer to regional actors’ human resource needs and what are the benefits, challenges and limits of such alignment? How have curriculum development and teaching processes changed to include regional perspectives and actors?
3. **Knowledge production:** How have research processes within universities and between universities and their partners been changed to facilitate innovation and address new challenges? What are the kinds of challenges that individual actors feel they cannot address alone but could only tackle in collaborative structures that reach across institutional boundaries? How do they organise such structures and exchange?
4. **Supporting structures (funding, services and infrastructures):** How do services and infrastructures contribute to the competitiveness of a region? How do they contribute to the cohesion of different actors within the regional innovation system? How have they developed in recent years? What are their challenges and how do universities contribute to meeting these? How have funding instruments and incentives developed and what effect have these developments had on regional innovation processes?
5. **Institutional and regional strategy processes:** What are the strategy development processes at regional level between universities and other organisations? (How) does strategy matter? How does the university act as a strategic actor and what is the impact of its strategic role?
6. **Network communication channels and formats:** Which forms of communication are seen to be effective in bringing different actors together and facilitating knowledge transfer between them? What is the unique role which universities play in such networks and how has this role changed in recent years? What are the success factors of fulfilling this role effectively?

Methodology

1

1.1 Approach

In order to provide an in-depth account of the types and forms of interaction between universities and its regional partners in innovation processes, a qualitative case-study approach was chosen. While such an approach cannot isolate individual factors to measure their contribution to regional innovation processes, as large-scale quantitative studies might, the qualitative case-study method allows a presentation of interactions in their multi-dimensional complexity as well as of emerging forms and cultures of innovation.¹⁵

Any attempt to take account of the ways in which a university develops its impact on regional innovation should consider:

1. the multi-dimensionality of outputs and impacts: The university's impact on regional innovation is all too often reduced to its technology transfer activities. More attention is deserved by the university's contribution to social and cultural innovation as well as its relational role in developing a community with common norms, communicational practices and collective "cultural memory" (Assmann 2012).
2. the heterogeneity of regional environments: As the socio-economic impact of higher education institutions depends not only on their own interventions but also on their regional situation, one has to do justice to the uniqueness of the setting.
3. the openness of regional innovation systems: The role of global knowledge channels and inter-regional spill-overs should be considered an integral part of a region's innovation system.

With this in mind, our case study interview design focused on a **wide range of institutional activities and actors** to ensure that it reflects a large view of innovation and of the university's role in it. In particular, the study ensures that learning and teaching (an often overlooked area) is changing to respond more closely to regional needs. It ensures that students are taught, coached or counselled so that they can develop awareness of, or engagement with, regional opportunities and qualification needs.

Secondly, while the case study results seek to provide additional depth to discussions on regional innovation processes and ideas on how to structure and orchestrate such processes, it cannot offer ready-made good practices and recipes. Approaches and measures of one university cannot be easily transferred to another setting with different pre-conditions. Instead, our choice of case studies reflects the **diversity of regional situations** and addresses situational particularities. Accordingly, we have chosen case studies from all over Europe. Even though there is a correla-

tion of GDP to regional competitiveness (Huggins et al. 2014: 69), we have chosen not only case studies of universities from the top 10% of the most competitive regions in the EU but also cases from regions with below EU average GDP in order to take into account a wide range of regional differences.

And thirdly, the **global orientation of a university's knowledge production**, and indeed of a regional partner's innovation management, will be taken into account in the interview design, given the openness of the knowledge systems. Indeed, we look also at possible tensions that may be experienced at universities and other organisations that want to do justice to their global interactions as much as their regional ones; after all, universities – and firms – select their cooperation partners based on their relevance and reputation rather than their geographic location, and interaction channels are regionalised only to a limited degree (Power/Malmberg 2008, Huggins et al. 2012).

1.2 The case study sample

The nine cases were selected on the basis of three criteria. First of all, we selected regions and universities that were known to be competitive with respect to their innovation processes. These regions and universities would provide insights into **effective innovation environments** or effective innovation management processes that could serve as a **stimulus to others**. This selection is established on the basis of data provided by the most recent Regional Competitiveness Index of the EU (see annex 1 for overview data) as well as on the basis of EUA's accumulated experience with university practice in the framework of activities relating to smart specialisation.¹⁶

It should be noted in this context that the Regional Competitiveness Index, which was first established in 2010 and has now been published for the third time (in 2016), offers aggregate and differentiated data on a wide range of dimensions which are not only, strictly speaking, economic in nature. EU's Regional Competitiveness Index¹⁷ integrates the perspectives of companies and residents, defining competitiveness as “the ability to offer an attractive and sustainable environment to firms and residents to live and work” (EU Regional Competitiveness Index 2010, 2013), on the basis of a methodology developed by the World Economic Forum's Global Competitiveness Index.

In spite of its relative breadth of perspective, however, we could not limit ourselves simply to choosing regions from the most competitive 10% since this would not have covered all parts of Europe. Moreover, we wanted to include the valuable experiences accumulated by universities in regions that make substantial use of structural funds and have experience with smart specialisation strategies as an ex ante conditionality of EU structural funding. By implication, this means that these regions had a GDP per capita below 75% of the EU average. Because of the correlation between GDP per capita and regional competitiveness, this implied that we included regions that are not among the most competitive in Europe.

While competitiveness remains a key concern of innovation processes, it has been crucial to approach innovation with a wider angle and look at the broader role that universities play socially and with respect to solving local and global environmental challenges. As the sustainable development agenda is rapidly growing in importance for universities as well as for other regional actors, it was important that the study looked further than competitiveness in the narrow sense and also took note of the larger societal agendas. The idea was not to see competitiveness and sustainability as separate agendas. Instead, we wanted to see how communities with diverse socio-historical and economic contexts saw sustainability as an agenda for their innovation ecosystems. We looked at how they linked sustainability with business opportunities as opportunities to meet commonly perceived challenges.

A second consideration in our choice of regions was that the **sample should reflect** the EU's **diversity of regions** in different respects. We wanted to present case studies from regions in the North and South, East and West, but also in different situations with respect to centrality within the country: capital regions (Helsinki-Uusimaa, Paris-Île de France, Warsaw), regions with a large metropolitan city (Barcelona in Catalunya, Munich in Oberbayern, Manchester in Greater Manchester) but also universities in cities that are situated away from the immediate orbit of a metropolitan area (Brno in South Moravia, Braga in Northern Portugal, Eindhoven in North Brabant).

The third consideration was the exemplary character of the cases. While taking account of the particularity of each region and its unique opportunities and challenges, we included in all instances (including the selected five cases that do not fall into the category of the top 10% of competitive regions) cases that present interesting examples of innovation processes. The examples of innovation they offer are interesting either in aspects of regional competitiveness (technological readiness, business sophistication, innovation performance, investment in higher education and life-long learning) and/or in the university's institutional practice, as evident in the EUA's work on smart specialisation.¹⁸

The sample is also supposed to be diverse with respect to the profile of the universities, i.e. not only technical universities, whose close engagement with innovation processes is part of their mission and historical *raison d'être*, but also large comprehensive universities with different kinds of focus areas for their innovation management.

1.3 Data collection

For each case in the study, data is collected to present a wide angle onto the region's and university's unique assets and challenges. First, quantitative data was collected from the above-mentioned Regional Competitiveness Index (see Table 1 in Annex 1). It should be noted that the NUTS (Nomenclature of Territorial Units for Statistics) 2 regions, which are the units for which the Regional Competitiveness Index aggregates its data, are administrative or statistical regions which do not account for functional economic links. For example, they do not take into account the qualifications of people living in adjacent regions and working in the neighbouring region of a different NUTS code. To address this problem, additional data were collected to differentiate the NUTS 2 region internally in order to do justice to the university's functionally relevant regional environment. In addition, the most important strategic documents, such as regional strategies, university strategies, cluster policies, thematic or sectorial reports of key thematic areas, background data on key regional actors such as multi-level companies, important intermediary agencies or other innovation actors were collected. Furthermore and even more importantly, before each site visit, a wide set of quantitative and qualitative data were collected from the universities, on the basis of a common set of questions and guidelines.

Against the backdrop of this *ex ante* data collection, the most important qualitative data of which this study consists was collected through 136 semi-structured interviews with 173 persons during the site visits. The choice of groups to be interviewed combined multiple perspectives on the innovation processes of the region. Even if the main focus is on the university's role in the region, other knowledge actors from large corporations to smaller businesses, including start-ups as well as governmental agencies, were interviewed to obtain a multi-perspective view of regional networks of interactions, and to see how institutional processes are perceived and encountered by other actors in the system.

For each of the nine case studies, the site visits comprised 13-15 interviews, each 1-1.5 hours long. The following groups of interviewees were chosen with the aim of reaching multiple levels within the institution and the region, with a view to meet the challenge of multi-level governance:

- University: President and/or vice president(s) research and/or innovation

- University: Vice president(s) for teaching and department heads or 2-3 programme coordinators responsible for curriculum development

- University: Four professors who are leading researchers/coordinators of at least two different clusters or centres or subject areas with a high density of regional cooperation

- University: Head of administration and heads of research support office and technology transfer office

- University: Head of continuing professional development/continuing education office

- University: Head of start-up support service

- Regional development agency or city/metropolitan area government agency: director(s) of economic development and/or research and innovation

- Director/s of important regional intermediate agency/ies/clusters/network)

- Representatives of big companies in charge of cooperation with university

- Representatives of small or medium-size companies or start-ups

- Director of incubator or accelerator or techno park or other key business-supporting infrastructure

- Director of funding agency or foundation with strong role in regional development, director of venture capital fund

- Non-governmental organisation representing civil society regarded as important regional actor

- Group of students or graduates actively engaged with regional development (through start-ups, consultancy, volunteer services, etc.)

The interviews considered five key dimensions of innovation systems and its communication processes, following a key set of questions that inform the interview guidelines:

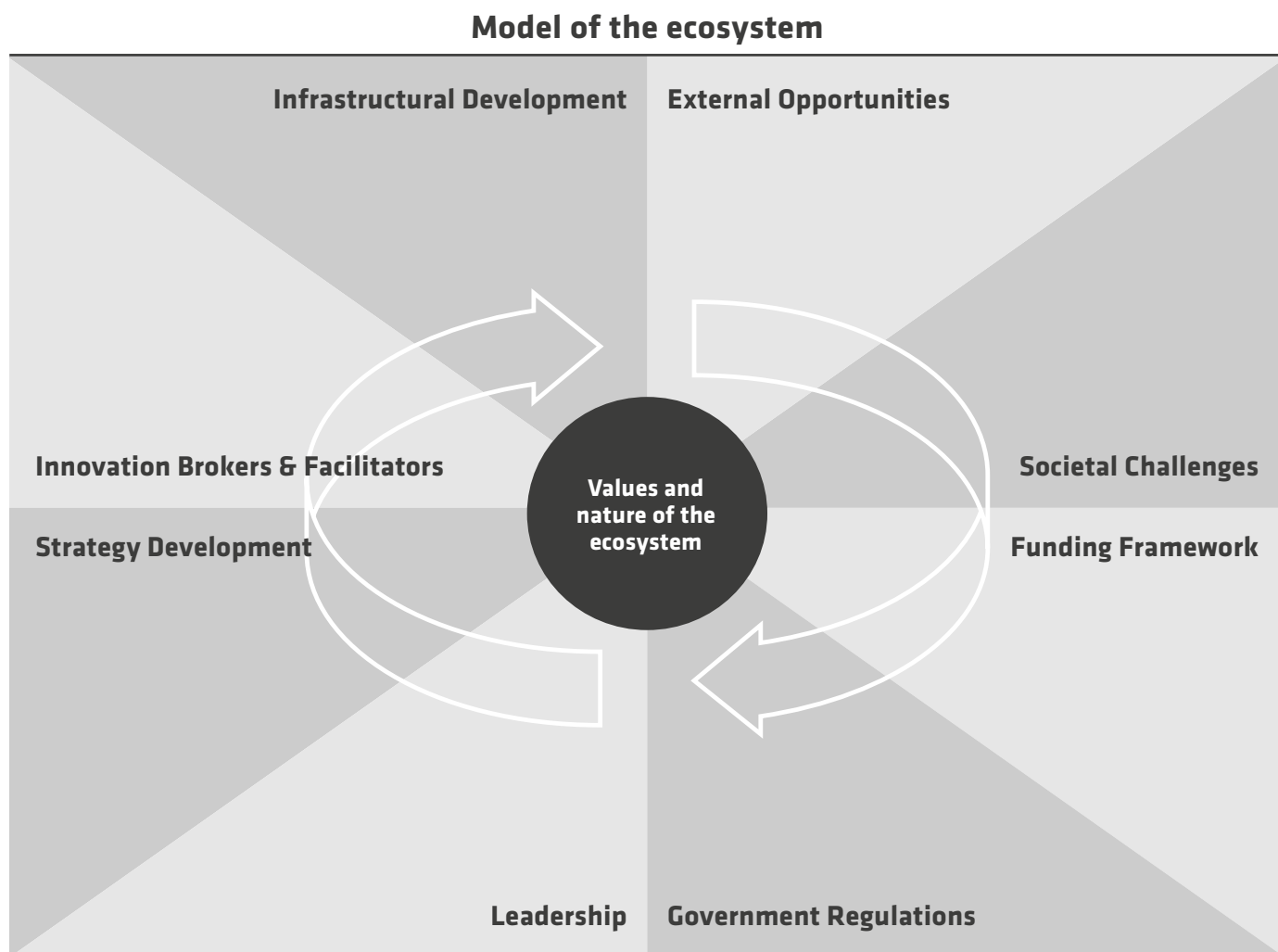
1. the cultural assets and norms of a region, including collective narratives, traditions and communicational attitudes and expectations that are regarded as definitive of regional interactions;
2. the process of policy and strategy development, including the strategic opportunities which regional actors identify and which form the focus of regional development;
3. the funding framework and most important financial instruments for regional development;
4. the set of key actors and their functions, i.e. the roles of national, regional and municipal government, companies, intermediary agencies, and most centrally, for this study, the role of the university. This included different levels and groups of agents within the university, such as its leadership, students, researchers, and university managers;
5. the most important aspects of infrastructural development.

The semi-structured interviews ensured that the following key questions were answered by several types of actors:

Table 1 Questions answered during the semi-structured interview**The semi-structured interviews ensured that the following key questions were answered by several types of actors:**

1. Who are the key actors in the region driving the innovation fabric, both in terms of institutions and individuals?
2. What is the special role of the university, as compared with the other institutions?
3. How does the university respond to human capital needs of the region?
4. What is the role of the university in Continuing Education and Professional Development of regional partners?
5. What is the university's contribution to the analysis of the development of regional competitiveness, assets and potential?
6. How do different regional actors contribute to the process of regional strategy development?
7. How does the university's strategy take account of regional development?
8. How do different regional stakeholders aim at creating or retaining critical mass of research and innovation assets?
9. How do different regional stakeholders ensure its actors interact dynamically to create synergies?
10. How does the region make use of formal and informal networks to enhance its competitiveness and what is the role of the university in these networks?
11. What channels and formats of communication do intermediaries use to bridge different perspectives?
12. What funds and incentives can regions and universities make use of to develop regional competitiveness and how can universities help to mobilise funds?
13. What are the benefits and problems of financial incentives? (short, medium and long term funding)
14. How do infrastructures sustain regional competitiveness?
15. What is the role of universities in ensuring their competitiveness?
16. What do regional actors do and how do they join efforts to attract talents to the region? What is the specific role of the university in this?

At the end of each site visit, a report of the regional case study was drafted on the basis of the interviews and accompanying data and documents so as to make the data available for validation by EUA experts and the project advisory board, and for future perusal by researchers or practitioners. The reports all follow the same structure. Interview data were summarised with respect to: cultural assets, norms and narratives, strategic development processes, the role of leadership, the funding framework, the roles of the different institutions (universities, companies, governmental agencies, intermediary agencies) and infrastructural developments. The key elements of the reports were also presented in a visual chart to give a summary overview of key external and internal determinants of the role of the university in the regional innovation system, as the below example illustrates (see annex 3 for all charts):

Figure 3 Model of an innovation ecosystem

The changing role of key actors in regional innovation systems

2

2.1 The role of universities

The central role of knowledge creation in post-industrial economies and societies has given universities a pivotal role in society. This move has changed the role of the university as the traditional hub of knowledge production, giving it a new twist. The **university's new centrality is inextricably intertwined with its role of orchestrating multi-actor innovation networks**. The old key functions of the university of research and education have been given a new emphasis on networked processes of knowledge creation. The case studies provide rich evidence of ways in which the new formats of producing and sharing multi-actor knowledge are superposed or integrated with old roles of educating students and developing research. Indeed, the new roles of orchestrating innovation processes and mobilising entrepreneurial engagement give new interpretations to traditional concerns of universities with creativity and the realisation of creative potential.

2.1.1 Education: providing human “capital” for innovation

There is an overwhelming consensus that the university's most important contribution to regional innovation is to educate students and prepare them for diverse roles in future academic and professional development and leadership. For universities and their regional partners, the central concerns relate to sufficient quantity and relevant quality of 'human capital': are there enough graduates and do they have the right skills and competences?

Figure 4 Means and goals for learning and teaching

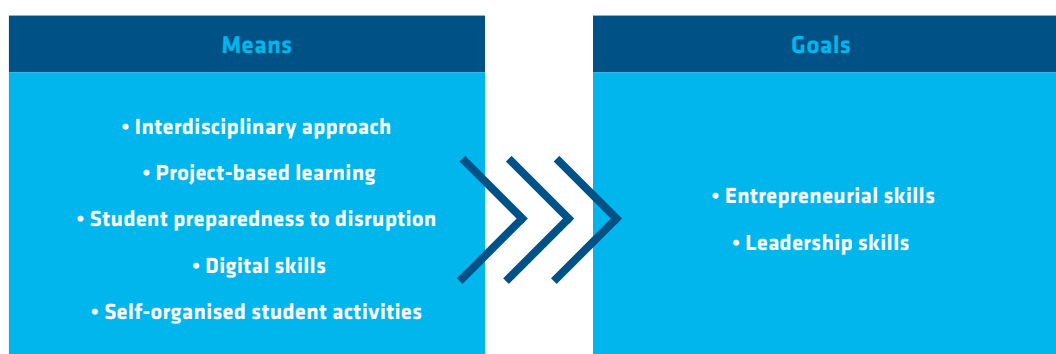


Table 2 Learning and teaching: needs, responses and framework conditions

New needs and concerns related to universities' role in innovation	Institutional responses of universities	Necessary framework conditions
<p>Qualitative aims:</p> <ul style="list-style-type: none"> • Prepare for disruptive innovation • Promote systemic understanding and competences • Create game-changers • Extend students research-related competences • Promote digital skills • Foster entrepreneurial mind-set and skills 	<p>Teaching reforms:</p> <ul style="list-style-type: none"> • Extend interdisciplinary, project-based learning • Support student self-organisation • Improve teaching innovation services • Extend mentoring, including by external stakeholders • Provide entrepreneurial modules, as extra offer or integrated into curriculum. • Develop digital skills modules • Encourage and support start-ups 	<p>Regulatory:</p> <ul style="list-style-type: none"> • Sufficient academic autonomy of universities for introducing new study programmes and design their content • Sufficient academic autonomy of universities for the selection of students to study programmes <p>Financial:</p> <ul style="list-style-type: none"> • Sustainable funding for low student/staff-ratios to allow for project-based learning, orientation in diverse learning paths, and mentoring
<p>Quantitative aims:</p> <ul style="list-style-type: none"> • Extend the skills base for the region or country • Increase engagement in the STEM area, particularly regarding digital know-how • Develop continuing professional development for employers, helping their adaptability • Re-skill and upskill in response to innovation needs 	<p>Outreach:</p> <ul style="list-style-type: none"> • Working with schools to promote STEM (for instance targeting girls), entrepreneurial mind-set, and digital skills • Working with schools to update and develop teaching skills • Extending continuing professional development offer and acting as contact points for easy access of businesses to universities 	<p>Regulatory:</p> <ul style="list-style-type: none"> • Sufficient financial autonomy of universities to fund continuing professional development through alternative funding streams, including fees <p>Financial:</p> <ul style="list-style-type: none"> • Provide enough resources for staff time to invest in support for schools • Provide financial incentives for continuing professional development in areas of high innovation need

Quality of higher education: what competences are needed to optimise innovation potential?

The key question is whether the competences that the universities are developing in their students match the needs of current and future challenges. This means answering the question of what conditions are needed for individuals to realise their full potential and to contribute to society, particularly in a context of change.

1. At all universities visited in this study, academic leaders and innovators emphasised the importance of interdisciplinary approaches to defining and solving knowledge problems. They insisted on the necessity of **integrating interdisciplinary approaches into teaching curricula and methods**. Interdisciplinary curricula or specialisation tracks and project-based learning served to connect scientific technological disciplines or to bridge exact sciences and human sciences in order to embed technological development in the context of human action.

In Paris, the flexible options of the new curricula, including majors and minors, at Sorbonne had attracted more and highly motivated students. In Munich, the Technical University of Munich (TUM) had integrated social science and humanities modules into their engineering curricula, in addition to promoting digital and entrepreneurial skills across all disciplines.

Some systems with traditionally lower levels of academic autonomy have seen obstacles to the creation of new, interdisciplinary study programmes; however, the legal framework has become more flexible recently. In Poland and the Czech Republic, universities welcomed the changes in the legal framework and the quality assurance system, which give more flexibility to introduce interdisciplinary programmes. Masaryk University had thus been able to introduce a curricular structure to promote interdisciplinary competences among its students.

2. **Universities strongly emphasised the importance of preparing students to address disruptive social, technological and economic challenges in the future.** At several institutions (Aalto, TU/e, TUM), fostering innovation in the twenty-first century is associated with the idea of helping students or young researchers become “**game changers**”: innovators who are able to fundamentally rethink problems and find or adapt to disruptive innovations. These three universities have also linked their quest to recruit and produce “game changers” to taking on the institutional identity of an entrepreneurial university.
3. Every university in the study mentioned placed an increased emphasis on **project-based learning** as a key ingredient of teaching methodologies and curricula. In particular, it was stressed how important it was to link theoretical learning with the solution of real-life problems presented by companies in the region. These problems are solved by students from different subjects in interdisciplinary teams, sometimes mentored by academics as well as by external professionals. But even in a more purely academic environment, project-based learning is experienced as an important fundament for enabling students to become future innovators, as the example from the University of Warsaw’s Faculty of Physics illustrates.

The **Faculty of Physics** organises challenge projects in order to unleash creative potential and promote independent problem-solving skills. Students have to come up with a problem to solve, find a tutor and the means to solve the problem themselves, all in a challenging but safe environment. Feed-back shows that, for students, it is very important to feel that they are the actors of the creative process. Furthermore, they are supposed to learn how to work and solve a problem in a team, a vital skill for academic as well as other professional careers in all knowledge-intensive sectors. In order to be able to move beyond incremental innovation and allow for more than the rapid application of scientific results, future innovative thinkers and problem solvers should be able to think against the grain of existing knowledge. Thus a leading physicist of the department comments: “Ultimately, it does not really make a difference what they study as long as they are able to develop their critical thinking, their intellectual capacity to abstract knowledge and solve problems, and methods and attitudes that allow them to not be helpless in the face of difficulties. These are the capacities that will allow them to be truly innovative in the future.”

4. At all universities visited, no matter whether they are technically oriented or comprehensive in their portfolio, there are **concerted efforts to promote entrepreneurial skills** and mind-set through extra modules, special projects, or mentoring. In most institutions such an offer was optional, but often integrated as recognised credits into regular curricula. Eight out of nine universities mentioned special **challenge projects** or competitions in which students organised themselves in inter-disciplinary teams in order to solve a particular real-life problem with a deadline. **The ideas of self-organisation, collaboration in teams, and project-based learning and ownership of the learning process were regarded as central to these learning formats. They were the key to acceptance of these formats among students and their future success as innovators.** Aalto’s approach to promoting student entrepreneurship is a good case in point.

Aalto University aims to provide every student and staff member with experiences of entrepreneurial thinking and actions. The education system supports entrepreneurship by trusting

the students in their first initiatives. Successful initiatives further enhance trust and build confidence among students. The university believes in not too much intervention, but in ensuring a multidisciplinary, encouraging environment where students can meet colleagues from other disciplines through curricular or student initiatives. The teaching involves a lot of team-work and mutual learning, emphasising real-life problem-solving through projects for companies, internships, or by integrating real-life cases and lectures by corporate partners into curricula. The Product Development Project (PDP) courses, which are open to students from all disciplines, use a problem-based learning approach to solve problems given by companies. As a symbol of this approach, the most comprehensive iconic initiative in this context, is the internationally renowned *Design Factory*, which combines a student entrepreneurship research programme with a university-business co-creation platform:

Since 2008, **Aalto Design Factory (ADF)** has been a model for Aalto's role in the innovation ecosystem. After the foundation of Aalto University, it has been one of the most visible manifestations of the new interdisciplinary university. ADF is both a physical space which hosts project-based courses, and an operation model for co-creation that helps to build a coherent innovation ecosystem. Most importantly, ADF stands for Aalto's approach to education. Aalto University, in its own words, is addressing "the challenge of educating students for an unknown future, to solve ever more complex, so-called wicked problems. In addition to learning competences in specific fields, there is an increasing need to provide learning experiences that better prepare graduates for co-creation. The more they understand and respect experts from other fields, and are trained to work with open-ended problems, the better they meet the expectations for working life. With the right attitudes—curiosity, hunger for learning, entrepreneurship—the graduates will adapt to the future, and they will have a strong impact on making the future." (Internal Self-Evaluation Report in its Research, Art and Impact Assessment 2018, Field 8: Innovation Ecosystem).

Thus, ADF offers a home base for long student research projects, courses and events, for students across all disciplines. Roughly 1500 students make use of the ADF infrastructure and services annually. They look at some challenge presented by a company, then develop a prototype as part of a multi-disciplinary product development project course. Concretely, students select 15 out of the 20 cases proposed by the companies, and then form student teams to meet the challenges. Sometimes the problems are redefined by the students. The students are paid 15 000 Euro by the companies, which thereby gives them the opportunity to access new talent. Many of the students will later take up a 4th-year summer internship or Master's thesis at the company after the course.

The Design Factory thus provides a platform for a new kind of learning: "In a safe way they take you out of your comfort zone. The physical space is open 24/7. Externals can come in. There is low threshold for talking to people and join projects. One of the rules is that one has to talk to the strangers." ADF experts help students, teachers, research projects, and start-ups by providing short courses, workshops, consulting, prototyping, and testing. For teachers, the Design Factory served "as a sandbox for pedagogical development and experiments", supporting teaching innovation.

Most visibly to external stakeholders, ADF has become a platform for interacting with industry to apply research results as a co-creation platform for prototyping and testing new innovations. The prototyping facilities are shared by students, researchers and external project partners. The whole facility is run by a head of research who is also a professor of practice. The number of spinoffs, start-ups, and small business partners exceeds 50. ADF shows bigger and smaller companies how to utilise the expertise in the university. There are 2000 official visitors a year.

With the overwhelming success of ADF, other universities have been interested in setting up design factories in their innovation ecosystems. Since 2011, 24 design factories have been established at other locations in a franchising model after paying a 5000 Euro fee. An international design factory week brings all design factories together (www.dfgn.org).

5. All universities are concerned with the challenges of digital transformation and what it means to future graduate profiles and are thus considering **integrating digital skills more widely into other curricula**. According to university and company representatives in several regions (Barcelona, Brno, Manchester, Warsaw), their national systems would benefit from developing a more differentiated set of IT career paths, including IT-versed high school graduates who could go straight into coding jobs in companies and many more higher education curricula that combine IT skills with different disciplines.
6. The promotion of **leadership skills and social responsibility** among its students was an important institutional concern at the Universities of Manchester, Warsaw and Sorbonne. The most systematic realisation of this concern could be found at the University of Manchester.

The **University of Manchester** attributes great importance to **social innovation** in its social responsibility programme, which is supported by a Social Responsibility Service, headed by a Director who reports to the Associate Vice-president of Social Responsibility. The university offers a wide array of civic activities: from supporting local schools by mobilising interest in highly needed skills or even through voluntary engagement of its academic and support staff as school governors, to helping reinsertion of long-term unemployed into employment through low-threshold positions within the university. It also systematically mobilises students to participate in such activities as part of its social leadership education in its undergraduate core programme *Stellify*.

Stellify, which was implemented through extensive curriculum changes, promotes a series of transferable skills, including personal, social and leadership skills, to foster social responsibility and global citizenship. *Stellify* (“to change, or be changed, into a star”) challenges undergraduate students to take action and “embrace learning without barriers” in work placements or voluntary work in the local community, sustainability challenge weeks, or leadership positions within the student body, or participation in the Manchester Leadership Award programme. It thus helps students to expand their horizons beyond their specialisation. Thousands of students participate in *Stellify* annually.

7. **Self-organised student activities** were important at all universities. There was a strong identification (including self-identification) of the students being ‘millennials’, with attributes like pro-activeness and idealism. Institutions tended to support these activities as an important contribution to the learning environment. At **Aalto University**, student-led activities were particularly visible, with students organising innovation events for start-ups and investors (www.slush.org), hackathons, and running a venture capital fund. At the University of Minho, the student union likewise acted as a key promoter of innovation.

Start-up Braga, an accelerator and innovation hub in digital business, digital health and nanotechnology which is publicly funded by the national government, originated in a community-driven informal initiative of a “group of restless students”, when many had to leave the country in a time of crisis. They believed that it was possible to change things locally and engaged other students in a small revolution to support start-ups. Supported by the student union, they involved stakeholders and managed to get public support.

Still today, when Start-up Braga has become a government-funded professionally run service, the highly active student union of the university offers start-up support to lower the first threshold for entrepreneurial students. The student union is the first and only student union to have an entrepreneurship department, with an office to support start-ups (“lift-off”), set up in 2013, co-funded by EU ERDF funds (Norte 2020), a regional programme cohesion fund. They hold meetings with individuals interested in start-ups, and support projects (23 last year). Alongside with the university start-up service, the entrepreneurship department has created a network to organise talks and workshops, a “working ideas” programme, and a white night challenge project.

The union is supported by 37 student employees (a majority of whom are volunteers, 15 of whom are employed with support from the university). The union provides volunteer opportunities, is closely engaged with the community, with more than 30 groups of different activities, in distinct union departments. In addition to the student start-up service, the union runs the office “GIP” (a government brand, but this being the only one run by a student union), for students and graduates under 30 years old to help with job opportunities, organising a job fair with 70 companies, with over 110 single meetings, and 1000 students directed to job opportunities. All of these activities are regarded as important for creating a common “can-do” mentality and solidarity that is regarded as highly motivating by the student community, and that carries on into a supportive alumni network which includes a growing number of mentors.

Ensuring sufficient numbers of skilled graduates

Apart from the wide range of curricular and extra-curricular initiatives aimed at providing the right competences, skills and mind-set to students, the case studies revealed a wide-spread concern about simply graduating sufficient numbers in certain disciplines. Particularly with digitalisation being a transversal societal trend that requires specific skills, there is apprehension of the need to recruit enough students in areas where there are imminent labour shortages.

In a majority of the case studies (Brno, Eindhoven, Helsinki, Manchester, Minho, Warsaw), the universities were keenly aware of the current or foreseeable shortages, especially in the STEM subjects, and IT branches in particular, and were spending time and resources on marketing and developing the regional talent pool.

At **University of Warsaw**, the problem of limited availability of digitally qualified graduates has been addressed in the new six-month programme called “**Humanities in New Technologies**”, which adds additional optional courses to normal standard curricula. In addition to teaching programming skills, tools and science, the programme pursues paths in new technologies (information social media, testing, big data) that are relevant to the humanities. The key idea is to present students who are studying cultural and social theories with real-life problems and ask them to find solutions and to develop systems that are ready to be deployed so that they learn how a real project development process works.

At the department of physics at the University of Warsaw, an internationally highly visible research centre, the faculty is investing considerable time and care into awakening a keen interest in physics in the next generation, with hands-on experimental projects at kindergartens (Physical Merry-go-round) or schools or with research workshops for gifted school children (funded by the Polish Children’s Fund but conceived at the university). Many of those who came from rural areas and benefited from the opportunity to enter a university education at a time when university participation rates were still very low, are keen to give something back to

the communities where they came from, and are often engaged in such projects at schools in their regions of origin.

While **Masaryk University's** offer in STEM subjects is successful in attracting students, and has been able to provide the booming regional IT sector with enough graduates, future shortages can be foreseen. Already now, the local problem of an over-heated IT economy is blocking more radical innovation paths since it is much better, from a salary point of view, to be a corporate employee in the IT sector than to begin a start-up with a clever business idea or an exciting PhD research project. Since the whole society needs many more IT workers, there is a need to broaden the pipeline, and to enhance IT preparation at schools.

For now, the university is engaged in mobilising under-utilised potential by addressing young girls. The programme "Chicitas" is motivating girls to code, changing their perception of technology as something cool for girls. Moreover, the university is trying to leverage the under-exploited potential of combining IT skills with other disciplines. Like Google, where the best workers are those that have IT skills and other competences and knowledge which allow them to think outside the trodden tracks, the university aims to develop a more differentiated set of IT university and career paths, including humanities graduates with IT coding skills.

All universities visited contribute clearly to ensuring a sufficient quantity of qualified graduates since they attract students to the region – an increasing number in a majority of cases – and contribute to a high proportion of their graduates remaining in the region. For most universities, the proportion of graduates that remain in the region is higher than the proportion of students that originally come from the region. They are thus net importers of talents (see Annex 2). Also at the PhD level, significant increases imply a net import of talent.

The role of the university in innovation is linked to teaching reforms

In light of the fundamental questions which universities are addressing in their response to innovation challenges, all universities visited in this study attempt to **align learning and teaching reforms to their role in innovation**. Reforms of learning and teaching have been high on the agenda for European universities for a large part of this decade, spurred by a cultural change towards student-centred learning. Many of the examples above fit the turn towards these learning models, in particular learning in small groups and problem-based learning, which have become widespread among European universities (Gaebel et al. 2018, pp 53-56).

At Aalto, Eindhoven, Manchester, Minho and Munich, such reforms were explicitly and systematically linked to the university's role in innovation. At Sorbonne University and Masaryk University, such reform processes had involved the introduction of new curricular structures and of add-on entrepreneurial programmes. At the Polytechnic University of Catalonia (UPC) in Barcelona and the University of Warsaw (UW), reform measures were still voluntary and punctual, but were also seen to have a transformative role for individual departments or faculties, and to constitute role models for other parts of the university, as the example of Warsaw illustrates.

At the **University of Warsaw**, against the backdrop of more traditional teaching, there is a range of recent initiatives to help students realise their potential by orchestrating independent, team- and project-based learning experiences in which analytical and problem-solving skills are developed systematically. These programmes also promote entrepreneurial attitudes by requiring initiative, self-organisation and team skills, and the ability to channel and apply analytical understanding to the solution of real-life problems. Many of these initiatives aim to enhance the attractiveness of the programmes as well as the employability of their graduates.

At the Master's level, a course on "ideas and informatics" for mixed teams of students in computer science and other fields aims to convey a broadened scope of innovation. Participants propose ideas, discuss them from different perspectives, propose what competence they bring to their further development, and later form teams to develop an idea of a project that could be realised in practice. Thus students go through the process of working through economic challenges, questions, steps, and market analysis. At the end they have to submit a proposal for a business, after which a small number is selected for continuation.

The programme includes classes directed to the management of small businesses. Although the course is still in its first trial period, its graduates' success is already apparent: the 700 graduates of the first cohort offered an unusual profile, combining analytical understanding of human cultural contexts with IT skills and interdisciplinary problem awareness – which proved to be very attractive for companies. The strong demand by students also shows how attractive such professionally relevant additions to theory-based university curricula is to them.

Other examples include the "start-up path" which the Faculty of Computer Sciences introduced as an optional path in the Master's programme in order to stimulate awareness of economic demands and business challenges among computer science students; or the Humanities in New Technologies programme or the challenge projects of the Faculty of Physics which promote independent problem-solving skills.

In current teaching reform discussions at UW, a new consensus is emerging that methods and contents of teaching could be adapted to include a more dynamic integration of theoretical foundations with exposure to practical problems. This would encourage creative thinking and motivate students to think independently and use analytical problem-solving skills. This would not, however, undermine the deeply held belief that serving curiosity is the *raison d'être* of all university teaching.

Beyond a rich array of individual reforms, some universities managed to undertake more far-reaching teaching reforms all across the institution, including common curricular features and teaching methodology guidelines which were closely linked to the institution's ability to foster innovation leaders. TU Eindhoven (TU/e) offers a case for a comprehensive reform which was based on the realisation that the engineer of tomorrow would need to be trained differently from the one in the past, as well as on the perception of cultural changes in the values of student body and academic staff.

At **TU/e**, it was widely appreciated that the new generation of students and academics show a keen interest in having a wider impact on society and economy, building on but also going beyond their academic interests. Challenge projects undertaken by teams of students who mobilised resources of local companies and university labs developed such momentum and public visibility among students and external stakeholders that the university decided to embed similar experiences more systematically into all curricula.

The attitudes and skills that became evident in these successful student projects were then linked to the teaching and learning reform that the university had undertaken in the last decade, which had combined a major curricular reform with emphasis on learner activation.

The curricular reform introduced a basic core of common maths, applied sciences, mostly physics, and information systems, and included history of technology and ethical, social and user contexts. After this, a wide range of course options could be chosen, many of which focus on engineering design in multi-disciplinary groups. The teaching methodology reform emphasised learner-activation, more coaching, more opportunities to choose learning paths, more

problem-based learning with problems from industry, as well as organised challenge projects to develop innovation skills. Analysis of student success, completion rates and time, and competence assessment, now gives ample evidence that the reform was worth the effort.

At the University of Minho, Aalto University and TUM, the teaching reforms included exposure to external stakeholder perspectives and entrepreneurial thinking.

At the **University of Minho**, the responsiveness of the teaching and learning offer to regional and national stakeholder and qualification needs was systematically ensured through:

1. mentoring offered to students in their second year, offered by alumni across disciplinary boundaries, as a university programme which is run by a psychologist;
2. internships that are integrated into curricula;
3. engineering PhDs having the option of undertaking projects in industry;
4. a diverse offer of continuing education and continuing professional development (CPD) courses, both as part-time degrees or short certificate courses as well as online support for professional learners;
5. distance learning courses which were expanded especially in areas where Minho is cutting edge, such as polymer and tissue engineering;
6. executive business education UMinhoExec (Business School and Law School), in short courses, sometimes tailor-made for companies, with full cost tuition income (reinvested for hiring researchers and equipment), with their own advisory board;
7. a diversified offer of language courses and intercultural learning (BabeliUM).
8. a very successful reconversion programme for STEM degree graduates to overcome ICT skills shortages: ICT skills are trained in six months (training done by professors for ICT, curriculum together with the university, course for credit, approved by the university senate, then 2-3 months in a company).

The teaching strategy of **Aalto University** was developed on the basis of an extensive teaching evaluation, and oriented toward the goal of providing a co-creative challenge-driven education of game changers. The student-focused, challenge-based way of learning includes opportunities for students to learn across the boundaries of disciplines, programmes and schools, while optimising the connection to real-life cases and projects in multi-disciplinary teams in close collaboration with surrounding society.

The close interaction with external knowledge creation is supported systematically by the orientation of the Master's degree programmes of which 75% are developed together with companies, so as to integrate real-life problem-solving into the programmes as study-related activity. Independent learning is also enhanced by the tradition to leave enough time in every day study life to include internships, volunteer and part time work as part of student life. In addition, many students have summer jobs. By the time students graduate, some have up to two years of work experience and 90% already have a job when they finish.

The regular teaching offer at **TUM** includes more project-based learning. All students are offered lectures about innovation and entrepreneurship in order to enhance awareness of innovation

opportunities and challenges. These include basic notions of the role of IP, and of business creation, usually conveyed by successful entrepreneurs. Many events showcase interesting and successful start-ups to encourage entrepreneurship. Most importantly, entrepreneurial initiatives of any type are encouraged. Student initiatives, such as the TUM Business Plan Competition that encourages students to develop their own business ideas through a game, are strongly supported.

According to interviewed students, innovation attitudes are pervasively instilled in a student career at TUM: trying something out is encouraged, thresholds are low, attitudes towards failure are benign and encouraging, and there is a huge pool of courses to explore innovation processes and opportunities. Moreover, the course organisation gives students a wide range of options and possibilities to change focus, so as to strengthen ownership of the learning process. The *Centre for Digital Technology and Management (CDTM)* was set up in 1998 to teach highly motivated students of any discipline to prototype by working on real-life projects provided by big and small companies, and to encourage working in cross-disciplinary teams. The digital and management know-how has given some students ideas for start-ups, and conveys important innovation skills for any professional career.

For such sweeping teaching reforms to take place, some institutional preconditions are regarded as crucial to ensure the desired flexibility and adaptability to regional innovation needs. At Eindhoven, TUM and Aalto, and Minho University, representatives stress the vital importance of:

- a rich research base which allows for innovation and project-based learning;
- student-staff ratios that allow for individual support and mentoring in such project-based learning processes;
- dense interaction with industry and other stakeholders to allow for access to real-life problems for project work, as well as for abundant mentoring and external teaching staff;
- a governance that allows for modular and flexible course organisation;
- communication and cooperation between different disciplines and faculties.

The following institutional features were also seen as important:

- cumulative short courses, with the flexibility of being combined differently in different programmes and tracks;
- a pedagogical training and teaching innovation centre, which can provide a regular update of teacher training and teaching methodology and support wide-spread use of new teaching methodology, including project-oriented teaching that integrates different disciplines (and departments or schools);
- professional curriculum development, with university teaching staff being supported by a service (providing, as mentioned by the University of Minho, first benchmarking, prototype development (elements presented in a workshop and adapted after first feed-back), marketing (e.g. marketing students looking for markets for distance courses, as part of their curriculum), academic approval in senate, and regular evaluation).

At Aalto, the University of Manchester and TUM, university representatives also pointed to their ability to have selective admissions procedures for students so that they can adapt entry criteria to the qualification profiles of the programmes.

2.1.2 Research: knowledge (co-)production for private and public value creation

Table 3 Research: needs, responses and framework conditions

New needs and concerns related to universities' role in innovation	Institutional responses of universities	Necessary framework conditions
Produce relevant knowledge: <ul style="list-style-type: none"> • Short-term: concrete solutions to current innovation problems • Long term: scanning horizon of scientific, technological and user developments • Co-creating knowledge by connecting different actors to address common innovation challenge in knowledge-intensive areas 	<ul style="list-style-type: none"> • Support curiosity-driven research with long-term perspectives • Adapt hiring policy to combine research excellence and impact criteria • Strategic partnerships with few companies, organisations, including foresight function • Contracted research for specific solutions • Research support and business facilitation service as contact point for businesses • Promote interdisciplinary networks • Create and moderate thematic clusters bringing together diverse disciplines and institutions 	Regulatory: <ul style="list-style-type: none"> • Sufficient organisational and academic autonomy of universities to allow for flexible, strong interdisciplinary units Financial: <ul style="list-style-type: none"> • Support curiosity-driven research with sufficient core funding • Support schemes for university-business collaboration • Provide medium-term competitive grants for thematic cluster development
Access to research infrastructures: <ul style="list-style-type: none"> • Sharing expensive large state-of-the-art infrastructures • Access to technical facilities and equipment with technical support staff 	<ul style="list-style-type: none"> • Strategic investment in large research infrastructures, also as public-private partnerships • Provide long-term technical staff for infrastructures • Establish co-creation spaces and access to research facilities for externals 	Financial: <ul style="list-style-type: none"> • Provide sufficient institutional core funding for infrastructural investment, maintenance, technical staff • Provide special competitive funds for large-scale research infrastructures

The second dimension of the university's role in fuelling regional innovation consists in **(co-)producing relevant knowledge**. In its role as a motor of regional (or national) innovation, the university has to look for an intersection or balance between international research and regional relevance. This knowledge has to reflect the international research frontier in the given thematic area to ensure academic excellence and to help companies or public stakeholders face global challenges. **University research helps to give access to a "global pipeline" of knowledge to regional stakeholders in their innovation processes.** Moreover, such knowledge has to be translated into the stakeholders' own concepts and contexts so that it may be absorbed and create value. Hence, **whether or not a university succeeds in becoming a global knowledge pipeline for external stakeholders depends on the quality of the translation process between academic knowledge and external knowledge sectors of the business or public spheres.**

In their pursuit of internationally competitive research that is also relevant for external stakeholders, all universities emphasise five important developments:

1. *Promoting interdisciplinary collaboration in research to address major challenges:* While interdisciplinarity has been a prominent concern for over a decade, universities have been addressing it with increased urgency in recent years, both in recognition of scientific developments and in response to external research funding opportunities. Indeed, interdisciplinary approaches to research are seen, by university and company representatives alike, as a pre-condition for its relevance to real-life problems and applications. In most regions, universities and external stakeholders stress the importance of systemic competences in this context. Many institutional incentives facilitate research and teaching team collaboration across disciplinary (and departmental or even faculty) boundaries so as to address major challenges and real-life problems. Interdisciplinary research initiatives most often include multi-actor partnerships, adding to the diversity of perspectives. Company representatives in several regions (Manchester, Barcelona, Helsinki) even felt that **facilitating and conducting interdisciplinary research was the most important incubating role of the university in innovation systems.**

Accordingly, **cross-disciplinary networks are the key organisational preoccupation of any research-intensive innovative university.** Interdisciplinary networking is fostered with the help of intramural competitive funding, usually with the aim of helping collaborative projects develop into interdisciplinary clusters that combine strengths in different departments and position the university visibly in emerging research fields. Examples include the University of Manchester's Research Institutes or the Integrative Research Centres at the TUM (see example). In Barcelona, Eindhoven, Helsinki, Manchester, Munich, and Paris, supporting interdisciplinary research had led to major investments into new institutes and infrastructures, and had helped to expand research strengths or clusters of the university, such as Advanced Materials, Data Sciences, Energy Systems, Industrial Biotechnology, Precision Medicine and Cancer Research, in the case of Manchester University.

The strategic attention to interdisciplinary research and education is regarded as one of the key tasks of academic leadership at **TUM** and seen to have a significant impact on cooperation with regional actors. As part of its excellence strategy (in the context of the German federal excellence initiative in which TUM already obtained the excellence label in the first round in 2006 and kept it in subsequent competitions), the university supports so-called **"integrated research centres"** which reach across faculty boundaries.

A critical mass of professors is engaged in these new research focus areas, in concerted research collaboration. Examples comprise the new *Munich School of Robotics and Machine Intelligence (MSRM)*, the *Munich School of BioEngineering (MSB)*, the *Campus Straubing for Biotechnology and Sustainability*, the *Munich School of Engineering (MSE)*, which provides teaching and research in the areas of Environment & Climate, Energy & Raw Materials and Mobility & Infrastructure, or the *Munich Centre for Technology in Society*, which is dedicated to understanding the interactions between science, technology and society and social challenges of techno-scientific developments. All these centres receive additional funding (through the German Excellence Initiative Award) and benefit from hiring priority and the right to award doctoral degrees according to their own criteria. Thus, the status of these clusters is akin to faculties in institutional weight and decision-making power.

2. *Specialisation within a range of commonly accepted challenges and enabling technologies:* Perhaps not so surprisingly, the priorities of the individual institutions show a large degree of overlap from one region to the other as they reflect the major technological and societal challenges of industrialised countries. Overall, regional research priorities reflect large thematic areas that are of economic and societal relevance, both in terms of application and as cross-cutting enabling technologies, always clustering research interests across a wide range of disciplines.

While there is a striking overlap in the identification of the challenges, university research priorities identify particular niches within these large thematic areas, where outstanding research strengths have been identified and through which it positions itself nationally and internationally. Thus, while every region prioritises health research and innovation, one region may focus more on big data analytics for clinical trials and cancer treatment (Manchester), another on medical devices and imaging (Eindhoven); while all may address challenges of mobility, one may focus on driverless cars (Minho, Braga) while another addresses mobility systems (UPC, Barcelona). With regard to enabling technologies, the range was somewhat smaller, and some technologies are becoming ubiquitous due to their wide range of applications, particularly digital technologies, with artificial intelligence, more precisely machine learning and big data, mentioned everywhere. However, some regions had particular strengths in advanced materials, often emerging from industrial traditions from textile manufacturing.

Figure 5 Challenges and technologies

Priorities	Number of case study universities	
Application Areas		
Health	9	Medical devices, pharma, data, treatment/prevention, clinical processes
Advanced Manufacturing	7	Robotics/automation, sensors, self-adaptive systems, IoT
Energy & Climate	7	Energy sources, energy systems, distribution, efficiency, climate change
Automotive and Mobility	6	Vehicles, automated driving, mobility systems
Creative industries	5	
Food & Environment	5	EIT Food
Enabling Technologies		
Digital	9	IoT/5G, Big data, machine learning/AI
Advanced Materials	5	Smart materials, Materials for automotive industry
Photonics, Nanotechnology and Quantum Computing	9	Micro&Nanofabrication, Imaging, remote sensing, Nanoelectronics

In several national funding frameworks, research priority areas and cluster initiatives are supported through substantial competitive research funding. According to reports of university representatives, the universities needed to show in grant proposals to open competitions how they would cooperate not only across disciplines, but also between the university and business or public stakeholder sectors.

Hence, institutional support for research cluster development usually also aims to obtain such external research grant income. **Mobilising external funds for major interdisciplinary research emphases was widely seen as a key role of academic leadership**, either as thematic research orchestration, at the level of research leaders, or as lobbying for support by important external partners, at the level of institutional leadership.

3. *Pursuing innovation with a broad scope, including social innovation:* The role of university research in fuelling innovation is understood more widely than common innovation discourse may suggest at first. While current university discourse seemed to first understand their contribution to regional innovation in terms of economic value, in practice, universities strongly emphasised the societal challenges linked to technological and economic innovation and often actively supported such links. Institutional support prioritised questions of sustainable use of resources or social equality, for instance. Notably, the idea of linking innovation for commercial purposes with the search for addressing societal challenges, was often emphasised. In particular, solving environmental challenges was seen as a business opportunity as well as a way of building a more sustainable society.

Hence, at a deeper level of institutional value systems, universities' pursuit of a key role in regional, national or global innovation processes was experienced as a **search for a wider impact** of academic knowledge. At national levels, the search for impact of academic research is integrated into funding schemes of research councils and other public grant providers, either through special funding schemes or as evaluation criteria. This is most pervasively implemented in the UK where all research council projects are evaluated partly on the basis of fulfilling impact criteria (20%). At the level of individual actors, this longing for impact was most noticeable among students and the younger generations of researchers who were reportedly looking for wider impact of their research more often than the older generations. At the institutional level, there were examples of universities joining the growing trend of using the sustainable development goals as a strategic tool for the institution (TU Eindhoven) or as a common reference for the region (Aalto/Espoo). At Aalto University, TU/e, the Universities of Manchester and Minho, the quest for impact was presented as a key feature of the whole university.

4. *Substantial rise of external research income and of its proportion from industry:* A rich portfolio of applied collaborative research is widely regarded as a key ingredient of a lively innovation system. Universities play a decisive role in providing the researchers and competences for such collaboration. At all universities visited in the study, a **substantial increase in applied collaborative research** has been observed in recent years. Accordingly, **the external funding generated from industry sources has increased substantially at most universities included in the study**, even doubled at the University of Minho, or tripled at the University of Manchester and TU Munich from 2012 to 2017, while other research funds have declined with the crisis in some countries. To explain this rise, university interviewees point to an increased emphasis on applied research among research councils and other funding agencies (see 4.2.2) as well as to their own institutions' increased attention to research collaboration with external partners.

In some countries, such as Spain, the Czech Republic and Poland, the increase in industry research income for applied research had partly compensated for a decrease of funding for basic research and was even partly used whenever possible to subsidise basic research. Accordingly,

the proportion of external income generated from industry as compared to external income from public research competitions had risen substantially.

5. *Balance between curiosity-driven research and use-driven research:* The above-described shift of emphasis to more applied collaborative research that is oriented to, or driven by, external use was also observed with some concern. At all universities, researchers and academic leadership addressed the **complementarity and precarious balance between academic, purely curiosity-driven research and research for concrete use** or application, as well as between research excellence and innovation.

It should be noted that many scientists emphasise that there is no necessary opposition between academic progress and international research excellence, on the one hand, and the pursuit of its impact and contribution to commercial innovation, on the other. In fact, both aims can be mutually supportive: the most successful researchers in terms of international publication performance and public research grant acquisition are also often those that attract most interest and support from industry sources.¹⁹ Many institutional leaders will also point to researchers that combine international excellence with high innovation impact.²⁰ Indeed, some clearly fundamentally scientific pursuits, like research on the origins of the universe, can lead to the most lucrative innovations: radio astronomy at the University of Manchester was linked to the development of artificial intelligence, and physics research into the complex dynamics of RNA interaction at the University of Warsaw led to a start-up which was sold to a big pharmaceutical corporation for hundreds of million Euros.

Researchers also point out that collaborative research with external partners may raise problems and questions that are of great interest from a purely academic point of view. Not only have the borders between fundamental and applied research blurred or even dissolved in many fields but use-driven research may also generate exciting questions for curiosity-driven research, not just vice versa.

Nevertheless, researchers and leaders from universities as well as strategists and executives from large corporations frequently emphasised that substantial breakthroughs with high commercial innovation value presuppose more than the rapid application of scientific results. They require investments that can live without foreseeable commercial results for more than 10 years, and thus need increased public resources. While the traditional juxtaposition between fundamental research and applied research may not correspond to research practice any longer, there is still an important conceptual juxtaposition to be made between long-term research, on the one hand, which is driven by curiosity and pursuit of knowledge for its own sake, and research for medium-term use and economic value added, on the other.

All universities emphasised the importance of the long-term perspective of innovation. At Aalto, university leadership even accepted a reduction in industry research income in order to shift from the tradition of commissioned applied research to more long-term explorative applied (or fundamental) research in university-business collaboration. At some universities (University of Minho, UPC and the University of Warsaw) where such reduction was not affordable, university researchers and leaders were looking for ways to make the more short-term problem solution-oriented collaboration projects benefit more long-term academic research. At Warsaw, for instance, the university leadership provided matching funds so that research income from industry would benefit basic research even when the concrete targets of the grant project would not.

Across all regions, a wide range of interviewees from academic research as well as from corporate strategy underlined that **if the shift of interest to impact-driven research that was noted in all case study regions occurs at the expense of curiosity-driven research, rather**

than complementing it, this would ultimately threaten the breeding ground for all innovation. In doing so, it would jeopardise the innovation pipeline as well as the ability to foresee and adapt to more radical forms of innovation.

In balancing academic research with research for external use, researchers and academic leaders frequently expressed their concern that the relevance of knowledge production for external stakeholders should not undermine the pursuit of knowledge for its intrinsic value. Such a shift would compromise both the intrinsic motivation and ability of scientists to pursue difficult ground-breaking research as well as their long-term competitiveness as researchers and access to the frontiers of the field. This would, in turn, undermine the sustainability of the innovation pipeline. Instead, universities see their role as key contributors to innovation in a medium-term as well as a long-term perspective. In their institutional responses to technological, economic, and social innovation challenges, they have developed new institutional approaches to research and education that address both current and future innovation capacity, blurring boundaries between traditional research and education and knowledge exchange, as the following graph illustrates.

2.1.3 Knowledge exchange for innovation systems: From technology transfer to multi-actor co-creation

Table 4 Exchange and knowledge transfer: needs, responses and framework conditions

New needs and concerns related to universities' role in innovation	Institutional responses of universities	Necessary framework conditions
<ul style="list-style-type: none"> Facilitate joint innovation between universities and companies, public organisations 	<ul style="list-style-type: none"> Create incentives to reward academic staff to engage in cooperation for external societal impact Create joint labs with external partners Establish and use advisory boards level to develop common agendas Develop framework contracts for partners Expand research contract support and business facilitation service 	<p>Regulatory:</p> <ul style="list-style-type: none"> Facilitate private-public partnerships by helping to minimise regulatory hurdles and transaction costs <p>Financial:</p> <ul style="list-style-type: none"> Provide competitive support schemes for common research and research structures Provide sufficient core funding to allow universities to be equal partners in joint structures
<ul style="list-style-type: none"> Create and protect value from IP Create new businesses with high innovation and growth potential 	<ul style="list-style-type: none"> Develop technology transfer/IP service Develop start-up support service and spaces for students and researchers Connect with external actors, such as start-up services, science parks, and investors 	<p>Regulatory and Financial:</p> <ul style="list-style-type: none"> Provide financial support for business creation and growth Establish or support establishment of Venture Capital
<ul style="list-style-type: none"> Promote social innovation, including civic participation 	<ul style="list-style-type: none"> Reward engagement for social innovation symbolically and in career advancement 	<ul style="list-style-type: none"> Create financial incentives to reward research and teaching engagement for social innovation

Engaging with external stakeholders constitutes a third vital role of universities in their innovation systems. While this role has always been an integral part of university management and leadership and has attracted targeted institutional support in the last two decades, it **has now become a central strategic concern, often of the highest priority for institutional leaders.**

One of the reasons for universities giving engagement and collaboration with external partners a higher priority is the general opening up of the research and development processes of companies through new models of open innovation (Chesbrough 2003). Whereas the process from idea to product has traditionally been described as a funnel, where in-house research develops from a broad scope of ideas to a narrow range of actual products, in open innovation, the metaphor of the funnel is typically described as porous. The holes represent ideas that are not used by the company but shared with others to create value elsewhere (which in turn might be beneficial for the company later). The company likewise can take in knowledge from the outside to create value itself. In this model, sharing ideas becomes just as important as selling IP or incorporating IP from outside sources. The university and the knowledge creation that it facilitates, either through its own research, in its learning environments, or through its innovation activities, become central actors in the circulation of ideas and know-how.

To realise such knowledge exchange, universities focus on six types of activities, all of which have seen an expansion but also significant changes in emphasis in recent years as will be described below, namely on:

1. transferring technology and creating value and IP from university research;
2. facilitating business innovation through user-friendly access to university research;
3. conducting contracted research or collaborating with businesses in joint research projects;
4. building long-term strategic partnerships with businesses;
5. supporting business creation (student start-ups and research spin-offs);
6. offering continuing education/professional development courses for external stakeholders.

1. Technology transfer: In the beginning of the new millennium, many universities focused on the expansion of technology transfer services as the most prominent part of knowledge transfer. Technology transfer services were expanded to sizeable operations that often needed their own legal organisation to make profit. In some countries, organisational formats which combined a new legal status with ownership by the universities, such as private legal entities in Poland, were introduced. A growing emphasis on research commercialisation and IP protection spread from companies to research policies, funding schemes and reward systems, and then to researchers. Counting patents and licences as part of academic performance in grant selection criteria (Czech Republic, UK), performance-based financial allocations (Portugal, Poland) or promotion criteria, all form part of this trend.

Accordingly, the identification and protection of IP expanded considerably, both in terms of staff employed and in terms of income generated. At some universities visited in this study income from IP /technology transfer activities has more than tripled in the last five years: such as Manchester, reaching €3.6 million in 2017, University of Minho with €4.1 million in 2017, or TU Munich where it amounts to €1.8 million in 2017. Nevertheless, as university researchers and service managers often underline, such **IP-related technology transfer is actually still a rather small part of the overall contribution of the university to innovation and a small part of universities' income from industry research grants.** Their significance is reported to be inappropriately exaggerated by policy makers. In fact, to interviewees from companies as well as some university researchers, the university's quest for defending its own IP appears to be protectionist, sometimes ignoring external market needs and commercial innovation dynamics (as emphasised in Barcelona, Helsinki, Manchester, Munich, and Warsaw).

- 2. Business facilitation:** There is wide consensus, among university leaders, researchers and external stakeholders, that **facilitating access of businesses to research with high innovation potential is a more important contribution of the university to regional and national innovation than technology transfer** in the narrow sense of the term (IP-related commercialisation of university research). Some universities, such as TU Eindhoven and Aalto University, have adopted this conviction with vigour and have explicitly prioritised business facilitation over IP-related technology transfer. At TU Eindhoven, IP receives low institutional priority while business creation and facilitation are seen as a key institutional priority.

As a result of this consensus, a **good interface between university researchers and companies becomes a central strategic concern** for universities that emphasise their role as innovation motors. The quality of these interfaces is seen as a key to the capacity of the university or indeed of the whole region to address major economic and social challenges, and thus of decisive importance for its future welfare. In recent years, universities and their regional stakeholders have invested time, care and resources to expand the university's contribution to business knowledge absorption by optimising such interfaces.

Such interfaces are less of a challenge with regard to large knowledge-intensive corporations or high-tech start-ups that emerge from university research, than with respect to SMEs with no university-collaboration record. For these SMEs, access to a university's knowledge and research competences has to overcome a high threshold. Ideally, the first contacts should occur by way of time-saving low-threshold single contact-points, since the search for relevant knowledge to solve innovation challenges in SMEs is limited by human resources and often-times a lack of in-house R&D personnel. Moreover, there is a cultural gap between university researchers and SME owners. One interviewee referred to the SME culture as 'smart but unsophisticated' with more interest in practical application than the theories behind it.

Several universities, such as the Universities of Minho, Manchester, Warsaw and UPC in Barcelona, have invested considerable attention to developing smooth user-friendly interfaces between the university and SMEs in the region in order to contribute to increasing their knowledge intensity and innovation potential. One such service, TecMinho at the **University of Minho**, is perceived to be particularly effective and user-friendly by businesses searching for research, as well as researchers who need support with grant applications and research collaboration contracts, IP protection, or students who need help with the process of starting a business.

University's TechTransfer and Start-up Service: TecMinho

TecMinho was founded already in 1990 as the University's interface for commercialisation. Since 2005 it has also included the start-up service of the university. It is Portugal's biggest and most dynamic technology transfer office and a model service for many universities inside and outside of Portugal. After a very proactive entrepreneurship policy of the past president, starting 2009, it reached its current size of 28 full time equivalent staff and supports a turnover of €4.1 million (2017). TecMinho offers a comprehensive commercialisation service and interface between the university and companies in a wide range of different support schemes. TecMinho reports to the vice-rector of research, and works closely with the prorectors for research and projects and for infrastructure and life on campus.

In addition to proactively scouting and approaching researchers in their IP and/or business creation, and facilitating the whole process of patent submission, TecMinho helps the creation of new companies in its one-stop entrepreneurship office *Start@Minho*, with a wide portfolio of instruments. These include:

- the *SpinUM* award scheme for the best innovative ideas that demonstrate high market potential, and
- the *Idea Lab* which tests and develops entrepreneurial talent and market potential. The pre-incubation support includes tailor-made business coaching to prepare business plans, conducted by external consultants with business experience, and a network of mentors. Eventually, start-ups are connected with VCs.
- TecMinho also conducts a *Company Lab* for projects and existing start-ups that are already nearer to the market. It organises awareness-raising workshops on entrepreneurship opportunities, company creation, markets, financing, with study cases and open classes, bringing together organisations that support entrepreneurs and role model entrepreneurs (often alumni).
- TecMinho also manages a comprehensive entrepreneurship programme, which involves promoting an entrepreneurial mind set, culture and set of competences through project-based learning.

In the beginning of the business creation process, students or researchers do not need any money but just a mind-set. They can use university labs, make use of a service that is simple, aiming just at creating opportunity and adding value. The services are not just used by the technical or natural science departments but increasingly also the non-technological schools, in particular the social sciences, psychology, law, and economics departments, which also have many contracts with external stakeholders and hold service units within schools, providing services to external clients (for example, rehabilitation of ancient monuments, and geographical property protection). Awareness of entrepreneurial opportunities has now spread significantly, and accordingly the number of spin-offs has increased significantly in recent years. Overall, there have been 530 companies created by former students of U Minho over the years, with €2.2 million average turnover per company and more than 13700 staff employed.

- 3. Conducting university-industry research collaboration:** For universities, **collaborative research and research grant income generated through university-business research cooperation constitute a substantial and fast-growing proportion of institutional research and of its funding base.** With increasing intensity of collaborative research, researchers and academic leaders report that attitudes and expectations toward university-business collaboration have changed significantly in the last decade.

In addition to research collaboration and contract research, academic leaders and researchers increasingly emphasise **processes of co-creation with business innovators in some research areas**, especially in the context of joint labs and joint applied research centres. For co-creation to emerge, and for the translation between academic research and its application in innovation processes to work smoothly, bridges have to be built between the knowledge, problems and challenges that emerge from the business context and those that emerge from academic knowledge. Hence, the innovation-oriented university pro-actively searches for areas of mutual interest, which are developed at individual and small group level by academic staff and amplified at institutional level by supporting partnerships or systematic stakeholder exchanges. A number of institutional measures aim to foster such interlacing of perspectives and co-creational attitudes:

- Joint labs, co-funded by universities and companies

- Joint research infrastructures
- Open fab labs and other innovation spaces for multiple users
- Appointments of *professors of practice* (experts from industry who are employed part-time or are recruited as full-time professors at the university) or recruitment of professors on business-sponsored chairs
- Long-term strategic partnerships with companies

Representatives of several universities (UPC, Minho, TUM, TU/e) greatly emphasised that **sub-cultures of co-creation emerged from long-standing relationships of mutual trust**. University-business co-creation requires continuity to thrive. On the part of the companies, accumulated experience is needed to create trust that questions get answered, companies are listened to, and timelines and constraints respected. On the part of university researchers, accumulated experience is needed to show that enough time, space and infrastructures remain for undertaking research that is driven by academic curiosity, regardless of their future use.

Both company and university representatives emphasise this dual need: for the university to be responsive to industry needs and aware of its constraints, and for university researchers to be able to develop their own academic vision and projects. This is the case, for example, in the photonics area at Eindhoven or in the Bosch Done Lab for advanced additive manufacture at the University of Minho. As university and company partners underline, only with the right balance of cooperative openness and readiness to listen and respond, on the one hand, and independent analysis and foresight, fuelled by curiosity-driven science and innovation, on the other, can breakthroughs be achieved, next-generation technologies developed and triple helix innovation thrive.

- 4. Building university-business strategic partnerships with long-term perspective:** Universities and businesses are increasingly looking for strategic frameworks in which more open-ended, more potentially disruptive research challenges can be addressed. Here, the **university plays a key role in identifying and developing long-term innovation potential** for companies and regional stakeholders. A close partnership with carefully selected universities could help their mutual positioning as game changers or market vanguard. Working together, they can explore innovation potential and new technological development in an area which has been identified as strategically important but difficult to predict or map for future development.

Thus, in several case study regions, university leaders and representatives of larger globally oriented companies highlight the importance of a joint search for long-term innovation potential. This results in strategic partnerships that comprise a whole set of research projects and structures, building on, but clearly transcending previous (often long-established) medium-term collaboration projects. Academic researchers and business innovators join forces to identify opportunities, and define key problems to be solved to position regional assets, companies and academic research groups. In addition to strategic focus groups, joint labs and longer-term explorative research with a range of industry-funded PhD or other research positions will usually form part of such partnerships. This happens especially in technological fields and new constellations of technologies and market development where the potential is hard to grasp.

The long-term perspective of such **strategic partnerships and their emphasis on open challenges** make these collaboration environments particularly desirable to university researchers as they are **more compatible with curiosity-driven research**. Hence, the instituti-

onal leadership of Aalto and TUM sought to expand these forms of collaboration. Short-term applied research projects in which academic researchers are sometimes “reduced to industry workbench functions” were given lower priority. For regional and municipal agencies, such partnerships are also highly desirable as they attract major global companies to the region with a more long-term perspective that tends to result in multiple investments. Hence, universities create the particular glue to a region that cannot be easily copied by others.²¹

- 5. Supporting business creation:** All across Europe, the **most dynamic development has been the emergence of vibrant start-up scenes in and around university communities in knowledge-intensive regions**. Very often, representatives of such start-ups will themselves point to the importance of their regional innovation ecosystems, by which they mean the larger set of densely woven networks to which they have access. All student start-ups or university research spin-offs have benefitted either from their university’s start-up support or from a metropolitan or regional start-up service, all of which have expanded significantly in recent years. They can often choose from several support schemes for early start-up ideation or incubation. Acceleration is usually offered in the form of services that can be accessed after a competition, in which start-ups with an already developed business idea “pitch” their idea and business model to a wider audience of possible partners and investors.

During their early development phase, start-ups often use university or other public infrastructural support and spaces, in proximity to other start-ups, high tech companies and research labs, for example in science parks on campus or in the vicinity of the university. As described in Chapter 5, these spaces, and the accompanying networking events (most prominently the competitions where start-up founders pitch for funds from venture capitalists) have developed into a distinct sub-culture. Vibrant, enthusiastic, ferociously creative and urbanely attractive, these sub-cultures have gained the attention of regional and city policy makers, the media, and metropolitan developers. Start-ups have become the visible figureheads of innovation and urban revitalisation, the symbols of economic revival and creative gentrification, risk-embracing pioneers of disruptive transformations.

For universities, start-ups have come to symbolize their most dynamic contribution to regional innovation and often the freshest, most attractive and least predictable vanguard of its impact-driven research. Several universities, such as Aalto University, TU Eindhoven, University of Minho, Sorbonne University and TUM, have strongly supported their local start-up initiatives and seen a remarkable rise in the number of start-ups and spin-offs. The highest level of activity can be observed at Aalto where approximately 100 start-ups and spin-offs are created each year, or TUM with approximately 75. The newly merged Sorbonne University has also seen a rapid development of a vibrant start-up scene, emerging from universities and beyond, that, like Aalto and Munich, has attracted international investors from all over the world. At the much smaller TU/e, there are still more than 30 start-ups a year (152 from 2012-2016). Increasingly, universities focus on a few of the most promising start-ups with high growth and even support these with their own VC funds in early stages (TU/e, Sorbonne University and TUM).

The remarkable extension of start-up support services mounted by universities to nurture these environments deserves more detailed description in two examples of good practice. The example of Aalto describes the strongly student-run development of the university’s start-up scene while the example of TUM works as a private foundation which includes a wide portfolio of services as well as a venture capital fund.

Student start-up services at Aalto

In 2008, one year before the establishment of **Aalto**, in the midst of the crisis of the established companies, a group of students thought that their environment was not supportive enough of entrepreneurship and founded an independent entrepreneurship society. They obtained the space for free co-working from the university and set up the so-called “start-up sauna” as a volunteer-based organisation run by students. All later instruments of start-up and accelerator support that are described below were born in the framework of this Student Entrepreneurship Society (*Aaltoes*, <https://www.aaltoes.com>).

According to the interviewed students and alumni, the motivation to engage in start-ups is not money, but more a sense of belonging to something important, the longing to be able to change the world. The idea of being a founder and of having full ownership of one’s productive working life also provides a strong pull. The dream to perhaps achieve fame may also motivate some founders. (Some showcase successes contribute to this dream: for example, the Supercell gaming business which is worth more than \$10 billion, with shares owned by every employee.)

Start-uplifters (SL), a student-run start-up internship summer programme has been an important jump-start for the start-up ecosystem at Aalto. Since 2011, SL has been organising internship opportunities and sending students to internships in Silicon Valley where they learn about the mind-set of high-growth/scale-up start-up businesses. SL works like a recruitment company, identifying and contacting companies that would be interested in hosting interns from Finland.

Over the years, more than 200 students of engineering, business or design, have taken up internships for periods from 3–18 months a year. In recent years, some have also taken up such internships in Tokyo, Shanghai, Berlin, or Moscow. Upon return, they bring that knowledge with them, including the sense that such successes are achieved not by superhumans but by normal people who just have the right resources and mind set. The former interns have created a highly active alumni network, and some have started their own companies. Most want to give back to the student entrepreneurship society, having benefitted so strongly themselves. Aalto University supports the programme by paying the visas and the flights for the students. The members of the board of SL work full time (and get salaries from the university), while some students get monthly top-up grants.

Slush is a start-up conference where start-ups can meet investors. Unlike other start-up matchmaking events, it is run and organised by students, global in scope, and staged like a rock concert with laser light shows, to brighten up the grimmest, wettest Helsinki November season (with abundant slush). It started in 2008 as an ambitious project to organize a small gathering for like-minded entrepreneurs in Finland. In 2011, it was taken over by Aalto students through the *Aalto Entrepreneurship Society*. At that time, lack of funding was identified as a major challenge, and an important motivator to *Slush* was to connect international investors with promising Nordic start-ups.

Slush is very much a community effort, building on student volunteers and giving-back mentality of successful entrepreneurs. A few key people were able to attract notable speakers from Silicon Valley, who were sufficiently open-minded to come to Finland and give a speech, pro bono. Success in gathering funds to support the *Slush* pitching competition attracted startups to attend the event.

However, the key factor that has made it possible for Slush to double in size during the years 2011-2015, has been the volunteers who make it happen (more than 2000 in 2017). With a reputation for providing the best volunteer experience, *Slush* has always managed to attract student volunteers who are eager to learn about the start-up world. The team behind *Slush* changes every year, and therefore surprising elements are introduced and the event itself transforms from year to year.

The event has gathered critical mass to draw the best start-ups, first within the Nordic countries, later also beyond, and attracting investors from all over the world. In 2017, over 1500 investors participated in the event, representing close to 300 venture capital funds and over \$200 billion in assets under management. As many as 2600 startups and 1300 registered investors pre-booked over 10 000 meetings that were held during the two days of Slush through the matchmaking tool. Through an online application tool, start-ups and investors can pre-book meetings to be held at the venue. The tool enables the screening of all attending start-ups, reviewing their in-depth information and scheduling meetings in advance. With the international success and recognition of the *Slush* event, it expanded to other sites, such as *Slush Tokyo* which was started in 2015 by people who had attended *Slush* in Helsinki.

At **TUM**, *UnternehmerTUM* (UTUM) was established in 2002, with a multi-million Euro foundation by Susanne Klatten, the heiress of the BMW group, who wanted to support the next generation of entrepreneurs. The central idea of the service, with its wide portfolio of support measures for entrepreneurs from student education and early ideation, incubation to acceleration with VC investment, was based on the diploma thesis by its founder.

While it became part of the entrepreneurial strategy of TUM, UTUM always remained an independent organisation, though in a loose affiliation with TUM. UTUM's value creation addresses innovation processes for two target groups: start-ups in various stages of development, and corporate innovators who are looking for new methods of innovation development and ideas outside the box, away from their established innovation processes. Both groups learn from each other: students benefit from the experience and business know-how of established players, while corporate innovators learn to take off their blinders and benefit from the fresh thinking, new sensors and sense of the possible of young founders.

Within the Xplore Pre-Incubation Programme, 100 Technologies or Business Ideas are evaluated every year for their market potential and scalability, the *XPreneurs* programme, is an incubator for early-stage tech start-up, which supports 40 of the best start-up teams until market entry by helping them to build networks, gain access to the right investors, and find customers.

Advanced start-ups can benefit from an accelerator programme, TechFounders, in which tech founders are invited in batches for three months to receive intense training in their preparation of the development and working together with established partners at the end of which investors are invited. UT also supports high-tech startups to access international markets through their contacts and global projects, where they collaborate with "top players" in the most important start-up hubs.

For students, the *Manage and More* lecture series and seminar has become a highly influential and inspirational programme, which changes students' outlooks and broadens their sense of career options. A *TechFest* Hackathon /Makeathon brings 400 people and firms together in a joint challenge where they work on the development of a prototype, supported

by coaches and experts. The motivation to participate is linked to the excitement of solving a real-life problem, as well as engaging in a process where there are no limits to one's creativity or need to ask questions and understand, and where one can also dare to develop and create something even if this is done on the basis of incomplete information.

In recent years UTUM also established its own VC Fund. UTUM's *Venture Capital Partners* provides venture capital for promising young technology companies with international market potential in the areas of industrial technologies and smart enterprises. Its Venture Creation programme also offers consultancy to firms. The *Digital Product School* forms teams of firms' employees to develop digital solutions for the company's own product development. UT also hosts one of 12 hubs of the "Digital Hub Initiative" established by the German Federal Ministry for Economic Affairs and Energy (BMWi) and Bitkom, and co-funded by the Bavarian Ministry of Economic Affairs.

With the new launch of the *MakersSpace*, a 1500-square-metre high-tech workshop which is open to the public and provides members with access to machines, tools and software, UTUM caters to ambitious start-ups, active DIYers and creatives. It offers a place to implement ideas and innovations in the form of prototypes and small batch production. Various work areas are available, such as machine, metal and woodworking shops as well as textile and electrical processing facilities. In addition, 3D printers and laser and water jet cutters make it possible to fabricate new shapes and to process every type of material. The MakersSpace offers training and consulting services as well as events for members with any level of knowledge, providing them with support and networking options. As a subsidiary of UTUM, MakersSpace is intensifying the local network of the city, universities, start-ups, companies and the local creative scene, and is widely regarded as a major asset of the ecosystem.

The key basis for UT's operations consists in its dense network of firms, investors, university researchers and talented students and young entrepreneurs, all of which reinforce each others' innovation capacity and understanding of the business potential of technological development, with a focus on the future industries of Information and Communication, Medical Engineering and CleanTech.

- 6. Offering continuing education and professional development courses:** Universities are conducting knowledge exchange by way of diverse offers of Continuing Education and Continuing Professional Development. Here, the level of engagement differs widely: whereas continuing professional development programmes are highly visible channels of knowledge exchange at Aalto and UPC, for instance, they are not treated as a central strategic pillar of university innovation at Masaryk or at the University of Warsaw. At the same time, both the latter offer a lively adult education programme to nurture general public interest in science and scholarship.

UPC Foundation for continuing professional development and education

UPC's active engagement with innovation processes of its external stakeholders is also reflected in its wide offer of Continuing Education and Professional Development: More than 2770 continuing education students are enrolled in more than 238 continuing education programmes, which are developed and managed by a foundation. The offer or management receives no money from the university and operates on a fee-sustained basis. Three kinds of courses are offered:

- Continuing education courses for the general public as professional Master's or other postgraduate degree, focused in the main areas of the university;

- Tailor-made programmes for companies or government agencies. These are taught both by UPC specialists and externally recruited teachers in accordance with the programme contents. To be able to respond to companies' needs, continuing professional development consultants work with the company directly to find out exactly what they want, and contact specialists in the area to develop the programme.
- Joint Master's programmes offered collaboratively with international partners.

The offer reaches across the whole portfolio of the university, from environmental technology to quantum computing, and is often interdisciplinary, for example the "Water, energy and city" programme for civil engineers leading to a postgraduate certificate, which is supported by the city council and a gas company.

The business model offers the advantage of being close to market needs. However, programmes which would be needed in terms of innovation potential but which involve a high risk in terms of immediate return on investment cannot be realised since companies are usually not ready to invest even if they see the need for addressing the topic in the long term. If there are not enough students who are able or ready to invest their private money to take such a course and not enough companies or other agencies who are ready to subsidise a course for their employees, important innovation topics cannot be addressed by this model.

Aalto professional development and executive education

For decades, Finnish universities have developed comparatively large independent Executive Education units. The **Helsinki University of Technology** was particularly proactive in this area already before the merger of Aalto University. With the foundation of the university, the continuing education programmes were merged into **Aalto Professional Development** (in technology and art and design). In addition, *Aalto Executive Education* was founded by merging the MBA program of the University of Technology and the Business School, in 2014.

Whereas the university cannot take tuition fees, **Aalto Executive Education** (AEE) is a Limited Enterprise with paying customers (ca. 7000 course participants in 2017). AEE's mission to disseminate the latest knowledge is realised in dense relation with society. AEE offers open programmes, customised programmes, and executive degree programmes (Executive MBA and MBA). The executive education programme emphasises the link with digitalisation, IT leadership or service design, and is taught 60% by Aalto faculty, 40% by external experts. For all its courses, there is a requirement of a minimum of 40% of the offer being taught by Aalto faculty, or by 50% in technology-oriented programmes.

Programmes are designed partly by demand, occasionally on the basis of proposals of the faculty. Of the income, 70% derives from its executive programmes, and 30% from its technology programmes, such as courses to enhance understanding in nanotechnology, coding, or blockchain. The key idea of the increasingly popular technology courses is to allow business leaders to immerse themselves into a technology world in order to be able to make strategic plans and identify future needs. In its executive programmes, design thinking tools are adopted. For all of its offer, AEE benefits from university and research partnerships, but also facilitates interaction in its own right. Thus, during the modules, faculty members get familiar with people from industry, building trust on both sides.

AEE is both nationally and internationally well positioned, operating in 14 countries on a permanent basis. Its second headquarter in Singapore has existed for 20 years, ensuring a

strong presence in the Asian market, in partnerships with the Singapore University of Technology and Design (SUTD). It also collaborates strongly with Stanford Executive Education. AEE achieves a revenue of €20.5 million (2017), steadily increasing from €8 million in 2010. Its 125 programme designers and directors, marketing and sales personnel and a lean administration ensure academic and quality management.

AEE has also benefited Aalto with some models of operation, such as the Corporate Partnership model which has been taken up by Aalto University in its strategic partnerships. Also, the idea of building different tiers or partners, with some circles being more elect and exclusive, by invitation only (for example president's circle, dean's circle, CEO circles), with high trust conversations, and the supporting "loyalty marketing" has positively influenced university leadership in its corporate and alumni affairs. The experience with building the brand in different parts of the world, strongly supports the branding of Finland as an innovation system. AEE thus also works in close relations with the Ministry of Foreign Affairs.

2.1.4 Strategic transformation: embedding innovation

As many of the above-described institutional measures have shown, the **universities' role in innovation is often linked to a far-reaching institutional transformation agenda and deeper development strategy**. In many core institutional processes, universities are looking for **interfaces between research developments with high potential and innovation priorities of their regional or national innovation systems**.

In several cases, such as Aalto University, TUM, TU/e, and the University of Minho, the systematic search for a key role of the university in regional, national or global innovation challenges even defines the overall institutional transformation process. These universities combine strong technical orientations with responsiveness to stakeholder needs as part of their original DNA (as part of the mission of technical universities). At the same time, they have recognised that today's innovation challenges require a comprehensive portfolio of changes in research organisation, teaching methods, personnel development, internal governance and financial incentives, as well as an expanded support service portfolio. Thus, even the traditionally responsive, innovation-oriented technical universities are refashioning themselves to meet the new scientific, technological, and social challenges of the twenty-first century.

At the universities where institutional changes were not as far-reaching, the research, teaching and knowledge exchange projects which were undertaken to address innovation challenges served as models for institutional transformation for the rest of the institution, as the case studies of Masaryk University, Sorbonne University, UPC Barcelona, and the University of Warsaw show. Moreover, all universities included some measures that reached across the whole institution in order to enhance their capacity to contribute to social and economic innovation through research and education. In several cases these strategic transformations have been enabled by or gone hand in hand with reforms of the university governance and funding frameworks (see chapter 2.2)

As one of the most far-reaching strategic measures, several universities, such as Aalto, TUM, Masaryk University, and the University of Manchester, emphasise the **vital role of the staffing policy**. Favourable frameworks (see next section) are needed for universities to align the staffing policy, and in particular hiring, with an evolving institutional profile. Indeed, limited staffing and financial autonomy as well as insufficient core public funding are important restrictions in this regard. UPC in Barcelona faced such financial issues. The University of Warsaw worked under a legal framework that on the one hand does not prescribe a mandatory retirement age and, on the other, foresees strict conditions for dismissals, thus hindering development potential.

At TUM, like at Aalto, the transformative agenda of creating an entrepreneurial university was realised, first and foremost, through its hiring policy. The institutional leadership emphasised that the value of entrepreneurship should not be understood narrowly as a mere inclination to seize business opportunities and seek business innovation, but as the readiness to venture out to new scientific fields or academic practices as well as the search for impact on society and economic welfare. Hence, the most important instrument in establishing an entrepreneurial spirit in the university consisted of aligning its hiring policy with such ambitions.

At **TUM**, transforming the institution meant, first of all, reforming hiring processes to realize such quality standards. Any vacant position has to be redefined in its orientation, with the assumption that it would not necessarily be reallocated to the department in which it placed before. Hiring commissions consist of a maximum of 10 members with a majority of members being external to the department, the university or the country, including an independent rapporteur who oversees the quality of the process and reports directly to the president.

Most importantly, the commission and the president base their hiring recommendation or decision on selection criteria that weigh strongly whether the candidate is ready to go beyond the familiar comfort zones of the area of specialisation. The successful candidate should take an eager interest, based on an outstanding competence, in new definitions of research contents and fields, looking for radical innovations in the field and achieving a profound impact on the scientific community and/or its industrial and social context. Experience shows that academics with such a spirit of innovation will also be entrepreneurial in their knowledge exchange with external partners.

At **Masaryk University**, the strategic emphasis of the institutional leadership lies most strongly on extending the international orientation, visibility and composition of academic staff and recruitment processes. To help induce this change toward international state-of-the-art research and competitive external recruitment, an international scientific advisory board has been established with members from the Institute of Science and Technology in Austria, Ludwig Maximilian University in Munich, Cambridge University, and the University of Zurich.

With the help of their recommendations, a new recruitment programme was developed to allow for internationally competitive recruitment offers for highly qualified international staff. This instrument has enabled Masaryk University to recruit ERC grant holders from prestigious universities abroad in areas where Masaryk University is particularly well-positioned and could offer international state-of-the-art infrastructures. To ensure international competitiveness, the positions are open to any field, are advertised in *Science* or comparable journals, and are supported with start-up investment funds of up to 1 million dollars each. The well-placed Faculty of Informatics has adopted a very effective information and head-hunting campaign which is now widely seen as a showcase story of the possible and a catalyst of further institutional transformation.

Even without the more far-reaching possibilities of cumulated vacancies to fill and finances to support competitive hiring, universities can use different ways to align resources with strategic priorities. Building internal capacities for developing the interfaces referred to above can include providing in-kind resources (space, time, administrative support) as well as in-house monitoring of financial and partnership opportunities, as the example from UPC in Barcelona illustrates.

At **UPC**, given the absence of significant seed funding or other central strategic funds, the institution's leadership sees its strategic role as one of strengthening very active academics and their major initiatives by facilitating contacts, supporting lobbying and ensuring smooth administrative support. In the areas of mobility, internet of things, energy, photonics, or super computa-

tion, the rector has supported coordination efforts, granted reduced teaching hours for research leaders, and arranged for availability of space and high priority in administrative support.

However, while the rector and vice rectors are important for some personnel decisions, the most decisive strategic initiatives come from the researchers and their efforts to join forces with others to seize major grant opportunities. Nevertheless, to prepare for future development when financial and strategic opportunities may expand, the new leadership team is establishing a more systematic method to detect the institution's strengths, including a prospective research observatory so that international and local opportunities may be seized by aligning research capabilities with external trends. Thus, for the strong Catalonian position in biotech, bioengineering and health-related research, for example, data is being put together from internal research information, technological news from companies, and tenders, and is then fed into decision-making processes at different levels to invest into the most promising areas.

The institutional leadership, beyond providing internal support to staff and initiatives, has a key role in aligning the university strategy with other key stakeholders. Indeed, strategic development usually includes external stakeholders at some stage in the process and at different levels. The close alignment of the University of Manchester's strategy with that of the region, for instance, is the result of the mobilising role of its leadership as well as systematic investments and joint lobbying for major financial and infrastructural development of key thematic clusters. In its strategy process, internal and external stakeholders are systematically aligned by the institutional leadership, to the extent that regional and institutional strategy processes merge. Similarly, close alignments in university and regional development can be observed at TU/e, TUM, University of Minho, Aalto and Masaryk University.

Finally, universities are increasingly **aware of the vital importance which infrastructural development** can play in fostering innovation dynamics. Such infrastructural investments comprise both investments into state-of-the-art large research facilities that bring innovators to the region, as well as physical infrastructures that become hubs for co-creation. Researchers and business innovators are brought together in jointly used spaces. While the autonomy and capacities of universities to manage real estate vary across Europe,²² developing knowledge co-creation spaces, networks and platforms where creativity and knowledge creation can thrive is becoming an increasingly important dimension of university development. Such spaces make visible the university's role in fuelling innovation dynamics in the region. Moreover, such **spaces and infrastructures are reflected and redesigned in terms of cultural and social embedding (see chapter 3.5)**.

The **University of Warsaw** has been paying strategic attention to its infrastructural development as a vital contribution of its innovation ecosystem, recognising the importance of social dynamics on campus life and of the power of architecture in facilitating such dynamics. On the basis of sociological empirical data evaluating past users' experience of architecture for academic use, the new buildings and campus will integrate user needs and social innovation dynamics in a systematic manner.

The vice president for development created the Office for Innovation in Academic Space for exactly this purpose. It develops and coordinates the strategy and plan for the new university buildings and orchestrates the dialogue with departments and architects. In a wide interpretation of the innovation challenge, the office aims to improve internal communication, helping horizontal communication through a wide array of workshops and events. It builds on the experience of large social innovation projects and the success of the co-working incubator space which was set up in the central library building of the social science campus and acts as an innovation hub in its local environment. The idea of a campus structured around common spaces that will increase innovation dynamics will lead the infrastructural development process.

Paris-PARC is a strategic infrastructure development project of **Sorbonne University**. Dedicated to spin-offs from university labs as well as spin-offs and branches of innovative enterprises, the new 15000 m² building, which will be constructed from 2019 to 2021, will provide an incubator, an accelerator for emerging start-ups as well as a *hôtel d'entreprises* for expanding companies. In addition to support for start-ups and spin-offs, it will also host entrepreneurial training for students.

Paris-PARC plays a key role in the economic development spurred by Sorbonne University. It has been developed to create a place, in the heart of Paris and on the university campus, in immediate proximity with university labs, which will combine academic excellence with a capacity to transform academic knowledge into economic value. Paris-PARC responds to an increasing demand of innovative companies to access and share costly and complex research infrastructures, to make use of the high and diverse concentration of qualified personnel on campus, to access promising interns and high-level young graduates, and to become engaged in innovating and entrepreneurial activities with a high concentration of partners in a vibrant ecosystem.

2.2 The role of governments

For the development of effective innovation systems, governments and public authorities play a vital role at all levels, national, regional and local. To create innovation-conducive framework conditions, governments and public authorities act in various roles as primary regulator and funder, infrastructural developer as well as as strategy moderator and facilitator.

2.2.1 The government's strategic role

At all levels, governments and public authorities play an important role as coordinators and initiators of strategy processes that shape innovation environments. Often, this is done with the intention of promoting systematic approaches to innovation and establishing self-reinforcing innovation systems. At the national level, such efforts comprise the formulation of innovation policies. These include innovation-friendly regulation, funding schemes and institutional arrangements that strengthen innovation capacity in universities and the business sector, and attracting innovative talents, companies and investments to the country. Efforts to develop an innovation-friendly environment cover a wide variety of measures such as fiscal incentives to promote R&D intensity²³ or the creation of innovation agencies (as most recently done in Germany). Also, the reforms of higher education regulatory frameworks enhance strategic capacities of universities, enabling them to approach innovation activities more efficiently (such as in Finland in 2009, and Poland in 2018). Moreover, in all cases covered by the study, governments promote cluster policy initiatives in important thematic areas (energy, renewable resources, digitalisation, medical technology, advanced materials, etc.).

Depending on the political organisation of the country, the regional government's role as initiator and coordinator of innovation strategies has been a long-established feature of the system (Bavaria, Catalunya, Helsinki/Uusimaa) or has emerged already in the early millennium (Greater Manchester, Eindhoven/North Brabant, Northern Portugal (Braga and Guimaraes), or South Moravia). Ever since the requirement to develop smart specialisation strategies as an ex ante condition for the allocation of EU structural funds, such regional strategic engagement has been formally established in all regions covered by the study. In some cases, however, the unit to which this role is attached under the structural funds (the NUTS 2 regional units) is not a political unit or region with a common cultural identity, but rather constitutes a statistical construct. Hence, strategic development is not necessarily aligned with the NUTS 2 region. Instead, it usually involves an alliance of regional and municipal bodies, and individual leaders loosely assembled according to formal and informal networks, rather than formal political functions.

According to EUA's own work in the framework of the EUA Expert Group on Research and Innovation Strategies for Smart Specialisation, smart specialisation has provided a good opportunity to regional and local authorities and universities for developing a joint strategic awareness, evidence-based strategies and a clearer understanding of the benefits of joint efforts and interaction.²⁴ It is too early as yet to assess empirically how systematic such collaboration actually turns out to be (beyond already established networks), and how much difference it makes to designing new forms of interaction or to strengthening regional innovation capacity.²⁵ However, EUA's Smart Specialisation workshops in Madrid (2015), Warsaw (2016), Tartu (2017), and Graz (2018) offered a large range of successful case studies, which show how multi-actor strategies are developed and implemented to create added value.

Regional and national governments also play a vital role in **safeguarding regional attractiveness for innovation by ensuring international accessibility (traffic connections), state-of-the-art building infrastructures, digital connectivity and quality of life for internationally mobile talents**. In the case of the development of the innovation districts around Braga, for example, the connection to the motorway and availability of good flight connections is regarded as a key ingredient of its attractiveness for globally positioned companies. In Brno, companies and the regional innovation agency complain about the lack of international transport connections. In Espoo, the dynamic expansion of the Aalto campus and the agreement to its merger in the first place were predicated on the extension of the underground connection from Helsinki.

Equally important are the appropriate land planning regulations to allow for the right intermixing of labs, university facilities and student housing, so as to build vibrant innovation environments. In Braga, *InvestBraga* saw the opportunity of such a new innovation district for the city and helped to rezone urban planning. The importance of collaborative spaces connecting different kinds of actors has been a key realisation in Warsaw, where a special unit at the university supports the Vice-Rector for Development in coordinating infrastructural development.

2.2.2 The government's regulatory role

The regulatory framework is an important factor for the innovation capacity of individual actors such as universities and businesses and ultimately the system as a whole. The case studies show this in several respects:

1. The regulatory framework for universities determines the level of autonomy they have with regard to organisational matters (notably university governance structures, legal frameworks for collaboration with private organisations and the use of IP), financial matters as well as staffing and academic matters. This also impacts their ability to interact with external partners for the purpose of innovation. In the case studies, opportunities and limits to interaction offered by varying degrees of autonomy were abundantly evident:

- The organisational, financial, academic and staffing autonomy of the TU/e in the Netherlands and the University of Manchester in England allowed them to deal flexibly and swiftly with collaboration contracts, hire professional research or innovation managers with high-level experience in the private sector at competitive salaries, introduce new types of academic units or study programmes flexibly.²⁶ At TU/e, the university's ability to invest in venture capital, such as high risk ventures of university start-ups, is key to the institutional approach to innovation.
- In Finland, the 2009 reform of the Higher Education Act aimed at enhancing the contribution of higher education institutions to innovation with increased financial and staffing

autonomy, including real estate management, and the introduction of the status of foundation universities.

- Obtaining the status of a foundation university with increased financial and staffing autonomy was also a vital ingredient of effective innovation management at the University of Minho in Portugal.
- The TUM in Munich had managed to ensure increased autonomy via the development of a separate law which was specifically formulated to allow for more flexible management than would be otherwise possible in Bavarian higher education.
- In Brno, cumbersome and time-consuming administrative regulations are making everyday administration of research grants time-consuming and difficult. Furthermore, the detailed personnel planning which is required from universities makes it difficult to keep up with the pace of change. Interviewees agree that universities would need fewer regulations and greater flexibility with respect to financial allocations.
- In Warsaw, recent opportunities for innovation for instance, include revised IP regulation which now allow universities to create special companies entirely owned by the institution, which can in turn invest in start-ups. The new higher education law passed in 2018 provides fiscal benefits for R&D and innovation for companies. Before the reform, the regulatory framework for universities had been regarded as a major impediment to the international competitiveness and innovation capacity of universities. The governance and funding models were inhibiting central decision-making and financial steering capacity, with university budgets allocated directly to faculties. The new Law on Higher Education and Science is expected to enhance the autonomy of universities by increasing their internal organisational freedom, strengthening the central university decision-making power of the rector and of a new strategic university council that includes 50% external members. The law also provides more opportunities to create interdisciplinary studies combining the potentials of various faculties and to increase the wages of academic personnel.

Nevertheless, universities have limited options to make strategic use of staffing policy to promote innovation. Interviewees referred to the difficulties in fostering academic staff renewal due to limited autonomy on dismissals combined with the absence of an obligatory retirement age. Hence the younger staff amongst whom open attitudes to knowledge transfer and collaboration with external stakeholders are more widespread, are likely to remain in the minority.

2. Government regulations also include fiscal conditions for knowledge-intensive companies, for example by making R&D investments tax deductible, as is the case in 30 of the 35 OECD countries, and 21 of 28 EU countries. In all cases such tax relief is applied to the R&D funding; in the Netherlands and the UK, tax relief was also granted to the R&D performing institution.²⁷ Many other variations apply with respect to the type of relief and what revenues it is applied to, whether ceilings apply, whether it may be combined with external grants, for example from the EU. The importance of such regulations was emphasised in interviews in the Netherlands, Portugal and Finland, but is shown to be a key determinant in any region with respect to foreign direct investment, as a recent study of the European Commission's Joint Research Centre confirms.²⁸ In Brno, interviewees pointed to the innovation obstacles posed by inconsistent interpretations of tax regulations.

3. Sectorial regulations also impact innovation. This is for example the case in the health and biotechnology sectors with regulation regarding clinical trials, or in the automotive sector, providing reliable testing conditions for new automotive technologies or traffic systems. In

Portugal, for example, a law on clinical trials, which was strongly influenced by the health cluster of the Norte region, helped support the efficiency of the trials.

- 4. Government regulations strongly affect researcher and expert mobility** and the inflow of talent. In Portugal, such regulations were changed to allow for special accelerated visa procedures to host non-EU researchers (for example from Brazil) or to allow for competitive salaries and employment benefits since universities and companies are competing globally on the market of talents.

Figure 6 Role of government for regional innovation



2.2.3 The government's funding role

Public authorities remain the core funders of universities throughout Europe, accounting for the greater part of their income structure. Monitoring of the trends in public funding in the last decade²⁹ has shown that, in the context of the economic crisis of the late 2000s, public funding to universities was significantly cut in many European countries, affecting teaching and research activities as well as infrastructures.

Nevertheless, in all case studies, the government has been playing a strong role in supporting innovation through public funding schemes at national and regional levels. As the political discourse on the role of government in promoting innovation became more prominent, funding schemes have increasingly supported research and development cooperation between companies and universities, as well as, for example, the creation of companies or of support services. In many cases, even in times of economic crisis, the focus on **applied research, university-business cooperation and business creation was prioritised.**

Public funding allocation models have also evolved to incorporate performance-related elements in many countries. The limits of this approach were outlined in previous EUA work.³⁰ It has had a relevant impact on promoting innovation. UK interviewees noted the effect of the Research Councils' emphasis on university research impact, which now counts for 20% of the funding decision criteria. University representatives found that assessing impact criteria and requiring evidence of concrete collaboration or impact measures, including social impact, has helped to change awareness and engagement among academic staff. In many cases, exposure to such collaboration has resulted in positive experiences and changed attitudes. As several other countries, Poland adopted a performance-oriented funding formula that includes indicators related to patents and collaborative or contract research with businesses to mobilise inter-linkages and commercially relevant innovation.

Often, national and regional funding schemes prioritise particular thematic opportunities and challenges, such as digitalisation, advanced manufacturing, or renewable energy, supporting multi-actor collaboration and joint infrastructure development. In these sectors, cluster coordination and substantial research funds are made available for collaborative research between universities, research institutes, and companies.

Public funding also includes dedicated funding schemes whose main goal is to foster innovation in general. At the national level, innovation schemes, sometimes coordinated through national innovation research agencies (as in the Czech Republic, Finland, Portugal, or the UK), offer incentives for universities and companies to collaborate. In the UK, for example, *Innovate UK*, and especially its *Catapult* programme, provide important national incentives for university-business collaboration. In several regions (Catalunya, Greater Manchester, Greater Munich, South Moravia, Northern Portugal), deep-rooted traditions of university-industry collaboration are highlighted as an important asset of their regional innovation systems, even though national funding is needed to sustain such dense interaction.

In Finland, the long tradition of funding for collaborative applied research administered by *TeKes* or *Business Finland* (as it was recently renamed) is regarded as a key asset of the country's innovation landscape. Accordingly, the recent decline of *TeKes* funding was regarded by some interviewees as a major risk to Finland's future innovation capacity.

Business Finland (formerly: Tekes)

Applied research and university collaboration with industry has been supported for decades by the *Tekes* agency, and has helped to sustain rich interaction between universities and industry from which Finland has been benefitting for decades. Since January 2018, *Tekes* has been renamed *Business Finland*, after having merged with *Finland Exports*. Business Finland funds research with a 5–15 years perspective. In 2018, 600 projects have been realised, engaging 3500 companies, with a turnover of €0.5 billion annually. Co-funding is seen to be crucial, as it facilitates company R&D investment. Co-funding also includes money given to start-ups (€60 million investment on the part of *Tekes*) to match private money, thereby pushing direct investment. The most active investors know that such matching will occur and that it will increase the impact of their investment.

Since *Tekes* funding decreased by 30-40% from 2012-16, business funding has declined so that investments into future technologies have been sparse and many innovations have lived off old investments. Several interviewees believe the *Tekes* cuts reflect a lack of recognition that public support for company R&D was needed to engage university research in collaborative seeding grounds for future innovation. While companies have understood the importance of the skills base for their future success, private investments in R&D have nevertheless gone down in the last decade.

The rarefaction of financial support to infrastructure has been a particularly acute issue in some systems. Interviewees from the Czech Republic and Spain reported that public funding remained available essentially for selected research infrastructures supported through specific schemes. In this context, universities have been giving increased attention to contractual research opportunities with industry to fund applied research activities, as well as sometimes support curiosity-driven research. Institutions and individual researchers have therefore invested resources in identifying and adapting to the needs of industry or other external stakeholders, according to industry and company interviewees.³¹

Diversification of university income typically also includes a greater focus on funding opportunities at the European level.³² Catalunya offers an example of a successful strategy, in a context of receding national research funds. Researchers at Catalan universities and public research centres invested considerable time and effort to obtain EU funds to reduce the financial gap. In this case this approach yielded positive results, as Catalan researchers doubled EU research income from the 7th Framework Programme to Horizon 2020 (from €383 million for 2007-10 to €773 million for 2014-17), in spite of overall very low success rates in the programme. The collaboration instrument of European funds was also strongly used by UPC researchers for university-industry research cooperation. Catalan institutions obtained approximately 50% of all Spanish ERC grants in the last five years. The focus on European funding strengthened the already well-developed European networking of Catalan institutions further. However, it also creates a disincentive to partner up with other local universities, since the presence of two universities from the same city is usually not well seen in project proposals.

European funding also bears opportunities for universities that directly support innovation ecosystems. For instance, Horizon 2020 notably includes an “SME Instrument”, which was seen as an important incentive for collaboration in Aalto, Barcelona, Braga and Eindhoven. The most important contribution to such collaboration, however, occurred through the regional innovation funds associated with the European Structural and Investment Funds (ESIF).

Support for innovation has become all the more prominent with smart specialisation strategies as an ex-ante condition of Structural Fund allocation. Where relevant, regional innovation support is substantially complemented by ESIF, as representatives of Catalunya, Portugal's Norte region, Warsaw/Mazovia, South Moravia and Greater Manchester report. Structural Funds are used to

support increased collaboration between businesses and universities, most substantially through investments in infrastructure, but also in the form of innovation and incubation services. In Manchester, for example, around £356 million are being invested in the period 2014-20 into major new research and innovation infrastructure developments, especially in the areas of advanced materials and life sciences. In South Moravia and Catalunya, the region's prioritisation of innovation investments has been decisive in providing financial stability and safe-guarding long-term perspectives, interviewees report. This has ensured long-term attractiveness of the region all through the crisis years and across changing government coalitions at national levels. In all cases, it was emphasised how regional leadership had gone beyond party politics and partisanship in order to secure a long-term vision of the public good and engage in cooperative leadership involving all key partners.

National and regional incentives have fuelled companies' interest in university collaboration, as interviewees report in Barcelona, Brno, Manchester, and Warsaw. Especially, SMEs which do not have a research unit or larger research budget, appreciate public subsidies for university collaboration. Conversely, on the part of universities, the readiness to collaborate with companies is strengthened by the availability of public support as well. At the more technically oriented universities of Aalto, TU/e, TUM, UPC and Minho, where such collaboration has been part of the core mission of the universities from the outset, academics show even greater willingness to collaborate with the reinforcement of government schemes and relevant indicators, especially when funding generated by contractual research can support other independent research projects.

A specific related issue in the case studies was the place of curiosity-driven, long-term research in the funding model. With the exception of Germany, the perception of the interviewees in all case studies was that of a decline in the importance attributed (and funding allocated) to this kind of research. This development is seen to be highly problematic by universities and companies alike, since innovation capacity and its long-term sustainability are seen to be clearly linked to long-term investments in research without foreseeable medium-term outcomes, milestones or results.

Representatives of large global companies (in Barcelona, Braga, Eindhoven, Espoo/Helsinki, Manchester, and Munich) also pointed to the need for excellence in research quality as a key condition for their companies' strategic investment in a location. International research excellence, which requires the presence of both high-level curiosity-driven and solution-driven research, is regarded both by universities and the private sector as a pre-condition for the availability of the most talented graduates and researchers. Clearly, it is a decisive factor for company investment in a region, confirming the findings of other studies in this regard.³³

2.2.4 The government's role as innovation facilitator

Governments play a key role as facilitators of innovation processes at all levels. The case studies revealed an impressive wealth of such facilitating measures, including support schemes and services for business creation, knowledge transfer and university-business collaboration and co-location.

In Barcelona, Brno, Braga, Espoo, Manchester, Munich, and Paris, municipal and/or regional governments provide support schemes and incubators for student entrepreneurship and start-ups, in addition to the services provided by the university. The city of Espoo, for example, offers its own start-up support service in the internationally acclaimed *Espoo innovation garden*.³⁴ Espoo joined the Aalto students' innovation initiative since the beginning by supporting student-driven summer camps for entrepreneurship or by opening doors into city organisations for testing and piloting their products as reference cases. For the city, the new generation and its entrepreneurial

spirit is important economically but also contributes to the social and cultural capital for the high-tech labour market and innovation ecosystem.

In Barcelona, the regional government has developed a wide array of innovation programmes which are co-funded by European Regional Development Funds, including a start-up support, an industrial PhD programme, seed funding for knowledge industry projects, support for networks and clusters, and certification for tech transfer centres, to name just a few. These instruments are developed and administered through the Catalan agency for business competitiveness, ACCIO.

In North Brabant, the regional development agency (BOM) is a legally private holding with 100% of the shares owned by the province of Brabant, closely connected to the Ministry of Economic Affairs. Its role is, first of all, to help companies grow, both with money and support service. Thanks to its €250 million venture capital fund, it is able to invest substantially in new companies with growth potential.

In Brno, the city and regional government has joined forces with the four universities to establish a common innovation agency whose role is to facilitate innovation in all its aspects:

Brno - Regional Innovation Agency (JIC)

There is wide agreement that the Regional Innovation Agency (JIC) – a consortium established by the regional and municipal governments and the universities of Brno – has been the most crucial facilitating actor in the regional innovation system. It has also understood the huge opportunities associated with the structural funds, helping to identify strategic potential of the regional actors and facilitating joint strategy and project development between them. Given the complexity of conditions which the Czech government has attached to the use of structural funds, especially with respect to building infrastructures for science, JIC has also successfully encouraged universities in the region to prepare proposals for structural funds. These included the establishment of two big research centres, Central Eastern Institute of Technology (CEITEC) and RECETOX, which now act as major attractors to the region. Moreover, JIC has also known how to manage such complex strategy developments and how to coordinate complex multi-actor project implementation.

JIC was established in 2003. A majority of its staff (now 55 people) was trained in Prague and had all spent some time abroad, thus offering a stimulating outside perspective to the region. JIC staff comes from the corporate sector and have built networks. They are motivated because they identify with the area and would like to give back to the system. They helped to build a network of collaboration toward internationally oriented regional innovation. By 2010, the first successes were visible, which greatly helped to fuel the innovation dynamics.

JIC has two roles: It supports innovation in businesses, from start-ups to established companies, and it coordinates regional strategy development. It conducts both roles with an international outlook, which includes constant benchmarking with international good practice and searching for people from abroad to collaborate with, based on their excellent network.

The most widely used role of JIC consists of supporting entrepreneurs in different stages in their company development. To help start-ups or spin-offs (students or researchers), support begins with drafting business plans, facilitating contacts, connecting young founders with experienced company CEOs (in the case of spin-offs usually as managers for the companies), and giving them access to micro-loans.

At later stages, JIC also connects businesses to relevant venture capitalists and prepares them for the negotiations. Established entrepreneurs help emerging entrepreneurs to accelerate their nascent businesses. To help start-up networking, JIC provides physical incubator facilities, including services and a co-working space in the centre of town (*Impact hub*). Networking events include a roundtable, with every entrepreneur explaining in 120 seconds their product and services and what they are looking for in terms of cooperation, or sharing experiences. For example, roundtables may include experts and mentors from an inner circle of experienced entrepreneurs or successful founders of high-growth recent start-up companies sharing experiences with human resource development.

JIC works with a demand-driven process. They talk to the companies to see the strategic opportunities of interface, then look for potential partners, then tap into their network, ensuring that the SME remains in the driver seat. For mature SMEs, JIC helps to identify opportunities for improvement and for possible scale-up. JIC also supports them in developing their internationalisation strategy to go to foreign markets. For their biggest needs for improvement, JIC helps develop a project for improvement and finds coaches, from a network of 100 people within a radius of 100-200 km, who are entrepreneurs themselves and can act as interim managers.

To coordinate strategy, JIC provides the secretariat to a steering committee, run by the vice-governor with university rectors and CEOs of largest tech companies, as well as to a set of permanent working groups (on research, innovative companies, education, and regional marketing). It calls, prepares and helps to structure regular meetings, and ensures implementation progress in the ecosystem. Projects will be discussed first in the working groups, then approved by the steering committee, after which they become part of an action plan, with objectives, and monitoring methods. JIC is responsible for overseeing the implementation, financing, and reporting.

Among the major strategic projects with a structuring effect on their regions which JIC helped to launch, the establishment of the CEITEC has been the largest. JIC has also helped to establish an incubator for aerospace, making use of the concentration of aerospace companies in the region, especially BTU and Honeywell (with 1600 researchers), which builds on a history of aerospace since the 1920s and now focuses on IT in aerospace.

JIC is also engaged in entrepreneurship education. A programme that fosters entrepreneurial spirit at 60 high schools introduces students to the option of becoming entrepreneurs and teaches entrepreneurial thinking, from developing the first idea, to developing it with a team, and presenting the results, but also understanding how to approach failure. At university level, JIC supports the university in its development of an institution-wide entrepreneurship education, in close collaboration with technology transfer offices and Research Services.

Facilitation can also involve support for thematic, cluster or systemic research and development as a way of proactively developing the knowledge economy and society. In addition to national or regional funding support (see also 2.2.4), concrete support activities can be found at city level, as is the case in Munich or Barcelona, where the city government supports research in future mobility systems by organising a district as a living lab for complex system assessment. Barcelona, Brno, or Munich offer further examples, where cities offer particular roads for automotive testing. In Espoo, the municipal government cooperates with Aalto in their joint support of the Sustainable Development Goals and in engaging citizens in new technology development. These examples show the **importance of the city as a research environment for long-term solutions requiring input from multiple actors and disciplines.**

The city also plays an important facilitating role by helping to attract foreign investments and talents to the region. In Braga, for instance, *InvestBraga* is closely aligned with the university to

attract foreign companies to the region, benefitting from the compact size and small number of key stakeholders of the region in this context. They join efforts to argue effectively why Braga and the University of Minho provide the right context for technological and business innovation, and why companies should invest. The presentation of the university and its research strengths and dense collaboration with businesses is always included in the city's presentation to potential investors and to companies that might settle in the region. The university rector will inevitably appear at such joint "pitches" for foreign direct investment.

A similar account could be heard in Eindhoven and Espoo. In Brabant, the regional development agency BOM emphasises its role in attracting foreign investment and so-called anchor companies settling in the region (most recently Tesla), as well as in helping Dutch companies enter foreign markets. The regional development agency also supports the development of different thematic ecosystems, such as the life science or renewable energy communities.

Cities support universities directly in their attempt to attract highly qualified globally mobile talent, through career and relocation services. In Brno, for example, the South Moravian Centre for International Mobility has set up a relocation service for new expats and organises marketing and language courses to attract students from other Central and Eastern European countries to Brno (using their offices in Serbia and Russia, for example).

2.3 The role of companies

With the rise of open innovation (Chesbrough 2003) the relationship between universities and businesses has changed. Facing an accelerated pace and complexity of innovation, companies can no longer rely on their internal R&D processes alone but have to scan and absorb externally sourced relevant knowledge in a wide variety of disciplinary areas, sectors and institutions.

In most case studies, representatives from companies across the board comment frequently on such open forms of innovation, while acknowledging the continued importance of closed innovation for competitive product development. The interviews also revealed that most technologically oriented companies, and all of the large multinational ones, have developed their own strategic, sometimes highly systematic approaches to innovation scouting and knowledge development involving multiple actors. Companies explore innovation potential and partnerships with other companies, supplier firms and start-ups, in networks with a complex and constantly changing give-and-take of ideas, knowledge, IP, and market opportunities. Universities are key partners in such external knowledge sourcing. They provide the most needed resource, namely competent graduates, while continuously producing new knowledge, including research-based systems and solutions to concrete innovation challenges. Just as vitally, universities are naturally disposed to scan knowledge frontiers and explore the next generation of technologies. They can thus identify new kinds of technological, societal and environmental problems which may define future needs of users and markets. They are increasingly adept at looking for new, often interdisciplinary approaches to solving such problems, thus expanding horizons and showing the path toward future technologies.

In order to fully benefit from such dense collaborative networks of open innovation, businesses need some enabling conditions, however, which are listed in Table 4 below. In the case studies, large businesses place different emphases on such factors from small and medium-sized ones. Tech-based start-ups also responded noticeably differently from other SMEs.

Table 5 Core needs of innovative businesses

x = mentioned, xx = strongly emphasised

Enabling conditions for business innovation	Mentioned by		
	Large globals	SMEs	Tech Spin-offs Start-ups
Skills and talent			
Availability of skilled labour/ talents with scientific/ technical qualifications	xx	xx	xx
Low cost skilled labour	x	x	x
Availability of skilled labour (University graduates / Mobile experts) with interdisciplinary problem-solving skills	xx	xx	xx
Graduates / Mobile experts with (interdisciplinary) ability to identify future innovation potential, adapt to disruptive innovations	xx		
Flexible visa /working permit regulations for net in-migration of skilled labour	xx	x	
Attractive living environment for international mobile talents	xx	x	x
Favourable labour market regulations	x	x	
Easy access to identify relevant researchers	x	xx	
Concentration of internationally competitive/ excellent research in the sector	xx		
Language competences (English)	x		
Research and knowledge creation			
Availability of relevant university research for problem solution		x	x
Innovation platforms bringing relevant experts together to identify / scan new and future technological and social trends	xx	x	x
Companies, public agencies or cities which offer themselves as application systems or reference cases for new products			xx
Financial conditions			
Public funding for business-university collaboration	x	xx	
Level of public R&D expenditures in university sector	xx		
Venture capital			xx
Favourable fiscal conditions	x	x	x
Infrastructure and context			
Competitions, support services for spin-offs, start-ups	x		xx
Contexts for joint system developments (platforms, joint labs, bringing multiples disciplines and actors together)	xx	x	x
Access to shared or subsidised costly research infrastructures / shared facilities	x	xx	xx
Co-location spaces for joint innovation development	x	xx	xx
Critical size of region, density of relevant partners, customers	xx	x	x
Market size	xx		

Together with universities, knowledge-intensive companies have developed a varied portfolio of interaction formats to fuel their innovation processes, with different and complementary functions:

Table 6 Instruments of cooperation and business-university interaction

Cooperation instrument/ interaction format	Function for businesses, universities, students
Supporting Bachelor's or Master's theses, based on interaction between engineer/ external stakeholder, academic advisor and student	<ul style="list-style-type: none"> helps students expose themselves to real work environments and trains their problem-solving skills helps companies solve concrete short-term problems that demand some technical knowledge and several months of research
Providing internships for students in companies	<ul style="list-style-type: none"> helps graduates be more successful on the labour market; helps companies find and test potential future employees;
Courses and trainings given by practitioners, from one-day labs about a specific topic to lectures or seminars in standard module in university curriculum	<ul style="list-style-type: none"> provides students with insight into real-life professional challenges and solutions
Real-life cases and challenges integrated in university lectures/ seminars	<ul style="list-style-type: none"> helps students develop interdisciplinary problem-solving skills increases the relevance and hence the appeal of study programmes
Successful entrepreneurs as mentors for start-ups or role model entrepreneurs in entrepreneurship training	<ul style="list-style-type: none"> helps students consider the opportunities and challenges of starting their own business and to lower the threshold of becoming entrepreneurs themselves
Joint research projects	<ul style="list-style-type: none"> answers research questions brings industrial and academic researchers together helping mutual understanding of each others' interests and challenges
Contracted research	<ul style="list-style-type: none"> helps companies solve concrete problems and innovation challenges provides flexible funds to university researchers – apart from its use to solve the given research problem, these funds can be used freely for other research, infrastructural or maintenance purposes
Funding research labs at the university, (sponsoring the space and PhD students participating in the research),	<ul style="list-style-type: none"> develops specific technology solutions and prototypes for companies; enhances long-term innovative capacity of the company; provides costly research infrastructure for university researchers
Sponsoring professorships (internationally competitive salary, possibly also including start-up funds, research infrastructures)	<ul style="list-style-type: none"> strengthens key competence area for a company; helps the university's internationalisation;
Part-time positions for industry researchers at the university and vice-versa. Cross-appointments	<ul style="list-style-type: none"> helps mutual knowledge of needs and challenges, understanding each others' methods, concepts and attitudes
Joint Institutes or Labs	<ul style="list-style-type: none"> helps address long-term challenges which are of mutual interest to academia and industry helps support state-of-the-art infrastructure and thereby enhances international competitiveness co-funding (companies/public funds) alleviates public budget pressures

Long-term framework agreements for university-company collaboration	<ul style="list-style-type: none"> • lowers transaction costs for individual cooperation projects • creates transparency and reliability with respect to IP arrangements, preventing mistrust • helps justify long-term research infrastructure investments for companies and universities
Strategic partnerships	<ul style="list-style-type: none"> • helps companies address long-term ambitions by giving them access to scientific and technological frontiers • Scans future technologies, problems and opportunities which may require early positioning • helps universities develop long-term research directions with high demand from external stakeholders

In addition to individual research collaboration or student training projects, all larger and many medium-size multinationals are interested in more long-term framework agreements to reduce transaction costs and reduce the negotiation time for new collaboration projects. Some universities have taken great care to develop basic principles, quality standards and stream-lined processes for different kinds of framework agreements.³⁵

Large multi-nationals and universities alike favour strategic partnerships to face larger complex challenges and develop their vanguard position.³⁶ This is because broad and agile knowledge management which can identify the next disruptive innovation has become vital for their survival, while an overly narrow focus on one stream of product innovation may erode the company's market position in the long term. Hence, multinationals have recently begun focussing on fewer universities, carefully selected on a global scale, with whom cooperation and trust has developed over the years and over a wider range of areas. These selected universities are internationally particularly well-positioned in an area of strategic interest so as to help them face multi-disciplinary technological challenges of the next generation. In these partnerships, both strategy development and research cooperation projects are aligned, and cooperation frameworks are negotiated in multi-annual contracts so as to avoid larger overhead costs. In Helsinki/Espoo, the reasons for such a strategic partnership with Aalto University were explained by a Nokia representative:

“Long-term strategic partnerships help a big multi-national company expose itself to different global innovation environments so as to face the challenges of the next technological generation, such as 5G for Nokia. Even though most technological sectors, like the Telecom sector, include so many different technologies and user contexts that their exploration would go beyond any single university, and that an overall system design would no longer be possible, it is still vital for the companies to build such systems thinking. A good strategic collaboration with a university that is international in its research outlook but also embedded in a dense regional ecosystem can help build a holistic approach since researchers at good universities are aware of what goes on in neighbouring disciplines. Where such awareness exists, deeper innovative development can occur.”

From the point of view of universities, long-term partnerships help to strike the balance between neither wanting to emphasise contracted commissioned research, like an outsourced R&D department of a company, nor wanting to do basic research without any relevance. Thus, at Aalto University, a €20 million contract was signed with the SAAB company, with a mandate to distribute this money to research projects, on jointly planned research, so as to explore what aviation will look like in 15 years. For the university, the quality of collaboration with bigger companies hinges strongly on their readiness to engage with or even host PhDs.

In contrast, SMEs cooperate in a more short or medium-term perspective, often seeking concrete solutions to innovation problems for which they need applied research competences. Such needs can be met best by Bachelor's or Master's research projects or by consultancy provided by university researchers. SMEs also need affordable access to relevant technological facilities and networking opportunities to explore innovation potential and keep on their toes competitively. Since such technical research infrastructures are very costly, this is an area where public support or effective sharing of core facilities is most needed. All of these functions can be greatly facilitated by the university, as done for example at Aalto (in A-Grid), TU/e or UPC (in their applied research centres), or in the thematically oriented science parks in Manchester, Barcelona, and Helsinki/Espoo.

A-Grid. Aalto University

To address the **innovation challenges of emerging SMEs**, **Aalto University** is looking for a more systematic impact by accompanying them in their innovation development, "since growing SMEs usually do not have anybody who focuses on their strategy or talent development needs" (Vice-President, Research). *A-Grid* was established to provide a facilitating ecosystem where everybody can come and learn what is going on, and easily get in touch with researchers. It was launched in February 2018 as a new start-up hub with 25 000 employees from university spin-offs or student start-ups, or other actors interested in collaborating, sharing infrastructures and facilities, or events such as hackathons. Since match-making and finding the relevant researchers is vital for the companies, co-working areas with companies and researchers working closely together and sharing facilities can help the process. As an easy access for SMEs to university sources of innovation, *A-Grid* helps to develop innovation in small businesses through continuing professional development or research projects. Most often, the most direct contribution the university can make to SME innovation occurs through Master's theses work of advanced students.

Overall, the cooperation between universities and SMEs is still regarded as much more challenging than interaction with global knowledge-intensive multinationals, as emphasised by university representatives across all regions. SMEs have a harder time in finding interested university partners since they would most often need to find partners for developing solutions in interdisciplinary but short-term oriented development projects. Most often, these challenges would offer little academic interest, as many university interviewees point out.

For the companies, it is often difficult to find the right skills profile since they are only accessible via personal connections. Since it is not even possible to describe what skills you are looking for in codified terms, companies need functioning interfaces and personal contacts to find the right expertise or skills. This is also why a local open innovation environment is important.

At some universities, the technology transfer office's business facilitation units try to help such brokering. Often, thematic events may be needed to bring relevant companies and researchers together. However, university researchers that turn out to be relevant may still not be interested in dedicating their time to such problem-solving, as interviewees at Aalto University, TU/e or U of Manchester point out. In the Brno region, the regional innovation agency JIC is seen as providing excellent services in finding such leads which make it easier for companies to find somebody who could help them address their challenges. The cities of Brno, Braga and Eindhoven offer the advantage of being relatively compact, so that it is easy to find people who point you in the right direction, a feature which SMEs appreciate. Companies also realise that life is easier with a good network where reliability and integrity are shared community values.

The relation of SMEs with universities and the innovation formats of interaction vary widely however, depending on the knowledge intensity of the business and the industrial portfolio of the region. While some regions, such as Eindhoven in North Brabant, Munich in Oberbayern or Espoo

in Helsinki/Uusimaa, benefit from a high proportion of high-tech SMEs, and a rich industrial fabric that offers a wealth of opportunities for business-to-business companies, some regions are challenged by the high proportion of SMEs with a lower innovation absorption capacity and thus also lower ability to interact with university researchers.

To address this challenge, the University of Warsaw is hosting its European Enterprise Network as a facilitating brokerage service which helps SMEs find partners and increase their innovation capacity.

The European enterprise network in Warsaw

The Enterprise Europe Network has set up a Database of Executive Agency for Small and Medium-sized Enterprises (EASME) with descriptions of project, type of calls, and deadline in order to help SMEs and researchers of the region to find international project partners, for example for ESIF or for Horizon 2020 funds. The Enterprise Europe Network has also developed a research and service project (financed by Horizon 2020) to help SMEs analyse their innovation capacity and management, as a sort of benchmarking support and capacity building project, helping them to become more international. SMEs with innovative project ideas get help to build a proposal and apply for European grants. The support aims to help SMEs become more innovation-absorptive since there are no clusters for start-ups yet that would act as open innovation environments with intense networking opportunities.

University start-ups and spin-offs constitute a particular group of SMEs which share a common disposition to remain densely connected to their alma mater. Many continue to develop the technology of their products further, with the help of researchers from the university who used to be colleagues. Often, they have access to university research facilities or to research infrastructures that are provided as part of science parks or campus facilities where university and company research collaborate closely, as seen at Aalto's A-Grid facility, at the High Tech campus in Eindhoven or at the Garching campus of TUM.

Start-up representatives emphasise how important their universities of origin are for recruiting the right personnel in growth phases. Moreover, start-ups continue to contribute very actively to the open innovation networks with their technological expertise, fresh ideas, and entrepreneurial appetite for high risk, all of which greatly add to the innovation capacity of the region. As successful alumni, their founders often give back expertise and engagement to the university as mentors, future venture capitalists, or lecturers. Hence, in many ways, the creation of start-ups and spin-offs creates long-term benefits for the university that far surpass the effects of other forms of knowledge transfer such as the selling of licences or patents. Consequently, with respect to their innovation activities, Aalto University in Espoo, TU/e in Eindhoven, University of Minho in Braga or TUM in Munich are concentrating their strategic attention and energy on nurturing business ventures that emerge from the university itself.

Company representatives emphasise how crucial it is for them to be able to attract and retain qualified labour. All companies depend on the availability of qualified people that come from, want to come to, or decide to stay in the region in spite of attractive opportunities elsewhere. Hence, qualified labour includes a growing number of expats, and all regions rely in varying degrees on the inflow of qualified labour, as a benchmarking study of the Global Cities Initiative has shown.³⁷ In Brno, the statistics of expats are continuously growing. IBM alone has 70 different nationalities among its 3000 employees in their remote service centre.

According to company representatives, contributing to this availability is still the university's primary role. Some global companies in high growth sectors emphasise that they need a selective university that produces good graduates, so that they do not have to interview 5000 people if they want to hire a few hundred. In Europe, the graduate quality is often too mixed, from the point of view of some companies. In Helsinki and Munich, representatives from multinationals emphasised repeatedly how important the high quality of the university graduates were to them and how strongly this contributed to the attractiveness of the region. The most effective measure to assure the quality of graduate employees is to assess their potential in the framework of internships or Master's thesis projects in the companies.

Networking and channels of interaction: triple helix revisited

3

The strategic importance of universities to enhance their impact on societal, technological and economic innovation is mirrored through a similar strategic awareness among other stakeholders. Motivated by innovation needs that go beyond their own internal development capacity, companies rely on open innovation as densely networked collaboration and exchange with suppliers, partner firms, start-ups, and universities.

Meanwhile, governmental agencies, at national, regional and municipal levels, seek to facilitate university-business collaboration and business creation through regulatory frameworks, services, infrastructures and funding schemes. In all national and regional settings, we find policy attention to innovation processes becoming a priority, even if national regulation may still hinder a proactive role of universities in innovation in some cases and financial formats may not always do justice to the new forms of interaction.³⁸

All three types of actors aspire to orchestrate innovation as a joint process of knowledge production. This includes processes that combine interdisciplinary perspectives of academic research and education, and user-driven exploration of new solutions with markets and business processes to identify and leverage innovation potential. Notwithstanding the diversity of the nine case study regions, these are clearly characterised by a dual process of transformation. Not only are expectations, values, roles and interactions of universities, firms and governments changing, but these changes are accompanied by a common preoccupation with new forms of connectivity in order to mobilise innovative potential.

Together, the three types of actors – or four, if we count the users and citizens as a separate actor – develop a new motor of innovation, with intertwining common interests, values, narratives, strategies and investments. Thus, in the process of transforming their own roles, universities, companies and governmental agencies develop their connective tissue, or triple helix to use Etzkowitz's fitting description (2003). It is in this process that the embeddedness of innovation in the regional ecosystem becomes crucial. In order to help develop common agendas across the diverse cultures of different sectors, the new forms of connectivity have to feed on common values and narratives, on social ties and expectations, which are most easily established in regional proximity.

This new connectivity rests on five pillars: connective leadership, common norms and narratives, connective strategies, connective institutional structures, and connective spaces.

3.1 Connective leadership

In all case studies, big or small, it was remarkable to note that only a small number of people and a few small networks were seen as the mobilising force for the region's development. While some regions stress that teams are at the origin of their recent regional development (such as Eindhoven, Helsinki/Espoo, and Brno, for example), all regions pointed to some key individuals as key figureheads of a collective drive. However, while some leaders are mentioned by all groups, vital leadership roles can be found at all levels of regional systems and in all components of the triple helix.

In some regions, **university rectors or presidents**, in several cases also a vice-president, were described as the key transformative leaders for the region. Most often, interviewees described a crucial mobilising partnership between a university president and a leader from the city or region, joining forces to develop and realise this vision together. Such leadership was not linked to the office alone but seen as a personal quality, a visionary drive linked with the ability to win and mobilise others to develop this vision further into a common course of action, and to successfully orchestrate its realisation. Such leaders also often helped in mobilising private or public support for major regional investments. Moreover, the visionary and networking abilities of current and past university presidents, sometimes also vice-presidents, were seen to be instrumental in embedding the university into mobilising regional networks that would build a connective institutional culture. On the government side of the triple helix, most regions mentioned one or two current or former regional or municipal leaders who had excelled in their ability to engage local partners of different institutions for a common cause and to lobby for national support.

In many cases, **important entrepreneurs** of the region acted as key leaders. These leaders occupied high strategic positions at regional **anchor companies**, for example as directors of the company's regional or national office, or current or former CEOs or CTOs who are or were key networkers in the region. Especially the regionally embedded large multinationals, with headquarters in the region (Philips in Eindhoven, Nokia in Helsinki/Espoo, Siemens in Munich), can become central strategic motors of their own global development. Often the increased awareness of disruptive transformations in the wake of crises brings a sense of urgency to develop the key assets of the region, looking at global markets and technological diversity.

Other core leaders of regional development included some outstanding university **researchers** that combined international visibility and research excellence with an eagerness to achieve societal and economic impact through their research. Often such leading academics were directors of an internationally oriented large research institute or cluster, which they had successfully created. They were seen to have a gift for connecting people and engaging them for a common cause, being not only good scientists but also good communicators with partners beyond the academic realm. Starting from a vision for the future of their field, sector, and region, they are eager to share this vision and develop it further with others to achieve maximum impact.

Some regions showed remarkable leadership by **students and student associations or unions**, in opening learning and research processes to societal impact as well as in engaging regional actors as partners for their activities. In Helsinki/ Espoo, shortly before Aalto University was officially formed out of the merger, the students of the old universities were the first to see the urgency to develop the entrepreneurial dimension of their learning process and of building an entrepreneurship culture in the university. With the innovation agenda of the new university, their cause became the cause of the university. The heads of the student initiatives or associations became influential networkers in the region.

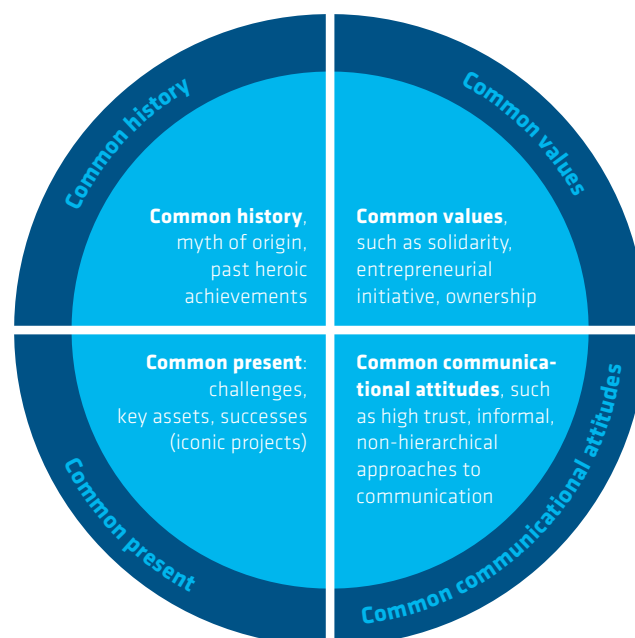
Similarly, at the University of Minho in Braga, the student association has played a key role in developing the start-up culture. Remarkable individual leadership could be found among students in all regions. It seemed to be driven by a sense of urgency of creating local impact in a global world that is clearly out of individual control. Moreover, former university students who have succeeded professionally, some as start-up founders or venture capitalists, have returned to the region to become key networkers and figureheads in the region. Some venture capitalists who were interviewed in the study as key actors in the region, mentioned their own alumni status and explained their engagement partly as an eagerness to help the region or university that made them thrive, thrive in return.

One set of leaders that may be easily overlooked can be found at the **head of the intermediary agencies** that have been set up to build the interface between the university and its external partners or to orchestrate regional networks. They acted as pioneering leaders in building their organisations and networks, but also as important nodal points in regional networks. The head of the Innovation Agencies of the Technical Universities of Eindhoven or Munich, the head of the Regional Innovation Agency of Brno, or the head of the BarcelonaTech Start-up hub were clearly such leaders with a widely noted impact on building connective tissue in their cities and regions.

3.2 Connective cultural norms and narratives

In all case study regions, large or small, interviewees across a wide range of institutions often referred to some core values and common narratives, a common past or future that served to mobilise actors around a common purpose and identity, a core of trust and mutual understanding. Confirming the findings of some economic geographers who have shown that regional histories play an important role in regional development,³⁹ the optimism of regional actors were often based on a common history or shared accounts of regional strengths, often in the form of frequently quoted iconic examples of outstanding achievements. The elements of these accounts (see figure 3) act as cultural enablers since they create a feeling of connectedness and inspire a willingness to join forces toward a common set of goals:

Figure 7 Cultural coherence



In several regions (Manchester, Barcelona, Brno), the **historical references** concerned successful or pioneering industrial traditions. Most often, the collective narratives that were recounted in the interviews across a wide range of different actors, linked current entrepreneurial successes to past evidence of an entrepreneurial tradition, constructing or reflecting a firm belief in a regional “can-do” spirit that was able to succeed against all odds. A strong trade tradition was frequently mentioned in Helsinki, Barcelona, Manchester, Munich, Paris, and in Northern Portugal, and was seen as a fundament for the international orientation and openness of regional actors.

Other references to regional identities that were shared by many interviewees pointed to historical reasons for the particular resilience and resourcefulness of regional actors: In northern Portugal, Barcelona, Manchester, or Brno, for example, the fact of not being a capital in a centralist nation where resource flows tend to focus on the capital, was presented as a challenge that regional actors had met with entrepreneurial resilience by finding support and resources elsewhere, often cooperatively and internationally. The disadvantages of being far-removed from the capital region was seen as the origin of dense intra-regional collaboration as well as of the region’s strong international orientation and. In Manchester, the city’s early industrial past and the extreme hardship of working conditions is held responsible for a high degree of solidarity among Mancunians and their readiness to help each other out. Analogously, interviewees from Eindhoven often referred to the difficult agricultural conditions of the region, which made everyone support each other in hard times. Still today, interviewees report, there is an expectation to help each other out as much as possible without asking for anything in return, with the understanding that the situation could be reversed one day. High expectation of reciprocity is also reported in Braga and Helsinki.

Regardless of the particular historical references, interviewees in every region point to the importance of **collaborative behaviour** and non-hierarchical communication. Several regions explicitly pride themselves in their **high-trust, low-threshold communicational culture** which makes it easy for anyone with an idea for an innovative venture to approach others, even senior executives or presidents, and possibly win support if the initiative contributes to the dynamics of the region. The ease with which new ideas can take off is associated with the readiness of leading regional actors to consider and possibly support ideas, no matter where they come from. Thus, the fact that young start-up founders could approach a CEO of a large established company with a relevant idea if need be, was celebrated with great pride in Eindhoven, Helsinki and Braga. In Paris, Munich and Barcelona, such attitudes were reported as a feature of entrepreneurial sub-cultures, for example within a particular research cluster or start-up hub. The term ecosystem was even used here to refer to such sub-cultures where a dense communicational network includes approachability and smooth exchange of ideas.

In all regions, some **iconic projects or events** were mentioned **as symbols of the possible**. Such major achievements that served to show that unexpected successes could be achieved in difficult or adverse conditions, such as the recent financial crisis or the decline of a technology or anchor company, inspiring others to follow. Start-up successes were mentioned most frequently, with ideas that had had a remarkable impact, or founders whose companies were now worth hundreds of millions, such as the computer gaming company Supercell in Helsinki/Espoo. In Helsinki and Eindhoven, the decline of Nokia and Philips, which set off an economic downturn and crisis at first, were now associated with new opportunities: the spin-offs and supply companies of the old giants gave rise to a closely knit collaborative open innovation network of close smaller companies that had grown and had formed innovative clusters that had attracted international companies and investors from all over the world. In Paris, the common reference was the emergence of vibrant start-up hubs that transformed Paris from a postcard city into an innovative arena for entrepreneurial initiatives and international venture capitalists. In Brno and Northern Portugal, some major new investments, including the settlement of multinationals as new regional anchor companies, were seen as tipping points that convinced others to follow suit. In Helsinki, the pride

in students' sense of ownership and their entrepreneurial achievement in a time of crisis, creating *Slush* and a whole range of internationally visible projects, contributed to regional confidence. Overcoming a crisis was mentioned in most regions – in Barcelona, Northern Portugal, South Moravia, North Brabant, Helsinki, and Manchester – as the origin of a new self-confidence, a revitalised regional prowess and the basis for future success.

3.3 Strategy development

In policy discussions of regional innovation policies and smart specialisation strategies, regional strategy development is often described as a multi-level process that brings together different actors in different thematic sub-groups.⁴⁰ The findings of this study confirm this description only partly: Only in the smaller non-metropolitan regions, with distinct industrial or economic traditions and only few globally visible clusters, is it appropriate to speak of a process of development that leads to one common, recognised strategy.

In contrast, the regions that are dominated by large metropolitan areas, such as the Barcelona metropolitan region in Catalunya, Munich, Paris, or Helsinki, may have a common understanding of strengths of the region and of some common strategic priorities, and even usually possess an official overall regional strategy document. However, their innovation processes are too multifarious to make reference to any such coherent strategy, be it a smart specialisation strategy or other unifying innovation policy action plan. Rather, their strategic development is characterised by a multitude of overlapping networks of actors that develop strategic agendas and measures together but are only partly aware of each other. Here, only a few leaders meet each other often enough to have developed a common sense of strategic direction. In the large metropolitan areas, the strategy process can even be said to live off the density of strategically oriented networks and clusters, rather than one common strategy.

Hence, our case study regions showed very different responses to the process of developing the smart specialisation strategy, which has to be developed as an “ex ante conditionality” of the European Structural Funds. While the development process involved a variety of stakeholders and always included the universities, the resulting strategy is more of a strategic guideline in some regions than in others, depending on the size of the region and the implementation capacity attached to the region as a political actor:

- In some regions, the strategy process around smart specialisation served as an important mobilising process in which actors that had not previously known each other's perspectives and medium-term goals developed mutual understanding, identified new opportunities of collaboration and broadened their horizon. The process deepened strategic awareness, opened international perspectives for some actors, and helped to develop common platforms of development. Brno/ South Moravia is a good case in point. Here the development and implementation of the smart specialisation strategy has created a structure for joint strategic measures and communication, which is monitored and adapted by the unifying eye of the South Moravian Regional Innovation Centre (JIC), which brings international perspectives and innovation management expertise to the process (see 4.2.4 for details). The lasting coherence of the strategy process was ensured by the combination of a competent innovation agency with a strong regional political power.
- In Northern Portugal, the process of strategy development also created strategic coherence while it was being devised. But here, given the lack of political competence of the NUTS2 or any other larger region in a rather centralised nation, the coherence faded away in the long process of implementation, overshadowed by smaller but vibrant strategic circles around areas of common thematic interest, such as the Health or Digital Clusters for example.

- In Greater Manchester, the goal of increasing local autonomy (in the national devolution process) made the common strategy development a central topic for the region. While the smart specialisation strategy as such is not mentioned much (presumably because its development was preceded by similar regional strategy processes), the idea and quality of joint regional strategy development and common large-scale strategic projects is a paramount concern and feeds directly into the priorities for the use of the European Structural Funds.
- In the capital regions of Warsaw and Paris, smart specialisation does not play a prominent role in the awareness of the innovation actors of the university, even though such strategic development processes exist. However, in the case of Warsaw, while the strategy itself is hardly known beyond the circle of university leadership, the strategic investments made possible through structural funds are widely known among university actors and their partners. Strategic development is too diversely distributed in the capital, and national references too prominent for smart specialisation to play a visible role. However, in spite of its limited role in guiding strategic awareness of a wide range of actors, smart specialisation strategies do reflect strategic investments after input. Joint priority setting of a wide range of actors should not be underestimated.
- In the capital region of Helsinki, national innovation policy and regional innovation strategy are well aligned since the capital region aims to develop nationally relevant good practice. Moreover, the region is so dominant in overall knowledge and industrial production, that its strategy is also decisive for leveraging national innovation potential. This is illustrated by the fact that Aalto university and its role as a motor of the regional innovation ecosystem is seen and supported as a model for the rest of the country.

Beyond the overall innovation strategy of the region, strategic development processes constitute important connective platforms at other levels. Most prominently, in all regions, some **thematic clusters are important platforms for regional strategic positioning**. They serve **as multi-functional platforms**, encompassing:

- technology and market foresight;
- formal and informal exchange of companies and researchers active in the thematic area on global and local opportunities, useful services and infrastructures, possible partners;
- information on relevant political frameworks, regulations and funding opportunities;
- brokerage for partners;
- service hubs;
- shared infrastructures (physical buildings and technical facilities).

Thematic clusters vary considerably in their degree of cohesiveness. Some are run as loosely coupled organisations, others coalesce strongly around some key research institutes that have acquired national and international visibility and act as a regional driving force. Often, internationally outstanding scientists are engaged in positioning the region as a hub for their thematic area, thereby also increasing its attractiveness for internationally mobile researchers and research funds. They can help to make a cluster highly strategically aware and focused on leveraging strategic opportunities.

In the health sector, the **University of Manchester** has driven the formation of a major strategic cluster initiative, namely the *Northern Health Science Alliance*. It brings together the health and data science research strengths of the university with the opportunities of the devolved health and social care budget, offering new research opportunities and mobilising major external funding. The cluster also hosts *Health Innovation Manchester*, as the commercialisation end of the health science sector.

Another beacon of the university, advanced materials, is also positioned by the university as a research hub with a strong business innovation role. Institutional and academic leadership made use of the outstanding global visibility of materials research, particularly graphene (which was discovered by two scientists of the university, for which they received the Nobel Prize for Physics in 2010), by developing successful bids for major investments into research and innovation programmes and infrastructures. The new research centre *Royce Institute* and its innovation and commercialisation arm, the *Graphene Engineering Innovation Centre*, constitute the most substantial investments in the region in recent years, and there are high hopes regarding future commercial dynamics.

University strategy development can have a substantial influence on regional policy and vice versa. The case studies revealed that universities which have made their engagement in innovation a core part of their mission undertake profound transformation processes that aim to establish connective tissue between university teaching and research at all levels. Wherever such strategic transformation is initiated, it begins at leadership level, with close alignment between university and regional strategic priorities (see chapter 2).

As a board member of **North Brabant's Brainport Foundation**, the Technical University of **Eindhoven** (TU/e) is intensely engaged with Brainport Development (www.brainporteindhoven.com) which positions Eindhoven as an innovation hub at a par with the other two other national hubs Rotterdam and Amsterdam. TU/e feeds the results of its own strategic explorations directly into the strategy development of Brainport. Thus, the current TU/e strategy development for 2020-30 focuses on a range of cross-disciplinary and cross-industry research themes – smart materials, high tech systems and smart mobility, renewable energy systems, regenerative medicine and data-driven society, and human-centred technology and environment – for which university researchers develop visions together with their strategic partners.

University leadership emphasises the interlinked strategic development: "We believe that the university strengths and Brainport strengths are intertwined and we focus on this set of strengths. Our university is an international player thanks to our regional ecosystem being an international innovation hotspot. We provide talent and knowledge, and increasingly aim to create innovative platforms for industry to grow on." When the university takes the initiative of developing a thematic area, as for example in its recent initiative to develop a large-scale photonics program, it forms a coalition of interested people from public research institutions, companies and relevant government representatives to move the agenda forward and feed its vision into policy development at the national and EU level.

Wherever the **city has become a key strategist and promoter of innovation processes**, as is the case in several case study regions (such as Barcelona, Helsinki/Espoo, Manchester), it concentrates its planning and strategic investment into innovation districts, which enable co-location of small or medium-sized companies, start-ups, venture units of larger companies, and independent research institutes or university research groups. Such innovation districts or "re-imagined urban areas" (Katz and Wagner 2014) are designed to enable co-creation across institutional boundaries in joint innovation processes, in a "new spatial geography of innovation", as a benchmarking study of the rise of such innovation districts in the US has noted.⁴¹ In Barcelona, for example, the city's

revitalisation programme, including the iconic development project 22@ innovation district, has attracted global attention as a model of good practice.

Barcelona City Council's recent strategy for economic promotion (2016-2019) prioritises six strategic sectors for the municipal policy in a common focus on transformation of production: the manufacturing industry, the digital economy, creative sectors, the green and circular economy, health and quality of life and the social and solidarity economy. All sectors involve university research partners together with company networks and citizen participation. In its priority area of circular economy, for example, the focus on sustainable mobility includes university research projects with UPC's Cooperative Automotive Research Network, initiated by SEAT, Volkswagen Group Research and the UPC, as an open hub for industrial and academic partners from the areas of automotive and mobility research and innovation.

The Barcelona compact urban model and supporting strategy have made Barcelona an urban benchmark in sustainable mobility, where 85% of internal travel is on foot, by bike or public transport. Barcelona was positioned among the top 25 most sustainable cities in the world in 2017. In this context, the city acts as a living lab to ensure that it moves to the forefront of innovative mobility systems, with city blocks or districts included in field research for new mobility systems. As one particularly visible project, UPC's CARNET presented the Virtual Mobility Lab as part of the Smart City Expo World Congress 2017 on the SEAT stand in the Mobility Hub, and on the UPC stand. The aim of the Virtual Mobility Lab is to develop new tools for urban planning. CARNET has been defined as 'strategic' by its global company partners, due to its proven experience in traffic simulation and the growing global need for new simulation tools to implement new mobility solutions for citizens.

In some cases, the different levels of strategy development may get aligned, for example when external opportunities and a common sense of crisis and potential push national, regional and institutional actors into a common agenda. This was the case in Eindhoven and in Helsinki/ Espoo where the decline of a dominant company (Phillips or Nokia respectively) and the belief in the potential of regional knowledge assets triggered a multi-level, multi-actor search for new innovation leaders and models. In Finland, the search for a new innovation model resulted in the reform of the Higher Education Law and the creation of Aalto University as a new model of a university that would combine research excellence with an innovation-oriented mission. The strategic development which underpinned Aalto University's launch is an excellent illustration of how such an opportune and systematic alignment of national, regional and university actors in their strategy development, results in thorough institutional transformation.

Aalto University defines itself as an innovation university and ecosystem par excellence. The three subject pillars on which it is built – technology, art and design, and business – are designed to realise optimal innovation potential. The central strategic agenda of the university promotes the key success factors of an innovation ecosystem: talent – in educating a generation of "game changers"; research – in expanding the international composition and competitiveness of its research groups; and knowledge exchange – by orchestrating a culture that is entrepreneurial, global in its outlook and value-driven in its orientation toward sustainability.

With the merger of three already internationally acclaimed higher education institutions, Aalto was designed to be the flagship of a university reform that was undertaken at the same time (2009) and culminated in a new higher education act. The new law increased institutional autonomy, with no more decisions of parliament to approve university budgets, and allowed the establishment of foundation universities. Aalto's origin as a reform project was symbolised by its new status of a foundation university, which was linked with the transfer of its real estate into the foundation, substantial government funds and a matching fund policy (with a

factor of 2.5) for all private donations. A total of €200 million were raised by private donations, matched by €500 million from the government. In a country where fund-raising campaigns are not culturally established and higher education is largely seen as a public good that should be sustained by taxes, this fund-raising success was only possible because many stakeholders were convinced that the new profile presented a necessary and exciting new model.

The idea of merging technology, business and art and design had been put forward in 2005 against a background of cooperation which had already seen some visible successes of such a combination as, for example, in the product development design course or the design factory. After conditions had been defined, including sufficient resources to facilitate a merger (shortly before the financial crisis), the added value and aims of the merger were clearly laid down. The new university was to achieve three things: nurture a student-centred learning culture, raise the quality of research, and link impact in society to all its endeavours. To orchestrate the merger, a founding committee was formed. Under the leadership of the three presidents of the “parent” institutions, 500 members of the personnel engaged in an extensive process to define in what way the new institution should differ from the old. In addition, a research assessment exercise of strengths and potential was undertaken to identify focus areas in which investments and hiring should be concentrated. The fundamental overhaul of existing institutional orientations presupposed a common agenda of transforming everything. This is widely regarded as key to Aalto’s success, and to the depth of its transformation programme.

Arguably the most important feature and enabling factor of the transformation agenda consisted of an extensive hiring policy, helped by the fact that a substantial proportion of professors was nearing retirement, and in the introduction of a tenure track system. The hiring policy was based on the goals that had been set after the research assessment exercise, and on the fact that all retirements were taken into a pool rather than automatically attributed to the units where vacancies occurred. Research development was oriented toward the dual aim of building internationally leading research groups and of achieving an impact on society. While the tenure decision rests most decisively on strong research evaluation and teaching excellence, impact is given more weight thereafter. The prospect of tenure (provided the demanding but transparent performance criteria are fulfilled) also makes these positions internationally competitive. As of 2018, 40% of the research and teaching staff is international, with 70% of applicants for professorships coming from abroad. Key research indicators (such as international high impact publications and successes in international grant competitions), which are improving in a steady upward curve, show that the research policy has been successful. Aligned with the hiring policy, research infrastructure has also been organised differently: instead of professor-driven infrastructural investments, the most expensive infrastructural developments were organised as shared facilities while some older heavy infrastructures were phased out.

The research strategy centres first and foremost on allowing people to realise their potential. It also comprises support for key focus areas in which Aalto seeks to be among the 100 best in the world in the medium term. To strengthen these areas, incentives to expand multi-disciplinary and inter-school collaboration have formed part of Aalto’s research policy, intramural investments and evaluations. While fundamental research is more centrally placed in the schools, the applied research ties naturally to this multi-disciplinary agenda. However, both are seen as parallel and mutually reinforcing pursuits, since in both, outstanding success is linked to the idea of being game changers, of bringing radically new solutions to science or technology.

To ensure that ground-breaking research can bring competitive industrial advantage, long-term innovation cycles are needed, with room to develop at university. An example is the fundamental research done in the 1970s, on coating in one atomic layer, which won Tuomo Suntola,

the inventor of atomic layer deposition, the Millennium Technology Prize in 2018. Some 15 years of technology development were needed before it could begin to rouse interest in a pre-industrial phase. Beyond individual project partnerships, the university has thus developed and invested in strategic partnerships in which it pursues a long-term agenda together with key stakeholders. Such strategic partners seek a presence on campus because they appreciate the presence of excellent research and a strong start-up culture, often sharing infrastructures with university researchers or start-ups on a full-cost basis.

3.4 Connective structures and infrastructures – intermediary platforms and co-creation centres

In recent years, universities, governments and companies, have gone beyond traditional forms of research collaboration projects and loose exchange of ideas on educational and training needs, to ensure optimal connectivity between universities and business innovation. They have concentrated their innovation strategies on setting up new networks, services, or organisations that aim to connect researchers and innovators from different regional institutions – universities, research institutes, businesses, and governmental or non-governmental organisations – in order to develop and implement a common innovation agenda.

In every region, these initiatives include research networks with events to connect actors, as well as common collaborative structures or infrastructures for universities and companies, from loose networks to joint institutes. Often, public research and innovation policies have included government schemes to help jump-start and even sustain such connective services or structures, using regional funding schemes, national sources or EU structural funds. Overall, these different formats of interaction are evidence of dense triple helix interaction, developing the strengths of an innovation ecosystem and creating conditions for cohesive networks of formal and tacit knowledge flows that cannot be easily copied elsewhere.

The triple helix of regional actors develops common networks, structures, and spaces in order to make optimal use of geographic and cultural proximity. It brings together actors from the university, companies, government agencies or other public stakeholders, to promote mutual understanding, develop common goals and projects, and build sustainable partnerships that help regional innovation. Regional innovation ecosystems are characterised by inter-connected triple helix actors who promote connectivity, seeking coherence in three dimensions:

1. **Organisational Coherence:** To achieve connectivity, joint structures set some common decision-making procedures and are based, at least in part, on joint resource allocation.
2. **Social Coherence:** In order to build trust, create mutual support and facilitate interaction, formal events are underpinned by informal events and networks.
3. **Spatial Coherence:** To help serendipity and maximise the chances of encounter, common events, services and technical facilities are provided in common collaborative spaces, making use of geographical proximity to build bridges between separate institutions.

The concrete elements to achieve coherence are interactive formats that cover all levels, from strategy interaction amongst the region's institutional leaders, to research co-creation projects or student team development projects for companies. Interactive measures range from individual mobility between different institutions and sectors (such as student internships, Master's and PhD projects in industry, industry professionals as part-time teaching staff, lecturers or mentors, or university laboratories) to structural formats that organise collaboration in a more sustained manner. There are different types of formats for interaction, according to their degree of institu-

tionalisation, purpose and contribution of different actors:

1. **Strategy networks**, which aim to develop a common long-term agenda, to address a major transformation in the region, or to foster dense cooperative structures at regional level. The above-mentioned Brainport Foundation is a good example for a long-term regional strategy network. More loosely coupled versions also exist, as for instance in Manchester's Northern Powerhouse Partnership.

In **Manchester**, the *Northern Powerhouse Partnership* was set up in 2016, upon the initiative of former Chancellor of the Exchequer George Osborne who coined the concept of a Northern Powerhouse to support an increased Northern English contribution to economic growth. As a group, with a board of leading figures of major businesses, civic and university leaders, it seeks to combine efforts across the Northern cities (all of which face similar challenges) to identify opportunities for productivity increases in promising sectors, and lobby for devolved budgets and major strategic investments of national funds, such as investments into improved transport connectivity. The Northern Powerhouse Partnership also conducts benchmarking to learn from cities and regions in other parts of the world. In its lobbying for devolved budgets, which would allow for more effective investments and responsiveness to local needs, it aims to extend the model of the health and social care budgets to transport skills and educational sectors.

2. **Thematic clusters** aim to bring developments of university research and business innovation together into mutually supportive agendas and dynamic environments for joint project development. Some thematic areas seem to lend themselves more to such cluster cooperation than others. Noticeably, in every case study region, there were dynamic clusters in the health and biotechnology areas, sometimes linked, and sometimes in separate clusters. Information exchange and collaborative structures are particularly needed in the health sector as it is an area of vibrant and accelerated research development across an increasing number of disciplines. Besides, it has a high degree of regulation and requires a long time to market research findings and inventions. Moreover, the health and biotechnology fields have highly differentiated service and supply chain networks, which require close cooperation to survive on the market. Furthermore, rising costs of health care and opportunities in big data analytics for digital personalised medicine and optimised hospital processes make close collaboration with hospitals and university researchers a must. The Health Cluster which was established in Northern Portugal is a case in point.

The 10-year-old *Health Cluster Portugal* serves 174 member institutions from the health value chain, comprising universities, R&D institutions, hospitals, private health care groups, or companies in pharma or medical devices. Of the organisation's funding, 50% comes from membership, while the rest is raised through external grant competitions. Some companies located in **Northern Portugal** that are now well established internationally have acted as enablers for others that are growing.

The Health Cluster was set up in this region because of a close connection between several departments of the University of Minho and some medical device companies. The regional development agency (CCDR-N) conducted an analysis of health-related industry and its potential in the region, which revealed huge potential because of the scientific dynamics of the northern region in this area (the region being responsible for 40% of scientific papers in health, nationally).

A group of leaders in the sector pushed for targeted measures to create critical mass and to overcome the division between different groups (doctors, hospitals, companies, academics).

Strategic measures were developed to “create glue between these three pillars”. Larger cooperative projects (with 20 partners or more) which combine research application and translational research to reach patients received funding from mostly European and Portuguese public funds and companies. The success of these measures has helped public policy makers see the health sector as an engine for economic and social development. Nowadays the total of health exports (€1.4 billion) approaches the income from wine exports (€1.9 billion) and amounts to more than double that of port wine exports (€0.8 billion).

One of the aims of the cluster’s activities consisted in changing the image of the health sector to mobilise new forms of support. Before, health was seen primarily as a public duty and source of cost, rather than also as a source of income. Moreover, commercial activity was looked upon with scepticism in the public health sector. With the recent drive to put the citizen at the centre of the system’s development, and to focus on patient-centred medicine, these attitudes are changing. The cluster promotes the idea of value-based health care, comparing value and efficiency, finding new ways of managing, paying according to results, and fostering accurate process management.

In order to bring the diverse interests of 175 members together, some common opportunities have been identified: 1. flagging the importance of translational research; 2. enhancing the already well-developed ability of regional health research to offer particularly efficient and rapid clinical trial processes; and 3. exploiting the potential of medical tourism further. Such common interests are promoted at national and international events, for example an annual conference where one issue becomes the focus of a national discussion.

The Health Cluster Portugal promotes the whole of Portugal as a brand. As it is difficult to attract foreign direct investment to a smaller country in the health sector (big companies would normally look first at countries that are important markets), Portugal has to carefully select niches where it has particularly strong comparative advantages. These might include the attractive balance between availability of qualified people and relatively low cost of these human resources, or the regional strength of UMinho and the Braga Hospital and Medical School to connect data science and health research.

3. Common **services to support start-ups** and technology transfer, most often as **incubators**, staffed and run by a triple helix board, offer large-scale events and marketing that may attract national and international attention and venture capital. While university tech transfer offices have diversified their support services and strongly expanded into this area (see 4.1.3) public and company-based incubators have also mushroomed in all regions, sometimes thematically oriented or specialised (especially the company-based ones), but always combining start-up or acceleration support with business development services and technical facilities. Often, such start-up and incubator services are run and/or funded jointly by the university, regional or municipal government and companies. Science parks on university campuses also always host incubators. (See 4.1.3 for examples, such as *UnternehmerTUM*)
4. **Impact-driven research centres** of universities have taken on a central strategic importance for the universities and become international attractors to the region. Hence, municipal and regional agencies integrate them into their regional and city promotion. Such centres have emerged from strong internationally visible research which is linked to impact-driven innovation, usually in an area with urgent major technological, social and economic challenges. In order to find innovative and sustainable long-term solutions, researchers include users, regulators, stakeholders, markets, public agencies and service providers, to address the complex use contexts of the research challenge, such as sustainability-oriented research, as is illustrated by the Research Centre for Toxicology in Brno.

The **Research Centre for Toxic compounds (RECETOX)**, was originally established in 1983, against the backdrop of the “black triangle” of coal mines that posed a major environmental problem to the region. The aim was to focus on environmental protection, in close cooperation with industry and local companies. As an independent centre of **Masaryk University in Brno**, RECETOX aimed to understand chemical environmental processes, such as toxic compounds of waste management and their social and economic consequences, but now covers a wide range of disciplines from molecular and environmental biology to material engineering, toxicology, environmental chemistry, ecotoxicology, and computational biology. In addition to collaborating with companies, RECETOX also collaborates densely with hospitals. The cooperation with hospitals, the School of Medicine and the School of Health, has now developed into a new generation of large-scale monitoring networks, analysing the health effects of basic environmental water and air. Hence, RECETOX is now focused on protection of human health, according to the Stockholm convention on persistent organic pollutants, with duties to follow the effectiveness of the convention. As a partner of the UN environmental programme, it ensures long-term monitoring data and its cost efficiency.

Recent developments have included efforts to broaden the impact in reducing environmental pollution by capacity building. RECETOX has established a regional centre for capacity building for Central and Eastern Europe, after positive evaluation of a bid submitted to the UN. RECETOX now receives money from the national government and the secretariat of the UN Convention to build capacity in the region, organising training workshops and international summer schools for government employees. It also helps less developed regions with data management and training, in capacity building centres in Africa (Kenya, Ghana, Morocco).

RECETOX has become an environmental study and research hub, a European infrastructure and an implementation agency at the same time. As such it is able to attract people and projects from all over the world, to conduct research that cannot be conducted elsewhere and to bring a wealth of opportunities into the region. The key success factors of its success and impact on the region, the country and the world, consist of a continuous inflow of competitive funding grants, support for infrastructural development and a persistent focus on system competences in its students and researchers. After years of building up such system competences through Master’s and PhD theses, some former graduates who were successful abroad became division leaders of the centre. For RECETOX, the EU structural funds made a decisive difference in catalysing a scale-up.

5. **Joint research centres** or joint research labs have been developed and set up conjointly by universities and companies in an area of common long-term interest, with staff and infrastructures financed by both parties. In all case studies, such joint research centres were presented as highly prioritised strategic measures that were seen as a cornerstone of university and ecosystem development. As an institutionalised form of collaboration, joint research centres combine applied research and prototype development with common co-financed staff and facilities, often including their own technology transfer and start-up services. Such joint labs or research centres sometimes receive additional support from the government during their launching phase by providing land, space and building permits, or even support for building the physical infrastructure. Joint labs can also take the form of industry labs on campus where facilities are financed by industry and primarily used for prototype development. The possibility of using these facilities for research that is not immediately applicable is retained, as is the case at the *Done Lab* financed by Bosch on the campus of the University of Minho.

Beyond collaboration projects in existing public university labs, joint centres or labs are set up to enable researchers to tackle ambitious research agendas that cannot be conducted alongside other public research, that need special equipment, and extra financing from companies. Moreover, for companies and university researchers, the facilitated support of technology transfer and IP makes innovation processes more efficient. In some cases, a thematically oriented incubator forms part of such centres as it can benefit from the dense networking which the centre organises.

Three examples serve to illustrate the advantages of such new joint structures as well as the important strategic function of these formats of co-creation for universities.

In **Warsaw**, the **Centre for Pro-clinical Trials and Technologies (CePT)**, established in 2007 with the help of EU sources, aims to increase the potential impact of university life science research on businesses and to facilitate cooperation between university and business researchers. The centre brings researchers together from several faculties and two universities and 10 Institutes of the Polish Academy of Sciences, combining basic science with applications. With the help of €400 million investment from 2010-2015 (85% EU Structural and Investment Funds, 15% national funds), state-of-the-art laboratories and equipment were financed and built as shared facilities. Criteria for participation were purely predicated on scientific excellence, with the aim of providing sophisticated services for the pharma and nanotech industries, in particular aiming at regenerative medicine solutions.

While the centre is clearly a research initiative and was planned without industry, it was created for industry and with a view to developing an academic-industry consortium. In the meantime, company involvement has grown, with scientists being shared between industry and science to work on common development projects. Moreover, spin-offs have increased substantially through these centres. It should be noted that, apart from the substantial financial investments, the centre has also benefitted from expanded university services such as the research support services, the technology transfer office and the start-up service. In the university community, there is growing recognition of the impact of the centre and its applied research focus. The cooperative structure has also led to a new PhD programme in medical technologies and biochemistry.

In an analogous manner, two other centres were established to provide such university-business research and innovation interfaces, namely the *Centre for New Technology* and the *Centre for Biochemical Science*. All three centres have contributed substantially to collaborations with businesses as well as to the spin-off dynamics of the university.

At the **UPC in Barcelona**, the latest pioneering instrument is the development of an overarching university-owned system of interface units through the **Innovation and Technology Centre (CIT)**, expanding the capability of the university to respond to business needs. While business creation and valorisation are well advanced at UPC, the university still perceives a gap between university research and markets, which would need an earlier dialogue between university research and companies in order to explore win-win collaborations. To bridge this gap, the umbrella service CIT was created.

CIT comprises 20 applied research centres which combine applied research with a lively engagement in business or social innovation and value creation. They are located on four UPC campuses and have generated about 20% of the R&D income of UPC, of which half was derived from R&D agreements with companies. Thanks to their legal status as a “specific research centre” they can operate largely autonomously, including in their ability to employ staff on contracts and in administering their everyday transactions. This nimble form of

operation is seen as an important success factor for their ability to respond flexibly and swiftly to collaboration demands and business needs.

The **Institut de la Vision (IV) at the Sorbonne University in Paris** is one of the most important European research centres on eye diseases. The Institut de la Vision comprises a research centre, a clinical investigation centre, a rare disease reference centre and an incubator for start-ups (*Incubateur Voir et Entendre*), in the legal framework of a joint Foundation *Voir & Entendre*. Conceived as a place of gathering and exchanges, the Institut de la Vision enables the sharing of ideas and skills, the emergence of new questions, and the delicate process of translating fundamental discoveries into new treatments. The institute brings together, in a single building, researchers, clinicians and industrial partners, with the goal to discover, test and develop treatments and technological innovations of tomorrow in order to prevent or limit visual impairment and to improve the autonomy and the quality of life of patients.

The activities are developed by more than 15 research teams (of Sorbonne University, Inserm, and the CNRS) working on different eyesight problems. Alongside these teams, companies settled in the institute to develop research projects in the field of vision for drug discovery, imaging, surgery, and new technologies. The latest developments in analysing, exploring and imaging are available for researchers and industry partners, who are grouped together in technological platforms dedicated to a wide range of different methodologies. The scientists of the Institut de la Vision work hand in hand with the clinicians of the *Clinical Investigation Centre* of the *Quinze-Vingts* hospital, which was opened in 2004 as the only Clinical Investigation Centre dedicated exclusively to ophthalmology in France. More than 50 studies (phases I to III clinical trials, physiological and physiopathological studies, etc.) are at present in progress.

Table 7 Stakeholder contributions to co-creation

Co-creation structure	University contribution	Business contribution	Government contribution
Strategy networks	Foresight of emerging research fields and technology developments	Foresight of emerging markets and technology developments	Regional or municipal development perspectives and investment planning
Research thematic clusters	Different disciplinary expertise on research development in thematic area Access to international research partners Ideas for new research Researchers and graduates	Expertise on market developments and potential Applied research and development expertise Access to global business partners Knowledge of global economic developments	Cluster-specific funding for staff staff Funding for research conducted by regional cluster partners priority areas Targeted start-up funds for priority thematic areas
Start-up or innovation services	Students and researchers with business ideas Community building among students and researchers Marketing and communication of events	Mentors Jury members Venture Capital Partners for start-ups (for example as first clients or demonstration cases)	Funding for service staff Funding and framework for venture competitions Start-up grants
Tech. transfer & innovation services	Financing and training staff Allowing commercialisation as acceptable pursuit	Mentorship and financial support for IP	Funding Services provided by government agency
Joint core technical facilities	Technical know-how and staff to ensure maintenance	Funding for infrastructures	Funding for infrastructures
Shared large research infrastructure	Research and technical expertise to ensure state-of-the-art status and develop methodology	Funding for infrastructures, technological expertise	Funding for infrastructures
University research centres with impact mission	University research with international visibility attracts national and international funds and talent to the region.	Companies and public external stakeholders adopt research in their development and cooperate to meet challenges together	Competitive funding to meet societal/ economic challenges Adapting regulations to meet challenges
Joint labs/ interface research centres	Provide researchers and facilities for applied research and prototype development Research expertise Researchers (Master's students, PhD, postdocs)	Funding and expertise for IP and commercialisation Funding for PhDs Funding for research infrastructures	Funding for centres Infrastructure Building permit Regulations for private-public partnerships Special framework contract for private-public partnership accounting
Joint campuses, science parks	Openness to external partners, private-public partnerships, in research and education to create dynamic campus environments	Infrastructural Investments private-public partnerships with long term perspective	Urban planning and zoning laws allowing mixed use Lobbying for European and national funds Infrastructural investments Coordinating ESI funds

3.5 Connective spaces: co-creational infrastructures and the staging of innovation

while innovation policies have long been concerned with creating common agendas for technology and economic development by fostering organisational and social coherence, the spatial dimension of collaborative networks has only received more attention from university leadership and regional or municipal authorities in the last decade. Indeed, our case study interviews revealed that the spatial dimension of innovation processes now occupies a central position in joint strategic deliberations.

In all regions, such strategic attention always includes some major research infrastructures that may act as attractors to the region (such as the Super-Computing Centre in Barcelona). Most prominently, however, it focuses on campus development projects that interlink university research, business innovation and public services in one location, by developing a university campus, science parks or an innovation district as part of the city. In any case, these infrastructural developments are conceived as knowledge-intensive, often technologically advanced areas, in which different types of institutions and groups develop greater dynamics jointly than they could if located in isolation.

Joint campuses or science parks aim to bring together university research groups, start-ups, small and medium-size companies or units of large companies, often clustered in thematically cognate areas. In close co-location, they can share some technical or research facilities and services, and benefit from common events that cater to diverse interests within this community. Rather than simply co-existing, there is concerted attention to offering services and orchestrating formal and informal events that create connective tissue between the members of the campus or science park. Thus, infrastructures become collaborative spaces.

While science parks had developed already since the millennium, the concern with collaborative spaces has spread to a more diverse portfolio of innovation initiatives, from start-up hubs, to core research facilities, to joint labs, and, most prominently, to an overall concern with campus development that allows for co-creation. Our case studies confirm the findings of a recent international overview of tech-based innovation campuses (Magdaniel 2017), which identifies a shared central focus on encouraging innovation, academic research and R&D to promote social and economic development and growth through triple helix interaction.⁴²

In all cases, the strategic boards of such high-tech university campuses or science-parks comprise city, company and university representatives, who oversee the orchestration of such spaces in terms of the right mix of institutions and support services and infrastructures. Campus management is responsible for creating the right formats to promote contacts between the different companies and research institutes. In some cases, the city authorities and university researchers are also exploring new ecological and social solutions in the process. Thus, social, cultural, organisational and infrastructural connectivity is combined with common urban development, promoting scientific, technological, economic, and societal innovation.

Some examples may serve to illustrate these triple helix-based infrastructural development projects:

TUM's largest **science and engineering campus in Garching**, a green field campus north of **Munich**, hosts more than 15 000 students and 3500 employees on 170 ha. Apart from the departments of chemistry, physics, mathematics, computer science, mechanical and electrical engineering of TUM, the campus also hosts seven research institutes of Max Planck and the Fraunhofer-Gesellschaft, as well as seven companies. Here the state of Bavaria has invested €1.3 billion since 1995.

The most decisive step for the attractiveness of the research campus for university members and high-tech SMEs was the connection to the subway a few years ago. Nevertheless, when reaching the limits of public infrastructural investment, TUM became the forerunner in the use of Public-Private Partnerships for the further development of its campus. In 2007-2008 a pan-European investor competition was conducted, and a group of several medium-sized Bavarian companies won, as the first public-private partnership at Bavarian universities.

In 2017, another milestone public-private partnership investment was completed with the opening of the Galileo Centre, which includes a new lecture hall and TUM academic facilities, as well as shops, restaurants, a hotel, a guest house and a congress centre.

The campus also functions as a living lab. If the rapid growth of the campus of previous years continues, there will have to be a realignment of the energy supply. Against this background, a scientific team is developing an innovative energy concept by integrating the existing and prospective building structures into an optimally energy-efficient structure, where energy production will be increasingly based on renewable sources. Therefore, the supply of electricity, heat and air-conditioning will be analysed jointly, not separately as is usually the case. The necessary methods will be developed in interdisciplinary cooperative projects, including business optimisation models. The federal ministry of economics affairs and energy is funding the project.

Eindhoven has been very successful in developing internationally competitive research campuses as key structuring instruments of its regional innovation system. Its first model campus, the *High Tech Campus Eindhoven*, was developed by Philips, first as its own international R&D campus (1998) and then as an early open innovation space, to reinforce the interaction between people with different technical backgrounds (2003). In 2012, the High Tech Campus was sold by Philips to a private investment firm, with Philips remaining on the campus as a tenant.

Today, the area is home to more than 140 companies and institutions, including ABB, Analog Devices, Intel, IBM, Philips Research, Atos Origin, Aquaver, FluXXion, Cytocentrics, NXP, Texas Instruments, and Dalsa. It hosts over 10 000 product developers, researchers and entrepreneurs in the areas of high-tech systems, nanotechnology, embedded systems, smart pharma, life sciences, and IT security and encryption. In addition to companies, the HTC also hosts several publicly funded research institutes as well as collaborative entities, such as Solliance, a cooperation between ECN, TNO, Holst Centre and TU/e, established to do research into thin film solar cells, or *EIT Digital*, the knowledge and innovation community of the European Institute of Innovation and Technology (EIT). The High Tech Campus Eindhoven has been praised as one of the best locations in the world for high-tech venture development and start-up activity.⁴³

The success of the open innovation model of HTC has led to further campuses being set up, aligned with larger thematic focuses. Examples are: the *High Tech Automotive Campus, Strijp S-T*, and TU/e's own urban science park, which has seen major capital investment in recent years, and the new *Brainport Industries Campus*, which is to focus on 21st-century manufacturing and is starting construction in 2018.

Campus development and cluster development are closely interlinked in Eindhoven. Campus development combines building infrastructures with major technological facilities and networks. For example, in the case of BIC, campus development includes a multi-material 3D printing lab, a flexible manufacturing field lab, a smart connected supplier network, and a High Tech Software Competence Centre.

The above-described attention to state-of-the-art research infrastructure, mutually beneficial co-location and enhanced collaborative potential can be found across a wide range of investments, from those that have been supported with EU structural funds, to regional and national investments. Sometimes national competitions or funding schemes, such as the Czech National Roadmap for Important Research Infrastructures, the German national support for regional excellence clusters, the Dutch investments in “mainport” or *top sectors*, or the British decision to provide a devolved health sector budget, have provided critical support for regional infrastructural investments.

In a majority of the regions visited in this study, investments in physical building infrastructures amounted to billions of Euros in just a decade. They served to revitalise whole parts of towns (for example in Manchester or Barcelona) or to create new models of urban development (for example in Eindhoven or Espoo). Most often, in order to justify such major investments (which also often entail substantial long-term annual maintenance costs), investment decisions are linked to competitive cases of outstanding research and innovation potential of a given university or cluster. In all cases, these large-scale infrastructural investments aim to deliver the glue that keeps a knowledge network together. Large-scale campus development projects and more recent science park investments pay considerable attention to the collaborative and socio-cultural potential offered by events and spaces, and they design their central facilities with a view to increasing interaction and flexible communication.

Thus, regional actors are acutely aware that a major research infrastructure or campus development is not just an enabling facility or space that underpins a critical mass of researchers and other innovators, but also a meeting point and attractor for more talent from outside the region. Most importantly, they are aware that a cultural environment has to evolve and is needed to nurture regional innovation, and that such cultures cannot be easily imitated or rebuilt elsewhere (as many interviewees emphasise). Infrastructural investment, if connected to socio-cultural connectivity, can provide the glue that keeps a global player in the region. In recognition of the importance of the cultural environment and its centrality to the regional ecosystem, some infrastructural developments even include internationally renowned iconic architecture, far beyond the usual sober functionalism of many public research buildings, to symbolise the spirit of the ecosystem.

Similarly, start-up hubs are designed with considerable attention to the possibility of chance encounters, a creative atmosphere, and an architecture that reflects post-industrial revitalisation. They are infused with the creative vibes of a high energy work-hard, play-hard scene. From Aalto’s *Design Factory* or *A-Grid* to Barcelona’s *Pier 1*, university or municipal incubators, fab-labs or maker spaces do not just provide space and technical facilities for start-ups, but seem more like stages for creative events that deserve a public viewing and a fitting setting.

Accordingly, public competitions in which young start-up founders pitch to obtain the next round of high-risk funding for the next phase of their new, promising innovative businesses are celebrated like theatrical productions or modern town pageants. Fittingly, the most successful orchestration of such venture competitions is the one that is organised by students in Helsinki each year. *Slush*, which is advertised as the “WORLD’S LEADING STARTUP EVENT WHERE 20,000 TECH HEADS COME FOR MORE THAN INSPIRATION” (<https://www.slush.org>) is organised by 3000 student volunteers, and has all the iconography of a rock concert.

Starting a business does not just need an idea, the right competences, equipment and a space. It also needs a dramatic challenge and a stage, an audience, a heroic feat, some losers, and a winner that defeats the foe. The modern twist is that the winner tends to be a team, and the heroic process of passing the test occurs through collaborative events. Young modern innovators are celebrated like heroes in a modern drama. Innovation has become the decisive heroic arena in which today's challenges are won.

Annexes

Annex 1 Overview of case study regions (according to EU NUTS2 definitions) with corresponding data from EU regional competitiveness index 2016

NUTS 2 Code	Name (NUTS 2)	RCI Rank /263 (national rank)	GDP p.c. Rank (Score, PPS) EU28=100	Stage of development	Capital/ metropol./ regional	Technol. readiness rank (score)	Business sophistication rank (Sc.)	Innovation rank score (rank 2013)	HE / LLL score (Rank 2013)	Tertiary educ. 2016 % (2012) No. students	University for case study (students)
CZ06	Southeast region (Czech Republic)	151 (2)	175 (78)	3	R	121 (72.7)	196 (24.6)	85 47.3 (153)	101 67 (165)	25.6 (20.8) 90 000	Masaryk University (40 000)
DE21	Upper Bavaria (Germany)	9 (1)	6 (180)	5	M	67 (88.5)	36 (52.9)	4 90.9 4	59 71.4 (60)	30.1 (30.0) 117 000	Technische Univ. München (40 000)
ES51	Catalunya (Spain)	153 (4)	78 (107)	4	M	150 (64.7)	125 (36.6)	100 45.4 (140)	193 55 (107)	38.6 (32.8) 175 000	Politecnica de Catalunya (33 000)
FI1B	Helsinki-Uusimaa (Finland)	11 (1)	21 (150)	5	C	7 (96)	37 (52.7)	5 87.5 (6)	3 93.4 (6)	51.6 (48.9) 90 000	Aalto University (17 500)
FR10	Ile de France (France)	8 (1)	5 (180)	5	C	109 (78)	16 (61.1)	10 76.9 (13)	30 78.3 (49)	47.3 (41.2)	Paris 6 (Pierre et Marie Curie) (32 000)
NL41	North Brabant (the Netherlands)	16 (3)	30 (135)	5	R	22 (93.0)	24 (56.4)	15 71.8 (34)	53 72.5 (33)	32.9 (29.9)	TU Eindhoven (12 500)
PL12	Mazowieckie region (Poland)	150 (1)	80 (108)	4	C	203 (41.3)	169 (31.0)	85 47.3 103	59 71.5 (128)	38.4 (33.4)	Warsaw University (47 000)
PT11	Norte (Portugal)	203 (4)	216 (64)	2	R	189 (48.9)	199 (43.3)	200 21.9 (208)	228 47.5 (154)	20.2 (16.4) 100 000	Universidade do Minho (19 500)
UKD3	Greater Manchester (UK)	44 (12)	125 (92)	4	M	67 (88.8)	14 (61.8)	84 47.7 (123)	55 72 (21)	39.3 (34.8) 99 000	Manchester University (40 000)

Annex 2 Overview of Institutional Data

2017 (2012)	Aalto University	Masaryk University, Brno	Sorbonne University	TU/e, Eindhoven
Number of Students	17 345 (19 447)	32 539 (43 253)	51 438 (48 643)	12472 (9194)
Bachelor graduates p.a.	1178	3 107 (4 037)	7 284 (5 037)	1010 (995)
Master graduates p.a.	1927	3 978 (4 252)	10 219 (8 785)	1 349 (1 057)
Doctoral students	2516	3 035 (3 489)	4 392 (5144)	1 706 (1358)
Doctoral graduates p.a.	256	322 (329)	1 046 (1 187)	352 (266)
Proportion of students that come from the region	N/A rising number of non-regional applicants	43,8 %	53,3 % (51,9 %)	
Proportion of all graduates that remain in the region	N/A (many graduates remain in the region)	60,7 % alumni employed in South Moravian Region (59,5%)	73,6 % (65,1%)	51% of the recent graduates
Number of academic staff	1447 (1519)	1 627,67 FTE (1 493,93 FTE)	4 666 (4 862)	615 (not incl. PhD fellows) (568)
of which professors	386 (288)	214 (214)	1 148 (1 181)	699 (656)
Number of research cooper- ation projects with industry/ companies/other regional institutions	649 Projects funded by Tekes: 311 Other industry coopera- tion projects: 482	n/a	416 (UPMC only)	140 (180)
Third party funding or other income for cooperation with industry/ private companies	€32.000.000. (€12.100.000 + € 20.4mill in Executive Education turnover)	37 462 103 CZK (€1.500.000)	10 161 K€ (8 236 K€ in 2012).	€20.700.000 (16.000.000 in industry projects) €4.700.000 realized in proj. with non-profit organisa- tions (19.800.000 in 2012)
Income from technology and knowledge transfer p.a. (patents, licences, CE)	€ 128 373 + €20,400,000 for CE	38 538 000 CZK	13 176 K€ (10 666 K€ in 2012).	N/A
Number of university spin-offs in last 5 years (2013 – 2017)	100 = 23 spin-offs + 70 start-ups p.a. (50% of university start-ups in Finland are from Aalto)	5 spin-offs (2008-12: 4) + unregis- tered number of start-ups 16% of ca. 2000 Czech start-ups are in Brno ¹	60 spin-offs from laboratories + 101 start- ups from students and alumni (former UPMC before the merging)	152 spin-offs and start-ups (2012-16)

1 Eliška Kozáková, Comparison of business support for start-ups in the Czech Republic and the Republic of Korea, Diploma thesis, Brno 2017.

TU München	University of Manchester	University of Minho	UPC, Barcelona	University of Warsaw
40.841 (31.032)	39 700 (39.953)	18 578 (18.836)	28.707 (31.223)	45 400 (50 400)
3 614 (2 763)	27 635 students (27.996)	2 304 (2.167)	5.695 (2015-2016) 4.842 (2012-2013 bachelor+ master grad.	5 300 (5100)
5115 (1 432)	8,490 (8,346)	1 826 (1625)	1.366 (2015-2016)	5 500 (8 000)
9 242 (6.461)	3 575 (3,611)	1 755 (1956)	2.157 (2.666)	3200 (3100)
6 033 ? check (4 900)		211 (186)	559 (354)	335 (256)
	27%	75%		60% (60%)
1 078 /1 432 = 75%	Ca. 50% Graduates: 470 (150)	90%	N/A	70% (N/A)
7.005 (6.546)	4,575 (3,849)	2161 (1803)	3.066 (2.431)	3 800 (3 200)
546 (509)	n/a	1220 (1180)		750 (860)
1200 (1000)	182 (124)	320 (n.d.)	670 (671)	370 (310) *mostly Warsaw located partners
€49.256.434 (€45.462.105)	£ 32.018.000 (2015-16) £ 23,186.000 (2012-13)	€ 22.468.344 (€ 11.755.311)	€ 15.149.300 (€ 15.782.402)	NA* (*in 2013 1 mln USD grant from Google for establishment of Digital Economy Laboratory at UW)
€1.846.634 (€ 507.497 in 2012)	£ 3,615,000 (£1,149,000)	4.1 million (2017) TecMinho turnover (n.d.)	€2.341.919 (2016)	190 mln PLN (170 mln PLN)
75 spin-offs and start-ups p.a. (2008-2012: 15-20 p.a.)	15 (2008 - 2012: 14)	46 spin-offs + 530 student start-ups known to have been created over the years (since?) (2008 - 2012: n.d.)	80 spin off (23 of them with UPC capital participation) + more than 250 start-ups created	2013: 0 2014: 1 2015: 6 2016: 7 2017: 7

TU/e – Eindhoven University of Technology, the Netherlands



Aalto University, Finland



University of Manchester, UK



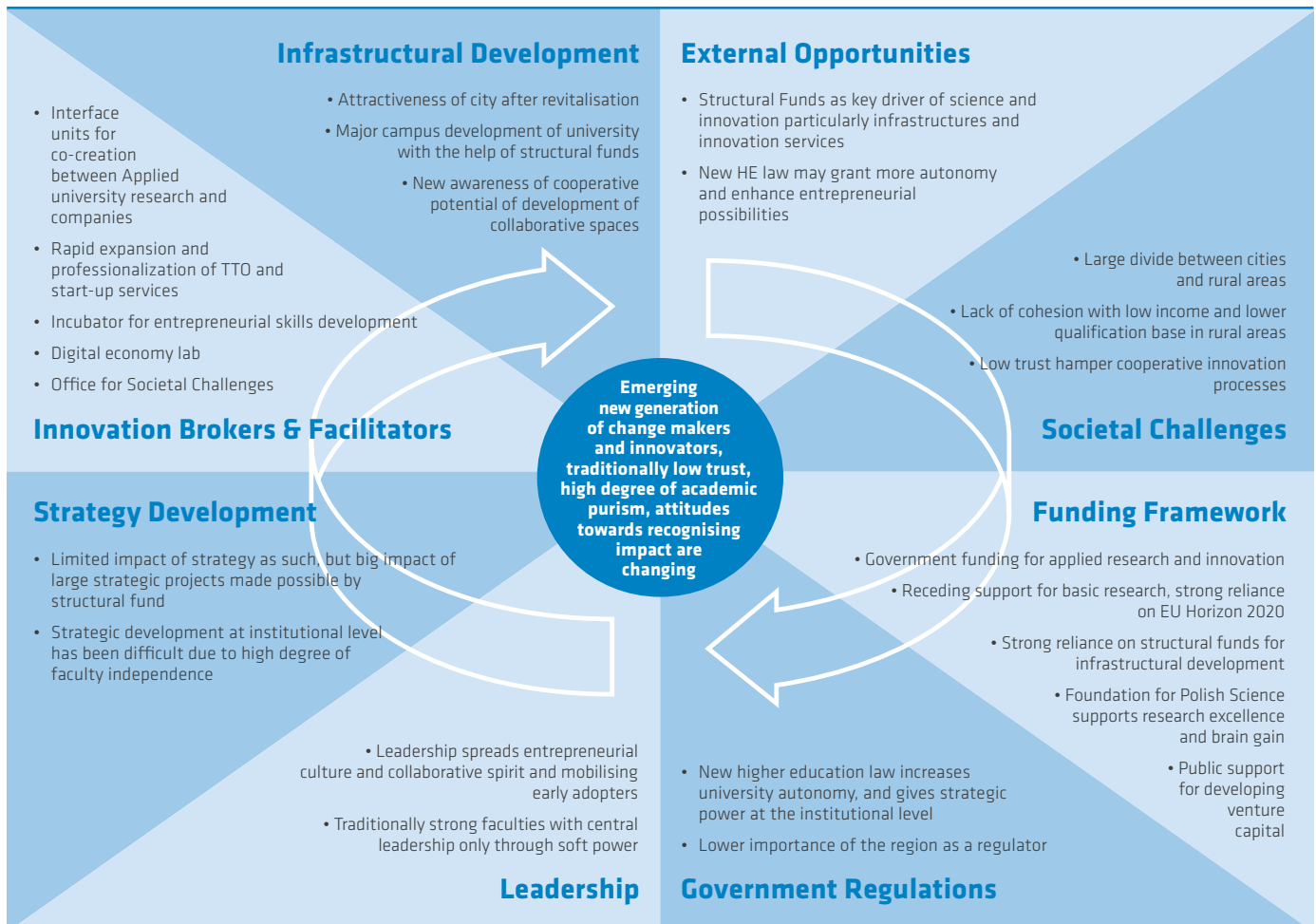
University of Minho, Portugal



TUM – Technical University of Munich, Germany



University of Warsaw, Poland



Masaryk University, Czech Republic



UPC – Universitat Politècnica de Catalunya, Spain



Sorbonne University, France



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Notes

- 1 Etzkowitz (2003): 294. According to Etzkowitz, "The university is emerging as an influential actor and equal partner in a "Triple Helix" of university-industry-government relations."
- 2 Pawlowski (2009): 51-64.
- 3 See <https://steinbuch.wordpress.com/2016/07/23/towards-the-4th-generation-university/>
- 4 Chesbrough (2003): 177.
- 5 Op.cit.
- 6 Etzkowitz (2003): 295. He observes that "the university has traditionally been viewed as a source of innovation, providing trained persons, research results and knowledge to industry. Recently, the university has increasingly become involved in the formation of firms, often based on technologies originating in academic research".
- 7 Huggins (2014): 22.
- 8 With Porter's *The Competitive Advantage of Nations* (1990), micro-economic notions that had been associated previously only with the capacity of a firm to compete, grow and be profitable, were applied to a territorial unit such as a nation. Thus, the Global Competitiveness Index of Nations, published annually by the World Economic Forum, defines national competitiveness as the "set of institutions, policies, and factors that determine the level of productivity of a country" (Schwab and Porter 2007). In the focus on territorial units for competitive performance, the region soon rivalled the nation as a preferred focus since it offered factors that could not be easily influenced at national scale. For more than two decades, researchers and policy makers have reflected upon the competitiveness of a region and the factors that contribute to its growth or sustainability.
- 9 See Goldstein and Drucker (2006): 26, and Hall, Jaffe and Trajtenberg (2000).
- 10 This differs from the focus on exogenous factors of traditional growth models. Endogenous growth theory understands the knowledge economy and its competitiveness as a result of a nexus of activities and resources that centre on innovation. The concept of regional innovation system was developed by Cooke (2004) and Lundvall (1992, 2010) who also influenced EU policy making in this area.
- 11 In this study, innovation systems theory is used as a basis for our inquiry since it looks at an economy "as an interlinked systemic network of components facilitating innovation" (Huggins 2014, Lundvall 1992). The difference of our approach lies in extending this focus to other dimensions of innovation and to focussing more explicitly on socio-cultural factors of such an approach. This does greater justice to the wider angle and long-term perspective with which universities approach innovation.
- 12 Drucker and Goldstein (2007).
- 13 Various attempts have been made to assess the economic contribution of universities to regional or national innovation; for an overview cf. Goldstein and Drucker (2006) whose focus lies on American Universities, however. For an assessment that focuses on European universities there is a recent report by the League of European Universities (LERU) by BiGGAR Economics (2017), *Economic Contribution of the LERU Universities. A report to LERU*.
- 14 A first study of new structures of collaboration conducted by H. Kroll on "new strategic models of science-industry collaboration" already pointed to new funding policy formats which sought to foster more long-term and institutionally anchored "pre-competitive" forms of collaboration to address a blind spot in the science/industry cooperation arena, comparing the French "pole de compétitivité", the German "Forschungscampus", the US "Engineering Research Centres", the UK "Catapult Centres" and the Finnish "SHOK Centres".
- 15 For a good comparison of the comparative advantages of different methodological approaches to regional innovation see Goldstein and Drucker (2006): 24-26.
- 16 See Morais e.a. (2016) and EUA (2018)
- 17 https://ec.europa.eu/regional_policy/en/information/maps/regional_competitiveness/
- 18 <https://eua.eu/issues/23:european-innovation-ecosystems.html#sec-smart-> Last accessed 10.11.18.
- 19 See Etzkowitz (2003), Huggins et al. (2011), Florax (1992), Jaffe (1989).
- 20 This finding is also confirmed by Etzkowitz (2003).
- 21 A detailed account of such university-business strategic partnerships (for the Dutch context) can be found in the study Tjong Tjin Tai et al. (2018), which confirms our findings, but gives detailed case studies on the motivations, formats, opportunities and trade-offs of such partnerships.
- 22 See Bennetot Pruvot and Estermann (2017): 23-24
- 23 For an overview of fiscal innovation incentives see OECD (2017).
- 24 See EUA (2018)
- 25 For a critical first assessment see Kroll (2017).
- 26 For accounts and comparisons of national autonomy frameworks see Bennetot and Estermann (2017).
- 27 OECD (2017).
- 28 Damioli & Vertesy (2017).
- 29 See EUA's annual Public Funding Observatory. Available at: <https://eua.eu/101-projects/586-public-funding-observatory.html>
- 30 Claeys-Kulik, A. and Estermann, T. (2015)
- 31 This was predicted by Chesbrough (2006): 45.

- 32 It should be noted, however, that evidence shows how universities that are well-funded at the national level fare better in European competitive funding than those trying to compensate for lack of domestic funds
- 33 See Huggins et al. (2011), Bathelt et al. (2004), Etzkowitz (2003).
- 34 For details on the Espoo Innovation Garden and its close collaboration with Aalto University, see Rissola et al. (2017).
- 35 See TUM Research and Commercial Cooperations. Basic Principles • Types of Agreement • Model Agreement Forms as an example of good practice in this context. Available at: https://portal.mytum.de/kompass/forschung_public/TUM_Forsch-Wirt_Brosch-en.pdf (last accessed 14 December 2018).
- 36 Our findings are confirmed by a recent study of such partnerships in the Netherlands by Tjong Tjin Tai et al. (2018).
- 37 See Clark and Moonen (2014):18.
- 38 This criticism is strongly voiced by the recently published CESAER White Paper on regional innovation, Bedford, T. e.a. (2018).
- 39 Boschma and Frenken (2006) and Franke (2018).
- 40 The 2015 and 2017 JRC Technical Reports on the role of Higher Education Institutions in Smart Specialisation Strategy development point to the factors and limitations of university engagement in the region and overlooked areas of relevance but still seem to take the search for an overall strategic coherence as a normative reference point. In regions with a large metropolitan city, such coherence may be neither possible nor needed to provide strategic awareness of potential and opportunities or sufficient density of knowledge-driven regional innovation.
- 41 See Katz and Wagner (2014): 2. The study emphasises that when such innovation districts contain economic, physical and networking assets that are combined with a supportive, risk-taking culture, an innovation ecosystem emerges as a synergy between people, firms and place that helps generate ideas. Our findings fully support this sense of innovation districts but strongly emphasise the crucial role of interaction with universities in their emergence.
- 42 See Magdaniel (2017).
- 43 See Wikipedia entry on the High-Tech Campus Eindhoven for references to benchmarks. Available at: https://en.wikipedia.org/wiki/High_Tech_Campus_Eindhoven See especially: McReynolds, C. *European Cities and Regions of the Future 2014/15, Financial Times* (17 Feb. 2014); Akhtar, D. *7 Best new Global Cities for Startups, Fortune* (19 Sept. 2012); and Pentland, W. *World's 15 Most Inventive Cities, Forbes* (9 July 2013). (Retrieved 10 April 2017).

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