Science, Technology and Innovation Studies

Dirk Meissner · Leonid Gokhberg ·
Yaroslav Kuzminov · Mario Cervantes ·
Sylvia Schwaag Serger *Editors*

The Knowledge Triangle

Changing Higher Education and Research Management Paradigms

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Leonid Gokhberg is First Vice-Rector of the HSE and also Director of HSE ISSEK. His area of expertise is statistics and indicators on STI as well as foresight and policy studies in this area. He has authored over 400 publications in Russian and international peer-reviewed journals, monographs, and university textbooks. Prof. Gokhberg has coordinated dozens of national and international projects funded by public agencies, businesses, and international organizations. He has served as a consultant of the OECD, Eurostat, UNESCO, and other international and national agencies. Leonid is also a member of the Global Innovation Index Advisory Board, the OECD Government Foresight Network, and OECD and Eurostat working groups and task forces on indicators for S&T and, as well as steering committees of various prestigious international and national initiatives. Prof. Gokhberg is Editor-in-Chief of the Scopus-indexed scientific journal *Foresight* and STI Governance and editor of the Springer academic book series Science, Technology, and Innovation Studies, and participates on the editorial boards of several other influential journals. He holds PhD and Dr. of Sc. degrees in Economics.

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Dirk Meissner is Distinguished Professor, Head of the Laboratory for Economics of Innovation at HSE ISSEK and Academic Director of the Master's Program "Governance of STI." Dr. Meissner has 20 years of experience in research and teaching technology and innovation management and policy. He has a strong background in policymaking and industrial management for STI with a special focus on Foresight and road mapping, funding of research and priority setting. Prior to joining HSE Dr. Meissner was responsible for technology and innovation policy at the presidential office of the Swiss Science and Technology Council. Previously he was a management consultant for technology and innovation management with Arthur D. Little. He is a member of the OECD Working Party on Technology and Innovation Policy. He is Associate Editor of Technological Forecasting and Social Change, IEEE Transactions on Engineering Management, Journal of Intellectual Capital, Journal of the Knowledge Economy, member of Editorial Review Board at Small Business Economics and Journal of Knowledge Management. He guest-edited Special Issues in Industry and Innovation Journal, Journal of Engineering and Technology Management, Technological Analysis and Strategic Management among others.

Sylvia Schwaag Serger, Professor, Lund University. She has spent 20 years designing, implementing, and analyzing innovation policy in a Swedish and international context. From 2018–2020 she was Deputy Vice-Chancellor at Lund University. Prior to that (2008–2017), she was Executive Director for International Strategy at the Swedish Government Agency for Innovation (VINNOVA). She has run an independent think tank on the knowledge economy, worked as Swedish Science Counselor in Beijing (2005 and 2007) and as analyst for the Swedish Ministry of Trade and Industry. During 2015/2016, she was senior advisor at the Swedish Prime Minister's Office for Strategic Development. In 2016, the Swedish government appointed her to coordinate the government's efforts to mitigate the effects of Ericsson's cutbacks in Sweden. At the European level, she has chaired an expert group on international research and innovation cooperation for DG Research. She has also served as a member of an expert group tasked with evaluating the European Innovation Partnerships and as member of the Expert Group on the Economic and Societal Impact of Research and Innovation (ESIR). She was one of the external experts in the OECD's innovation reviews of Finland and Norway 2016/2017 and has evaluated Denmark's Innovation Fund. Schwaag Serger is a member of the Austrian Council for Research and Technological Development, chairperson of the Swedish Foundation for Internationalization of Higher Education and Research (STINT) and member of the International Advisory Board of the Norwegian Research Council. She has served on the board of the University of Uppsala and on the Swedish Government Expert Commission on Research. From 2013 to 2016 she was a Guest Professor at the Chinese Academy of Sciences Institute for Policy Management (CASIPM). Since 2019, she is a member of the Swedish Innovation Council chaired by the Prime Minister. She has an MA in International Relations from the Johns Hopkins School of Advanced International Studies (SAIS) and a PhD in economic history from the London School of Economics and Political Science. Schwaag Serger was born and raised in Germany and the United States. She speaks German, English, Swedish, and French fluently and has a good knowledge of Italian and Mandarin.

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Abbreviations

Terms

FTA	Future Oriented Technology Assessment
GC	Grand Challenges
GVC	Global Value Chain
ICT	Information and Communication Technologies
iFORA	Intelligent Foresight Analytics System (HSE)
IoT	Internet of Things
PPP	Public Private Partnership
R&D	Research and Development
RRI	Responsible Research and Innovation
S&T	Science and Technology
SME	Small and Medium Sized Enterprises
STEEP	Social, Technological, Economic, Environmental and Political
STEEPV	Social, Technological, Economic, Environmental, Political and Value
STI	Science, Technology and Innovation
SWOT	Strengths, Weaknesses, Opportunities, Threats

Institutions

EC	European Commission
EIT	European Institute of Technology
HSE	National Research University Higher School of Economics
ISSEK	Institute for Statistical Studies and Economics of Knowledge, National Research University Higher School of Economics
OECD	Organization for Economic Cooperation and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEF	World Economic Forum

Part I

Higher Education and Research Management Paradigms in the Knowledge Triangle

Knowledge Triangle Targeted Science, Technology and Innovation Policy

1

Dirk Meissner, Leonid Gokhberg, Yaroslav Kuzminov, Mario Cervantes, and Sylvia Schwaag Serger

During the last decade, the concept of the Knowledge Triangle (KT) in the form of change processes that foster greater interaction between education, research and innovation activities has left the academic community and diffused to the higher education and research policy arena. As a result, numerous policy measures have been developed and implemented aiming at strengthening interaction between the different sides of the knowledge triangle. Similarly, structured and systematic efforts have been taken to describe and understand the important role of universities and other higher education institutions (HEI) in the innovation landscape. Universities fulfil numerous missions but they also face the challenge of meeting diverging expectations by different stakeholders. Furthermore, this challenge is complicated by the fact that universities and their surrounding environments are not static but co-develop continuously. Universities are also not hierarchical institutions like firms that can be changed through top-down processes alone. Research and teaching related university employees have power and influence that makes the reform of missions or their alignment very difficult to implement.

Realignment of organizations requires an internal commitment to change from the employee side which is even more challenging when the organization employs a significant number of highly qualified staff which is notably the case at universities (Carayannis et al. 2016). Furthermore, universities enjoy freedom of science and teaching; a constitutional right in many countries. Therefore, policy measures aiming

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at KT related alignment of universities require special attention already in the design phase and even more during implementation. Top-down approaches imposed from the policy side on universities and their employees might not lead to the expected results due to university internal resistance (Carayannis et al. 2017; Cervantes, Meissner 2014). The latter is an especially well known and studied phenomenon in change management of organizations. The strategies and visions of organizations are easily developed and announced in comparison to the implementation of the respective affiliated measures. Overall changing universities' alignments towards fulfilling KT related expectations is a long-term process with results not to be expected immediately after imposing measures (Goddard and Puukka 2008; Junior et al. 2020; Kergroach et al. 2018). KT related policy measures are often tied to overall university funding schemes, e.g. in the form of project funding which increases the share of overall university funding (Etzkowitz and Leydesdorff 2000). Project funding has received much attention by policy makers to develop universities and their research portfolios into directions that are somewhat in the interest of stakeholders outside the institution or the related communities. Project funding appears an efficient policy instrument for a somewhat covert intervention of the policy arena on the research and teaching activities of universities and university staff by means of setting the respective priorities for funding and, equally importantly, applying project funding proposal assessment criteria that are in line with KT related ambitions. In this respect, policy indirectly intervenes in the strategic orientation of universities in different form.

University staff at the same time is increasingly encouraged to attract third party funding to complement university funding for research activities but also to increase own income by means of performance-based contracts (Etzkowitz et al. 2008). The latter have become widespread in many countries and hence the percentage of third party funding attracted is one significant indicator of performance (Goddard and Puukka 2008). Such performance measurement approaches suffer from frequent resistance against organizational changes by employees, especially highly qualified employees. It is clear that the employee qualification level correlates with resistance against top-down changes since academicians usually have strong self-confidence and have most knowledge about their own activities. Externally imposed pressure to change direction is therefore unlikely to be welcomed if not initiated by them; academic staff responds to external requirements in creative ways without necessarily changing the actual substance. This is obvious especially when policy institutions aim to impose indicators for measuring university performance at all levels of the universities and tie budget allocations to institutional performance (Kergroach et al. 2018; Papa et al. 2020). Consequently, universities and their employees develop an ambition to focus on creating public awareness by means of regular public engagement with business and civil society (Meissner et al. 2018). However, public awareness is not always connected with academic, e.g. scientific and teaching achievements. For external performance evaluators it is nearly impossible to assess the actual impact, meaning and achievements from all different activities undertaken by university employees. This is especially the case for collaborative undertakings, e.g. joint initiatives or similar. Performance measurement indicators are often limited to counting quantifiable variables but cannot display the factual outcome or long-term impact. They neglect that the scientific community is global and much of collaborative activities are based on personal relations and trust between scientists (De Silva et al. 2021). In this regard, informal meetings are essential to build lasting relationships that finally lead to scientific achievements in one way or the other. However, performance measurement indicators do generally not cover this. There remains a significant shortage in indicators measuring the 'soft side' of university employees' activities. Another example of an approach to direct university staff activities from the top down is the question of accreditation procedures for individual and institution wide educational programmes. Here universities and educational programmes are forced to describe the competences students achieve in course of their respective programme. However, such pre-defined competences are nice to read for accreditation agencies but they can hardly be translated into quantifiable indicators and, more challenging, used to assess the achievement and impact of universities or their programmes. The reason is that it is very difficult to measure systematically learning or competence imparted on students.

Distinguishing between universities' ability to select students which will perform well, and the contribution which specific courses, programmes or institutions make to individuals' competences and learnings remains a challenge given that it is hard to convert abilities into quantitative indicators. Furthermore, university education helps students to develop a set of competences in course of their education but there is no substantial evidence of the eventual impact. Moreover, there appears a need to shift the main attitude towards education. So far, education mainly aims at training structured thinking in terms of solving concrete complex problems but the nature of problems is changing. Increasingly there are multiple solutions for complex problems with no clear right or wrong solution.

Searching for solutions of complex problems in the first instance requires the capability to detect and describe problems and apply the trial and error approach to finding solutions. This in turn means that individuals need to remain with open mind-sets from the outset (Carayannis et al. 2016; Junior et al. 2020; Perkmann et al. 2012). Furthermore, mind-sets should reflect the actual needs of people and society; the needs, weaknesses and limitations of existing solutions before research and development works even begin. This aspect is seldomly given sufficient attention by funding organizations when publishing calls for research proposals. Typically, the user needs (or the needs of solution applying entities) is little elaborated and requested by funding agencies. Instead of this, researchers are asked to provide indications of potential application fields, however given the basic nature of the underlying research work the application fields are frequently underestimated, if they are known at all. Even if there is an idea about potential application fields, it turns out impossible or speculative to define the expected potential economic and societal value. This is mainly due to the changing environments, e.g. there are many different publicly funded research based technologies that might potentially target similar applications (Pruvot et al. 2015; Power and Malmberg 2008; Weber and Rohracher 2012). At a first glance, this is an argument to foster competition in the research community, however due to uncertainty in achieving results the later application and equally important the acceptance by users is hard to detect. The common challenges of technology and innovation diffusion apply here. Therefore thinking should be changed towards anticipating the application and deriving requirements for research from this by means of clearly considering existing solutions and challenging such about their weaknesses which need to be improved to make a final solution accepted by the user and society. Until now user thinking and design thinking of innovation have mainly aimed at anticipating user needs but little critical assessment of existing solutions and questioning why these solutions are weak (Scuotto et al. 2017). In this light even public research needs to change the blue sky research paradigm away from doing the unknown things to a more targeted approach looking at the weaknesses of existing approaches. In other words, the research paradigm should be extended towards '*Identifying the Right Problem*'.

Problem identification requires analysis of the application in question but also the broader environment, e.g. a multi-level system analysis including a broader perspective of potential causes for diffusion failure. This is a priority for research funding and research project design but also needs to be included in the educational missions of universities. Typically, universities train students to detect problems for given applications but little attention is paid to the overall system analysis. However, in light of interdisciplinary and complex problem-solving skills, the system perspective in analysis becomes a core skill for researchers, engineers and the like. It is also a matter of attitudes and mind-sets how research approaches a problem. The most common approach used is identifying the problem and trying to solve it after intensive thoughts devoted to what might be possible and what might be the problems and limitations. Nevertheless, this neglects the critical discussion of which weaknesses are in which place and how to overcome them. This is especially important to consider in light of Knowledge Triangle based discussions about the role and missions of universities and related research and teaching organizations.

The book takes these into account in the following parts and chapters. It is structured in three main parts. The following part focuses on conceptual foundations of the Knowledge Triangle, the next part on Knowledge Triangle in Higher Education Institutes and Public Research Organizations; then the Knowledge Triangle related features of science, technology and innovation policy are discussed. The book concludes with a chapter on Knowledge Triangle targeted science, technology and innovation policy.

Part II outlines the main conceptual foundations of the Knowledge Triangle. *Groumpos and Meissner* challenge the Knowledge Triangle and its usefulness as a concept for aligning universities missions. They find that despite the long-lasting discussion about Knowledge Triangle and Triple Helix universities missions have not changed much. Discussions about these concepts remain at aggregate level resulting in several approaches for measuring universities performance but are clearly less developed in terms of management concepts and practical applicability. Accordingly, policy measures target at the symptoms and might show some initial impact but it is doubtful if they achieve sustainable impact if not implemented at the operational level. Policy reform of universities has always stressed the importance of transferring knowledge and technology for achieving economics impact, but less attention as paid to the transfer of competences from research to teaching which is among the main functions of universities. Eventually it appears that both approaches are suitable analytical frameworks for assessing the actual missions and position of universities but they are not suitable for designing and implementing institutional strategies and governance models. Instead, the perception should be changed towards '*Knowledge for the Triangle*' which requires a dedicated balanced scorecard for institutional governance and performance.

The second chapter in this part by *Unger and Polt* discusses the concept of the Knowledge Triangle as it has gained importance in recent years as a framework for innovation policies and popularity because it emphasizes an integrated ('systemic') approach to the interlinkages between research, education and innovation. They highlight the key features of this concept and try to contextualize it with other, at times overlapping, at others complementary, concepts, such as the 'third mission', 'triple helix' (or in an extended understanding, the 'quadruple helix'), 'entrepreneurial or civic university' models and 'smart specialization'. Against this background, the authors seek to analyse the roles, rationalities and challenges of different actors that are involved in activities relating to each of the three areas of the triangle. Actors are primarily HEIs, public authorities, research and technology institutes and private sector companies.

Daimer, Rothgang and Dehio introduce different approaches to regional embeddedness and the Knowledge Triangle in Germany. Their chapter discusses how different types of Higher Education Instructions in Germany develop their patterns of regional embeddedness and address the functions that are outlined by the Knowledge Triangle. Although the term 'Knowledge Triangle' is not widely used in Germany, they find that there are many developments with KT relevance taking place in the HEIs and PRIs. By taking two examples (Heidelberg University and University of Applied Sciences Bremen), they illustrate how third mission policies are thriving but adoption by HEIs and PRIs differs and depends on the institutions' structure, culture and location (regional context). KT models, in particular third mission activities, are highly diverse and do not serve the single purpose of generating economic impact but are also geared towards social and environmental goals. Furthermore, it is found that the location of the HEIs matters for the role they can play and for the effects, they can have on the region. In addition, both standard and non-standard national or institutional policies and strategies have played an important role in shaping regional embeddedness of HEIs in Germany.

Fischer, Schafler and Vonortas analyse technology upgrading in light of the Knowledge Triangle in Brazil. They argue that universities play significant roles for technology upgrading in National Innovation Systems. Nevertheless, it remains a challenge defining and implementing institutional adjustments that promote the integration of a broader spectrum of research-oriented universities into national and global value chains. Interaction of academia with productive systems needs to be a mutual exchange with knowledge dissemination from universities to industry but also from industry to university in different forms. Technology upgrading is a slow process and involves systemic co-ordination and paradigm shifts in the way academia is perceived. This is especially evident in Brazil where academic institutions, through the development of new technologies and knowledge transfer to firms, have supported the emergence of technology intensive companies and a long-term reliance on close collaboration with universities and public research centers. Research-oriented universities, however, have to be involved extensively in technology upgrading processes, strengthening linkages with the private sector and responding to the call for national efforts to close the gap with more developed economies and at the same time have to be at the leading edge of research in the global arena.

The chapter by *Roso, Stamm, Romme* and *van den Toren* on Knowledge Triangles in Dutch entrepreneurial ecosystems closes this part. The ecosystem context of knowledge triangles and, in particular, on two elements of the regional governance of the Knowledge Triangle strongly features inter-organizational knowledge networks and leadership via regional economic boards. The knowledge networks are mechanisms for providing connection, whereas leadership involves a mechanism for giving direction. Competitive and sustainable regional ecosystems are characterized by the awareness that regions need to build the ability to prepare the region for the future, to promote industrial clusters and achieve a balance between top-down steering and bottom-up leadership. The growing collaboration between universities in the region and (emerging) business activities may facilitate the development of new knowledge (networks) and thus make it more competitive compared to metropolitan areas. However, most of these collaborations are both fluid and fragile: good for flexibility, but a lack of commitment may also impede large-scale changes. In regions with a relatively homogenous and interwoven economic base and knowledge networks, effective collective action is more probable due to the shared understanding of how economic value is created in the region. In this type of highly distributed settings, bottom-up leadership in emerging niches might be much more effective. Regarding the ability to guide a region in a particular direction, targeted industrial policies seem to have become a remnant of the past. Overall, there are substantial differences between regional boards with regard to their ability to choose where, when and how to act—especially because of how they are funded and organized. Thus, there is optimal design for governance schemes; it always needs to account for the regional ecosystems' unique features.

The following part on KT in Higher Education Institutes and Public Research Organizations begins with a chapter describing attempts to develop research organizations towards Knowledge Triangle aims with project funding instruments by *Ukrainski, Kanep and Timpmann*. They explain the challenges the highly project-based research funding system is placing on strategically developing Estonian universities towards Knowledge Triangle aims. By looking at how this particular project funding environment creates impacts on researchers via the credibility cycle, on universities via the budget structure and strategic management restrictions, and on the system level by accumulating impacts on lower levels, they find that it adversely affects the creation of diversity and strategic flexibility of universities. The Knowledge Triangle aims are very difficult to follow when the bulk of the funding instruments relies on past performance rather than a strategic alignment with national or university strategies. For that matter, the efforts of the universities in Knowledge Triangle activities remain fragmented.

Kuzminov, Gokhberg, Fursov, Zaichenko and Meissner analyse how the Knowledge Triangle Principles are incorporated in a University Management System. They stress that the term ‘entrepreneurial university’ has been used frequently but often misinterpreted by means of an university which generates many spin off companies which are considered evidence of the entrepreneurial mindset of the respective institution. This however is only partially reflecting reality since an entrepreneurial mindset of an institution should affect all its activities but not being limited to a particular type of innovative activity only. This is even more important since university-based spillovers are manifold including spin offs, but also contributions to local, regional and national industry and society. Entrepreneurial universities are characterized by an organizational ethos that is not limited to the university leadership and the preparation and announcement of visionary statements but is in the mind of university members who are supporting the implementation of respective measures. Genuine entrepreneurial universities are capable of establishing an internal entrepreneurial culture that is driven by leadership and university members at all levels. It requires coordinated action initiated by leadership and communicated to all staff in transparent ways.

Open innovation platforms fostering the co-creation and value creation in the Knowledge Triangle are discussed using the Case of Tampere, Finland, by *Raunio, Nordling, Kautonen and Räsänen*. They focus on the emerging role of open innovation platforms (OIP) fostering the convergence of innovation, education and research activities. Under the broad label of KT, the case study of Tampere, Finland, introduces how open cooperation is organized to value creative innovation processes through open innovation platforms. The main hypothesis is that evolution towards more agile and user-driven processes of innovation is taking place, in which (open innovation) platform models provide key tools to orchestrate the processes. Open innovation platforms provide a new generation of co-creation spaces facilitating the interaction among research, education and innovation through a bottom-up process. The value proposition of the OIP approach is to engage a broader knowledge base for innovation activities while offering the ‘city as a living lab’ and user-oriented open innovation services for the use of firms and other actors (clients). In order to better understand the role of emerging OIPs in orchestration of innovation activities, three cases in the context of university campuses and their KT activities are analysed. The data was collected as part of the Six Cities Strategy of Finland (ERD, 2015–2018) in 2015 and 2016 with a participatory action research (PAR) approach. The data includes several interviews, seminars and workshops with policy makers, developers and other stakeholders in Tampere. Relevant documents were also consulted (e.g. assessment and evaluation reports). The chapter concludes by outlining some future research challenges and discusses the findings both from the academic and policy perspectives. The authors highlight some tentative policy implications and recommendations.

Perez Vico, Schwaag Serger, Wise and Benner consider knowledge triangle configurations at three Swedish universities. They argue that little is known about how the strengthening the linkages between research, education and innovation and their interaction are orchestrated at universities. Accordingly, the authors explore how these linkages are manifested in the organization and strategy of three different Swedish universities, and how the policy landscape conditions these manifestations. The article highlights that although the Knowledge Triangle remains a priority, explicit national policies are lacking, with the responsibility of integration falling on universities themselves. They observe a great diversity in how knowledge principles are orchestrated at the universities, e.g. through individuals' interpretations and attitudes, and through management strategies and incentive schemes. The three tasks have largely been handled separately, with weak co-ordination and generally limited ambitions from university managements to forge new combinations of remits. At the individual and group level weak task articulation, although some role models serve as inspiration is observed. Tensions emerge as the responsibilities of operationalizing the Knowledge Triangle fall on individuals who sometimes lack the appropriate mandate and resources. These findings raise questions for further research and implications for policy and university management.

Breasted, Borlaug and Aanstad focus on Knowledge Triangle in the health sector especially analysing the case of three health faculties in Norway. Differing from previous studies which primarily have studied the relationship between HEIs and industry, this chapter looks at HEIs' interaction with public healthcare services and private industry. The study of health faculties at three Norwegian HEIs shows that Knowledge Triangle interaction with both the private and public sector is a central aspect of current practices. The interlinkages between the health faculties and public healthcare services are especially interesting, as they provide other patterns of cooperation. Here, the cooperation on education, research and innovation is institutionalized through different instruments and agreements between the health faculties and the public healthcare services. We argue that this may serve as a model of cooperation between HEIs and private industry.

The next part discusses KT features in light of STI policy. The first chapter in this part by *Gokhberg, Gershman, Zaichenko and Meissner* takes an in-depth look at Knowledge Triangle governance in STI policy in the Russian Federation. They argue that STI policy finds itself often trapped in a dilemma: it is expected to design a future-oriented policy framework that promotes science, technology and innovation nationally but at the same time, it is expected to draw on evidence for policy interventions and activities based on experience. However, it neglects recent developments at least partially due to the nature of information and data used for collecting respective evidence. Therefore, maintaining the balance between evidence based STI policy and forward-looking visionary policymaking appears a major challenge for policy makers. This is also due to the typical long-time horizon of STI policy measures and the actors' desire for a solid, sustainable and reliable STI policy framework that proves essential for all related policy measures and changes in the overarching framework. Russia has implemented a number of policy measures that aim at first sight on improving the performance of the national science system by means of international measurement standards including a major revision of the science infrastructure mainly by bringing education and research closer together and orienting the public research base stronger towards output measurement and performance evaluation. The Russian case of Knowledge Triangle is controversial since the national STI system is suffering from protracted incomplete transition, and public funding and ownership is dominating still. Respectively, STI policies rely rather on a large-scale intervention and control than on ‘soft’ stimulation or assistance. On the one hand, ‘State dominance’ makes the STI system highly manageable and auditable at all policy levels; furthermore, tangible, intellectual and human resources, preserved from the Soviet period, are still significant, and being somehow reproduced. On the other, the state remains the key source of STI financing and initiative; regardless the government’s efforts, R&D and innovation in business are quite underfinanced and under encouraged.

The role of Knowledge Triangle policies in developing science-industry links in the new EU Member States are analysed by *Čadil and Kostić*. Their chapter analyses the influence of national and regional policies and programmes based on the Knowledge Triangle concept on changes of strategic behaviour of universities in terms of Knowledge Triangle activity development. The empirical analysis is based on a combination of in-depth interviews and desk research analysis of three universities representing three main university types: the University of Chemistry and Technology in Prague, the Palacký University Olomouc and the Technical University Liberec. The analysis revealed a positive influence of the national policy and programmes, which has been successfully transformed into actions of individual universities. However, development of Knowledge Triangle activities strongly depends on public funding, while there are no evidences that universities plan to use own sources for development of Knowledge Triangle activities.

Unger, Wagner-Schuster and Polt find that STI place-based policies appear at different levels of higher education policy making. In the Austrian case place-based policies are relevant at federal level including instruments and initiatives relating to public financing of universities within the three year performance agreements (subsumed under the header of ‘Lead Institutions Initiative’ (Leitinstitutionen-Initiative). Regions (Länder) also play a decisive role in the provision of relevant funds and programmes as well as in the definition of strategic priorities. The ‘Lead Institution Initiative’ sets out the respective requirements concerning the strategic interaction of universities and their location (region) in order to develop and implement regional STI strategies. Finally yet importantly, top-down empowerment of public universities’ engagement in the regional knowledge triangle is accompanied by bottom-up co-ordination of higher education institutions. The emergence of regional higher education conferences (*Hochschulkonferenzen*) was important to operationalize horizontal co-ordination. Regional higher education conferences are therefore mostly designed to address the needs for co-ordination of public universities, universities of applied sciences (UAS), university colleges engaged in teacher education, and, in some regions, private universities. Regional higher education conferences act as hubs concerning the implementation of coordinated projects and initiatives (together with other components of the knowledge triangle), both in terms of research and education. At national level, by contrast, the

Austrian Universities Conference (UNIKO, for public universities), the Conference of Universities of Applied Sciences (FHK) and the Conference of Private Universities (PUK) mainly act as interest groups and political voices for these three types of HEIs by allowing them to adopt a coordinated position concerning questions relating to social or higher educational matters.

The book concludes with a chapter by *Gokhberg and Meissner*. They develop a concept for KT-targeted STI policy. The KT paradigm is a useful approach analysing universities and their role in the national innovation systems. However applying the KT lens requires careful interpretation of universities activities and well-designed and targeted STI policy intervention meeting the following requirements. Among the latter is 'Freedom of Science/Research and Teaching' among the key factors that is often referred to in case of changing universities missions and reorganizing activities. KT and related themes are often narrowly focused on the interaction of universities with commercial partners neglecting the social impact and the training and education impact resulting from university activities. Ultimately, the success of the KT requires changing mind-sets of university employees in order to leverage the existing potentials and achieve lasting impacts.

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Part II

Conceptual Foundations of the Knowledge Triangle

Knowledge Triangle: The Right Concept to Align Universities Missions?

2

Peter P. Groumpos and Dirk Meissner

2.1 Introduction

Knowledge is the basis for all natural and human-made systems. It exists in several forms being available for human beings by means of teaching or self-learning. All teaching and all intellectual learning come about mostly from already-existing knowledge. Learning is the most important process that all living creatures are performing. Knowledge has been generated since ancient times. Managing and communicating knowledge have been extensively investigated for the last 50–55 years. The concepts of knowledge, education, research, innovation, business, entrepreneurship, public and private funding, and some other factors play a very important and crucial role in the economic growth and the sustainable development of a region or a country. But how are all these concepts-variables-factors been interrelated and what is their interdependence?

Geometry has been called to help. Specifically, in the early 2000s the geometric triangle came to address interesting and challenging issues especially the interaction between research, education, and innovation, which are key drivers of a knowledge-based society (KBS). Namely the triptych Education+Research+Innovation which was referred to as the Knowledge Triangle (KT). Since then the KT has been the main topic for discussion and further elaborated by all circles of the academic, scientific, and policymakers, especially all over Europe.

Mathematical approaches to the Knowledge Triangle (KT) have been discussed and analyzed since then. The Triptych Education + Research+ Innovation and thus

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the KT have been used extensively to the point to believe that the KT will be the nemesis for all the problems of the world. The relationship of the KT and the Lisbon Strategy, also known as the Lisbon Agenda, has been the central point of many decisions been made by the EU decision-making bodies. The proposed strategy and recommended actions by the EU Council and their relationship to the KT need further interpretation. The European Institute of Technology (EIT) was created by the EU to better implement the concept of the KT and to better incorporate the entrepreneurship factor. The implementation of the KT was considered of paramount importance in meeting the goals of the Lisbon Strategy. The ***Knowledge and Innovation Communities*** **(KICs)** were instituted in a formal way and were considered as the central vehicle to meet the goals and objectives of the Lisbon Strategy. Accordingly, EU officials considered the EIT and KICs as unique. They were set up to integrate education, research, and innovation, thus the so-called KT, in one common organization.

However, before going into a more elaborated KT discussion, it is necessary to consider the term "knowledge" itself. There are several definitions of knowledge and theories to explain it exist. Knowledge is an awareness, or familiarity, or the truth, or understanding of someone or something, such as facts, information, descriptions, values, or skills which is acquired through experience or education or both by observing, recognizing, discovering, perceiving, or learning or by a combination of one or more of them. Another definition, but very simple, is: knowledge is the awareness or familiarity gained by experience or education of a fact or situation.

But currently what is called or referred to as knowledge is under severe criticism. Many facts and information are created according to the wishes of certain people and strong organizations. Lately the term "true knowledge" is emerging in many situations. In this chapter, this aspect of knowledge will not be addressed.

The storehouse of ***human knowledge*** about the physical characteristics of the world we inhabit and the universe within which that world is embedded has been steadily expanding and sometimes at an unpredictable pace. New advances are added every day in all scientific fields: energy, health, transportation, robotics, environment, agriculture, space, and others. The role of humans in this strategy follows from the dependencies that link human systems to global ecosystems: air, water, land, sunlight, living organisms, nonrenewable resources. However, ***Knowledge*** alone will not provide solutions to today's world problems with its existence only but needs a clear communication and application strategy. The strategy for a ***knowledge-based society (KBS)*** calls for new kinds of ***knowledge*** partnerships among disciplines as well as among the major sectors of society. Knowledge typically appears as general broad knowledge which forms a basis of individuals' competences and is shared by the majority of individuals. Another form of knowledge is specialized in selected fields which is available and used by a small group of individuals. From the available knowledge base, individuals typically start developing new knowledge which adds upon the existing knowledge base.

Generated ***knowledge*** is usually communicated but implicit or explicit management is usually required for both***: knowledge*** Generation and Communication. ***Knowledge*** Management also requires knowledge generation and/or

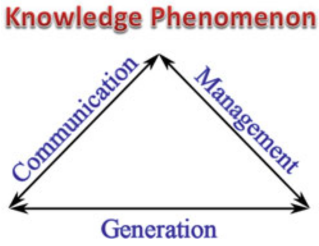

Fig. 2.1 The Knowledge phenomenon. (Source: The phenomena of ***Knowledge*** Generation, Communication, and/or Management have been addressed in the academic, private and public sectors; in universities and in business; in disciplinary research and in multidisciplinary projects. Support systems are being designed and implemented in and for the three sectors)

communication, i.e., ***meta-knowledge*** regarding knowledge management, which has been explicitly being addressed on the organizational level. These three knowledge dimensions are highly related among each other:

1. Knowledge Generation
2. Knowledge Communication
3. Knowledge Management

With the diffusion of Information and Communications Technologies (ICTs) Knowledge Generations, Communication and Management, as well as the relationships and linkages among them have become more effective and efficient (Fig. 2.1).

2.2 A Critical Overview of the Knowledge Triangle

2.2.1 Early Formulations of the KT

Surprisingly there is no accredited or even one definition of the concept of the "Knowledge Triangle." Furthermore, no one can clearly indicate that a historical record of the KT exists. Both conclusions are due to the fact that the "concept of Knowledge Triangle" was practiced since ancient times if we refer to Knowledge and Wisdom and more recently immediately after the Second World War. However, all explanations conveyed so far by academicians, researchers, scientists, policymakers, private sector leaders, and other practitioners alike point to the interaction between education, research, and business sectors: the three fundamental factors that contribute to the creation of a Knowledge-Based Society (KBS) and foster innovation.

It is natural for policymakers to turn to universities for solutions, but it is still important not to lose sight of the long-term perspectives. Universities should become less dependent on central lawmaking and decision-making. A modern university must be open to new ideas, new methods, and new ways of cooperating, and this is best served by greater autonomy. Here the Knowledge Triangle can be of some help.

The central role of the R&D, knowledge, innovation triangle has been a challenging question since the early 1990s. Indeed, the centrality of R&D and knowledge creation and use is set out clearly by Romer (1990). This already points to a multi-point relation of different actors, e.g., there are hardly bilateral relations only but the overall economic and thus innovation system is featured by multiple touching points. In a broader sense, this illustration is affiliated with geometric thinking. Geometry is one of the oldest sciences, part of the major of Mathematics. Plato has said "Αγεωμέτρητος μηδείς Εισίτω"—which means "Let no one ignorant of geometry enter." Tradition has it that this phrase was engraved at the door of Plato's Academy; the school was founded in Ancient Athens. In addition, a civil engineer will tell you "the triangle is the strongest and most powerful shape of all." The geometric triangle came to address interesting and challenging issues especially that one that couples in a synergistic way three major components—Education+Research +Innovation which was referred to as KT. The KT was a central theme of the EC's Lisbon strategy (2000), showing how education, research, and innovation might correspond together as powerful drivers of the knowledge society. Therefore, the **knowledge triangle** refers to the interaction between research, education, and innovation but hardly to each element as such (Groumpos 2013). In the European Union, it also refers to an attempt to better link these key concepts, with research and innovation already highlighted in the Lisbon Strategy and, more recently, lies behind the creation of the European Institute of Technology (EIT).

The usefulness of the knowledge triangle as a tool for describing and understanding the dynamics of education, research, and innovation working together has been discussed and debated extensively. However, in all circumstances **strengthening linkages between the three elements is crucial in ensuring the full benefits are secured from investment in any of the three**. In this way, multiplier and (often unexpected) spinoff effects of each one can be mathematically investigated.

When introduced into the European policy debate (Lisbon strategy, 2000), the knowledge triangle remained ill-defined as a concept and the difficulty in defining it illustrates the wide variety of experience and practice in linking education, research, and innovation throughout Europe since then. The knowledge triangle—the flow of added value between research, education, and innovation—is emerging as the central concept on the European innovation policy landscape, at the core of the next generation of policies and programs. The knowledge triangle has gained almost an iconic status in relation to European Research.

2.2.2 The Extended Triangle of Knowledge

The EU considers the knowledge triangle as an approach to leverage initial investments in education, research, and innovation through intensified and continuous interaction with the ultimate aim to contribute to strengthening the EU's innovation capacity. It is presumed that this goal can be achieved by supporting the enhancement and constant further development of a growing knowledge base is located in the public research sector and extending this knowledge base by an application dimension to ease transferability for actual use for products, services, approaches, and methods which benefit the economy and society. Furthermore, emphasis is given on creating and maintaining a creative, innovative, and entrepreneurial mindset among the respective communities which is expressed in the desire to include entrepreneurial attitudes in education and training. Taken together these features are thought to support the knowledge-intensive economy and society which is manifested in respective strategies.

Despite the many efforts undertaken by the European Union and its member states, the problem of effectively exploring the potentials of the triptych and the strength of the Knowledge Triangle remains. However, a positive result from all these vigorous discussions was the creation of the EIT.

2.2.3 Foundations and Activities of the European Institute of Innovation and Technology

The EIT is the research and development agency of the European Union. It was established in March 2008 with its headquarters been located in Budapest. The idea of a European Institute of Innovation and Technology was developed within the framework of the Lisbon Strategy. The initial concept for a European Institute of Technology was based on the Massachusetts Institute of Technology (MIT) which is renowned for its combination of a world-class application of the Triptych Education + Research+ Innovation since the early 1970s. MIT actually was implementing the Knowledge Triangle concept exploring the positive results of this structure long before the Knowledge Triangle surfaced in Europe. There were questions been raised early and before the Knowledge Triangle (KT) was identified. Six specific areas of concern have been raised:

- Translating R&D results into commercial opportunities
- Reaching a critical mass in certain fields
- Fragmentation of the EU's research and higher education system
- Lack of innovation and entrepreneurial culture in research and higher education
- Lack of a critical mass in small- and medium-sized enterprises
- Limited interaction between Academic and Research institutions with the Big and small industries

The above issues are present in all countries around the world. The answer to these issues has been to focus on integrating the three sides of the KT: higher education, research, and business sectors as been explained in the previous section. The EIT was founded on the basis of Knowledge Triangle as shown in Fig. 2.2. The concept of the EIT has been controversial since its initial proposal and foundation in 2008 by the EC. In order to comprehend better the strengths and weaknesses of the

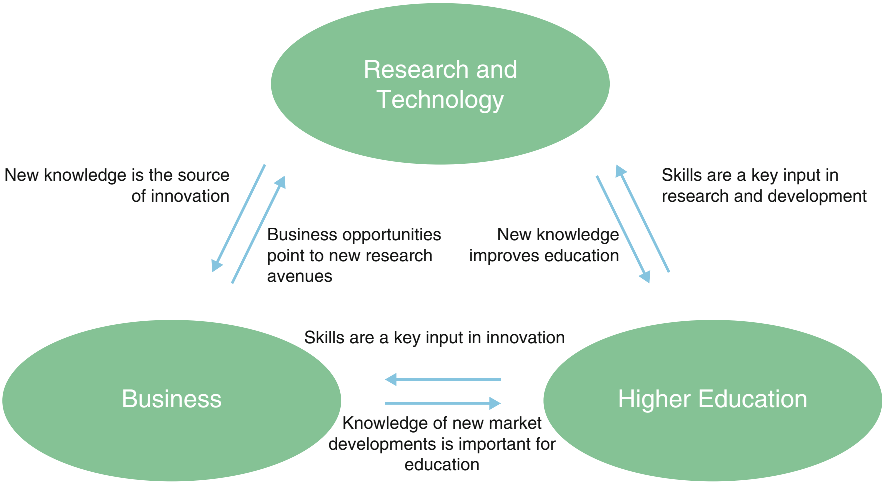

Fig. 2.2 The Knowledge Triangle (KT). (Source: Authors)

KT, we need to study the objectives been set and the main activities been implemented by EIT since its beginning.

The EIT should primarily operate through partnerships which should be selected on the basis of a transparent and excellence-based process and designated as Knowledge and Innovation Communities and been referred to as ***Knowledge and Innovation Communities*** **(KICs)**. This is a unique feature of the EIT and KICs are set up to integrate education, research, and innovation; thus the so-called Knowledge Triangle, in one common organization. The EIT funding model seeks to align, pool, and eventually leverage the Innovation Communities' innovation investments. In order to meet these objectives, the EIT applies a funding model where the EIT's financial contribution does not exceed 25% (on average) of a KIC's Innovation Community's overall resources over the KIC's lifetime. This is an important issue in financing the activities of the Knowledge Triangle (KT).

The KIC is the main operational unit of EIT. A KIC is an independent but operational part of the EIT, which puts the innovation web into practice. The KICs will be driving effective "translation" between partners in **ideas, technology, culture, and business models**, and will create new business for existing industry and for new endeavors. These partners **involve key actors from the three sides of the knowledge triangle**: research, higher education, and innovation-entrepreneurship-business. KICs build innovative webs of excellence across the knowledge triangle with the intention of addressing key societal challenges. KICs must address a long-term horizon of 7–15 years, but with short-, mid-, and long-term objectives that follow the mission of the KIC. Mainly "real life" examples of "knowledge triangle" activities, presenting dynamic and effective relationships between the three elements and analyzing the practice and showcasing those success factors which might be adopted more widely using effectively and efficiently human and natural resources.

There are some very interesting and worth making points here:

1. The implementation of Knowledge Triangular by EIT is performed in a strictly business manner.
2. There are not any limitations in attracting professors/scientists from all over the world.
3. Third-country organizations are encouraged to participate in the Knowledge Triangle.
4. The KICs' rights and obligations ensure an effective exploration of the Knowledge Triangle's positive results and added value.
5. There is a need to support higher education from the public sector.
6. Research, innovation, and entrepreneurship should be financed more from the private sector.

In conclusion, the EIT KICs should seek to raise an increasing financial contribution from the private sector and from income generated by its own activities. Therefore, it is expected that industry, the finance, and service sectors will contribute significantly to the budget of the KICs. The KICs should aim at maximizing the share of contributions from the private sector. The EIT Community is established across the European Union and Switzerland, in co-location centers. So far, we have seen the basics of the Knowledge Triangle as has originally been conceived in Europe. In addition, based on the KT and the visions and missions of the European Union, the EIT was established in 2008. Now 10 years later it is time to see how EIT has used effectively and wisely explored the potential strengths of the Knowledge Triangle. This is a grant example of utilizing the Knowledge Triangle. The EIT has a simple idea: through diversity, there is strength. It supports the development of dynamic pan-European partnerships between leading universities, research labs, and companies. Together, they develop innovative products and services, start new companies, and train a new generation of entrepreneurs. They bring ideas to market, turn students into entrepreneurs, and most importantly, they innovate.

2.3 New Concepts and Formulation of KT

A more careful analysis of all the above and many other studies on the Knowledge Triangle show a missing component, that of entrepreneurship which is also the main ingredient for the sustainable growth of a country. Science and Technology are vital not only for the progress and the exploitation of knowledge but also for the achievement of viable and balanced growth, stability, and prosperity of a country. The contribution of technology to economic growth and prosperity is of no doubt, mainly because of the recognition of the importance of innovation within an economy.

A major part of a strategy for all countries, regardless of geographic borders must be the development of regions, through initiatives that will eliminate inequalities in

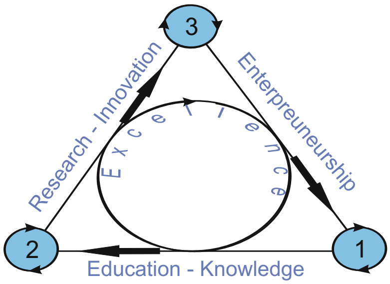

Fig. 2.3 The Extended Triangle of Knowledge (EToKN) based on excellence. (Source: Authors)

the periphery and will provide citizens and communities with a satisfactory level of welfare. To mention a few strategic perspectives (Groumpos 2013a):

- The development of effective Strategic Business Networks (not individual Strategic Business Units)
- Encourage collaborative advantage (not competitive). Competitive strategies create win–lose scenarios, often competing for a share of the same pie. Collaborative Strategies encourage win–win situations through symbiotic relationships. Knowledge grows and the pie gets bigger for all only through effective entrepreneurship.
- Collaboration between companies and public research and academic institutions, through the formation of regional and intra-regional clusters of excellence and creating a competitive entrepreneurship environment.
- Support of research capabilities, such as research infrastructure, human capital, IT and Telecommunications, and others within scientific areas that boost development and new business.
- Regional, trans-national, or inter-regional forms of cooperation that aim to introduce partnerships within research fields of high priority
- Support and enhancement of research and innovation within SMEs and access to research and technology outcomes of public institutions

Based on all these and based on excellence a new concept of the Extended Triangle of Knowledge (EToKN) is proposed (Fig. 2.3) (Groumpos 2008). The EToKN concept for sustainable development is presented mathematically using the three factors: Education-Knowledge + Research-Innovation + Entrepreneurship. A first approach to Equilateral Triangular Model Approach (ETMA) for control theories was presented by Groumpos (1999). It is important here to stress the fact that the triangle has been proposed as the basic concept for the mathematical development of the EToKN. Figure 2.3 shows an equilateral triangle, using the triptych and linking it to the Development.

2.3.1 Knowledge-Education

Knowledge has become a commodity but not a luxury or property of a few selected any longer. But which form and nature of knowledge should be transmitted via education? Recent knowledge features emphasize the combination of science and technology, which obviously arise from universities and/or research institutes laboratories. Also, knowledge converts into "product" and services which is at the disposal for use and application via different channels. The educational programs and the actual delivered programs would be appropriately designed according to the needs of the society as well as the industrial sectors of the grater geographical areas. New methods of teaching such as distance and e-learning must be part of today's educational programs. Furthermore, the educational programs must take into consideration the Knowledge Triangle.

Therefore, education has become a necessity for society. The emerging challenge for educational systems now is to application and use of knowledge and at the same time, emphasize the need for research for new knowledge generation. It is a frequent phenomenon among students, especially that they consider knowledge exists namely in digital format but hardly there is a need to understand the details and develop new ones.

2.3.2 Research-Innovation

Academic research aims at contributing to the body of existing knowledge. In line with the increase in available knowledge, research has diversified toward use and application which has exploitation potential in commercial but also nonprofit form. The latter has become a strong feature of regional and national science and innovation policies.

The term scientific research refers to the organized and systematic search for new knowledge. Research is traditionally distinguished into basic research, which aims at increasing the knowledge of science and applied research that is executed by specific applications, and finally, industrial research that deals with the conversion of applied research into industrial products. Innovation, as a source of competitive advantage for national economies, is setting the path for enhanced productivity but is fundamentally connected with research which appears as an integral part of entrepreneurship. More precisely, innovation is today at the edge of competition all over the world. The beauty of innovation is that it is in reach for everyone on the planet. It is even to a big extent independent or at least not restricted by access to resources be it human, raw materials, energy and others. It is basically an intellectual exercise shadowing all other competitive advantages that are in most cases only temporary (Groumpos 2013).

Innovation is a necessity for applying new technologies in different environments—labor, new products, and methods improving the performance of enterprises but also the well-being of societies in many different aspects. It is understood that research paired with additional efforts lead the path to innovation ins one way or the other including a significant time gap before a value added becomes crystal clear. And it is not always clear which research has initiated and contributed to which improvement and to which extend.

2.3.3 Entrepreneurship

It should be no surprise that earlier concepts of KT Entrepreneurship were absent. In the beginning, the KT had only: knowledge, research, and innovation (Figs. 2.1 and 2.2). It was only later that the first business was added and then entrepreneurship was the third side of the KT. However, in economic theory, entrepreneurship is the main element of production, accompanied by land, labor, and capital. The term derives from the verb "attempt" which means "I make efforts for something new." Therefore, the term already contains the significance of innovation. Thus, the conversion of an idea into a commercial, new or improved product, service, and method of production or distribution, constitute the innovation on the grounds of entrepreneurship. For some entrepreneurship is mainly the act of setting out on your own and starting a business instead of working for someone else in his business. While entrepreneurs must deal with a larger number of obstacles and fears than hourly or salaried employees, the payoff may be far greater as well. Many businesspeople would argue there is not one concrete recipe for success, but many successful entrepreneurs have in common certain characteristics that have contributed to the rise of their companies. With the rapid advancement of technology and communication methods, entrepreneurship has become a popular means for survival during the past 1–2 decades.

Certain factors and characteristics contribute to an entrepreneur's success. The most important ones are: creativity, leadership, innovation, responsiveness, interest and vision, organization and management skills, risks and rewards, rights, flexibility, knowing intellectual property laws and boldness. One person cannot have all these. Most of them are soft and not easily defined. Thus, it is very difficult to be taught. For example, how an educational program can provide ways for the motivation and entrepreneurial spirit of an entrepreneur. How early on a University curriculum, entrepreneurship courses would be included? However entrepreneurial thinking needs to be incorporated in tertiary education curricula early on as an approach to at least raise awareness. Entrepreneurship education should aim at providing *"all the tools"* to individuals to enter the entrepreneurial path. Not an easy task at all. However now with the new concepts and structures of the Knowledge Triangle, the effort to meet these objectives would produce positive results.

2.4 Conclusions: The Universities Missions and the KT

Universities' missions have not changed much over the last years, not even over recent decades. During the second half of the twentieth century, much discussion was devoted to technology transfer and knowledge transfer separately at different levels, e.g., among the academic community, in management literature, and also at policymakers level. During the last decades, the analytical concepts "Knowledge Triangle" and "Triple Helix" appeared; however, these trendy themes are clearly less developed in terms of concepts and practical applicability; thus, they provide the potential for further elaboration. It seems very much likely that these themes are given more attention in the policy debate and the design of respective policy measures with the aim of creating a policy framework that provides clear cutting-edge features to the respective countries' technology and innovation communities. Such approaches are often found especially in smaller countries in which the respective communities are considerably smaller than in larger countries that are confronted with more complex and varied governance challenges in the innovation system. Policy measures are often a prerequisite for Higher Education Institutes (HEI) and Public Research Organizations (PRO) to act and change their governance models toward more proactive roles in the named circumstance.

However, this isolated view is only partially targeted and allows no real evidence-based conclusions. The reason for this is found in the underlying nature and content of the themes and the dependency between them as well as the partial overlap. For example, knowledge triangle, technology transfer, research institutes, and venture capital are closely interrelated content-wise but obviously the knowledge triangle is an analytical concept looking at the different missions of higher education and research institutes primarily. Technology transfer however describes the means and channels of linking the different missions or research and higher education institutes together. At first sight, one might find that these themes are unconnected and given the frequency of mentions and use display changing attitudes of the respective communities. But a more in-depth view reveals that the terms are at least partially describing the same or similar content. For example, technology transfer is a trendy topic whereas knowledge transfer is a stable topic, e.g., mainstream. But the question arises of what the difference between technology transfer and knowledge transfer is from the content perspective. Although for both terms and their respective definitions the transfer object is slightly different, e.g., technology and knowledge, they share similar transfer channels. The latter naturally never occur as individual isolated transfer channels but in a mixed composition involving different channels. Similarly, can be argued when looking at absorptive capacities and higher education, tax credits, corporate taxes, tacit knowledge, and spillovers. All these terms appear different and isolated in the analysis but in practical terms, these are closely interrelated. Absorptive capacity means the capabilities of organizations to integrate external knowledge and technologies into their own research and innovation activities. Therefore, a clear link appears between the absorptive capacities of organizations—these include companies, research institutes, and also universities—tax schemes which are frequently designed to stimulate private innovation activities including tax credit schemes for selected target groups but also spillovers from organizations. Spillovers in turn involve diffusion and dissemination from organizations via different channels to other organizations be it intentionally or unintentionally. For spillovers being effective and productive absorptive capacity is a precondition to leverage the underlying potential. Therefore, it appears that policies aimed at one of the themes without considering the surrounding themes are less likely to achieve impacts because the environment will not allow the policy measure to create sustainable impacts. On the contrary, it is more likely that isolated policy measures are implemented without considering the overall frame of themes.

Eventually, it appears that HEI, namely universities, are following the KT thinking for a while already. But the public debates have always stressed the importance of transferring knowledge and technology toward achieving impact, especially economic impact from research and science. Less attention is paid to the transfer of competences from research to teaching which is among the main functions of HEIs. Skills and competences, therefore, were not highlighted in the debates; instead, the focus on transfer outside the HEI to commercial undertakings enjoyed publicity. This however is a much-limited perception of the real situation. In course of KT and Triple Helix thinking a hype of establishing offices for commercial relations, technology transfer, knowledge transfer or similar followed a decade ago initiated by policymakers. As it is often the case, the impact and value of these institutions remain somewhat undefined; there is hardly evidence that transfer achievements are due to these institutions but they remain in place since established. HEI research staff often wonders about these institutions since these people know well that bringing KT to live is subject of people, attitudes, skills, and ambitions. In order to leverage these organizations are requested to find governance schemes and models which empower individuals and their visions and missions. Administrative measures—such as transfer offices in any shape—are very likely to be taken note of but the actual value transferred stems from other activities. In line with this HEI internal schemes rewarding transfer is doubtful because it appears that research staff is tempted to engage stronger in transferring than actual research. The reason is found in the still prevailing fact that transferable research results need to meet the interest of recipients which are frequently rather short term driven instead of additional works invested. Close to application, e.g., almost ready-made solutions are by far the majority of transferable solutions from the research base to application and commercial exploitation. This is known under the buzzword "valley of death" also for long but instead of investing and creating appropriate infrastructures to closing the gap between HEI driven research and commercial application by means of dedicated institutions most HEI invest in transfer offices and organization internal reward schemes which certainly show short term effect but in the mid and long term hamper the actual research competence. Notably, commercial undertakings strongly emphasize the academic and research reputation of partners for engaging in transfer-related activities, e.g., there is significant importance of trust between the parties involved, trust by means of developing applicable solutions in a given timeframe and quality.

Eventually, we conclude that KT is a suitable analytical framework for assessing the actual missions and position of HEIs but it is not suitable for designing and implementing institutional strategies and governance models. Instead, the perception should be changed toward "Knowledge for the Triangle" which requires a dedicated balanced scorecard for institutional governance and performance boost.

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3 Knowledge Triangle Between Research, Education, and Innovation: A Conceptual Discussion

Maximilian Unger and Wolfgang Polt

3.1 Introduction to the KT Concept

The concept of the Konwledge Triangle (KT), unlike more straightforward models of knowledge transfer and the commercialization of scientific research, takes a more systemic approach to the *orchestration*[1] of knowledge creation and innovation processes by linking the three areas of (academic) research and knowledge creation, education and training, and (business) innovation. In the past, other concepts were developed, stressing individual actors and dimensions, i.e., *third mission*, *entrepreneurial university*, and the *triple helix*. These concepts are briefly described in Table 3.1.

These concepts offer different approaches both for analysis and policy, but they also have some common and overlapping features. Hence, it is necessary to elaborate the differences between them: for example, the KT concept covers much the same ground as the triple helix concept. However, whereas the KT employs an *activity*-oriented approach to linking the spheres of education, research and innovation, the

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[1] Wallin (2006) defines orchestration as: "the *capability to mobilize and integrate resources for the purpose of providing an offering to a customer and simultaneously creating value for the customer, the orchestrator, and the network members involved. The orchestrator considers the constraints, based on which conversations are nurtured, to define and execute the purposeful resource allocation to create, produce, and provide the customer with the offering.*"

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Table 3.1 Concepts of innovation system governance, which complement the Knowledge Triangle

Name of the concept	Description
Third mission (OECD 2015)	Calls for an extended understanding of HEIs' mission, referring to their social and cultural significance and their role as providers of knowledge transfer and commercialization activities. It has been taken up in government as well as institutional policies in many countries in recent years.
Entrepreneurial university (Etzkowitz 1983; Etzkowitz et al. 2008; Foss and Gibson 2015).	Whereas the "third mission" serves as a summarizing term for the expansion of the core missions of universities, the concept of the entrepreneurial university prioritizes the entrepreneurial activities of universities, relying on their research activities, as well as a new management paradigm for the provision of universities' tasks.
Triple helix (Etzkowitz and Leydesdorff 2000; Leydesdorff 2012; Ranga and Etzkowitz 2013).	Highlights the importance of the systemic coordination of actors from the higher education and business sectors with the state authorities to contribute to innovations and knowledge-based growth. In its extended understanding, the "quadruple helix," it also incorporates actors from civil society, such as individual citizens, NGOs (non-governmental organizations), consumer organizations, etc.

Source: Compiled by the authors

triple helix considers the *actors* in the respective national or sub-national innovation systems as a starting point. Hence, the concept of the KT is a functional model of interaction among these three areas with a specific emphasis on the following channels of interaction:

- *Research and Education:* Interactions in this channel are reflected, for example, in the geographical and sectoral mobility of graduates, postgraduate training programs, fundamental and applied research as the foundation for research-based teaching and measures to improve skill-matching between companies and graduates.
- *Research and Innovation:* Here, the support and intensification of the transfer of knowledge comes into focus, for example via (1) public–private partnership models (e.g., clusters, science parks), (2) the commercialization of publicly funded research (intellectual property rights, IPRs), (3) contract research and development services from universities for the industrial sector, (4) university spin-offs and academic start-ups, (5) knowledge and technology transfer offices (TTO), (6) incubators, (7) open science/open innovation platforms.
- *Education and Innovation:* Collaboration between actors is evaluated by considering the support for the development of an entrepreneurial culture

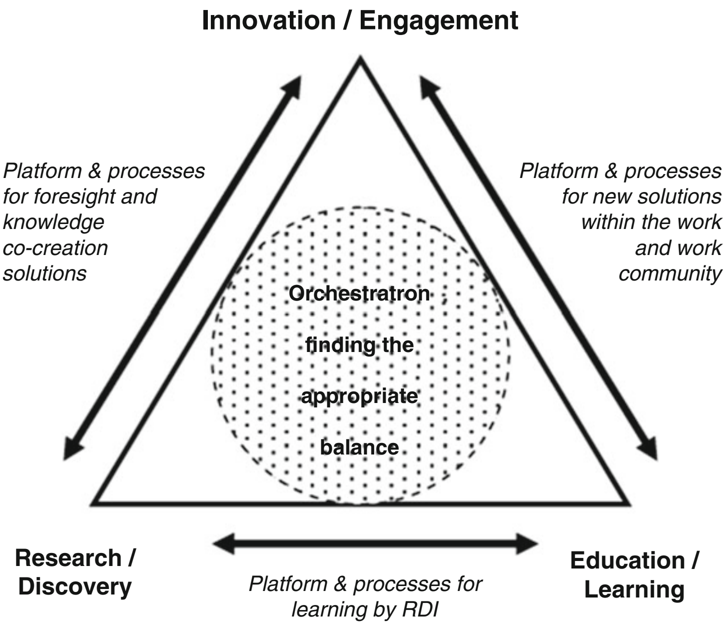

Fig. 3.1 The knowledge triangle of education, research, and innovation. (Source: Sjoer et al. 2011)

(entrepreneurial spirit) in the framework of (academic) training programs (e.g., industry-focused doctoral programs) and the formation of appropriate competencies (business plan development, management, etc.).

As Markkula (Markkula 2013) states: "*The Knowledge Triangle concept relates to the need to improve the impact of investments in the three activities—education, research and innovation—by systemic and continuous interaction.*" Hence, the KT can be defined as a set of actors, policy spheres (education, research, innovation) that span the space for collaborative activities (see Fig. 3.1).

The concrete manifestation of these interactions in the KT is very much dependent on the respective structure of the national or regional innovation ecosystem (Lundvall 1992; Edquist 1997; Jackson 2011). Hence, the KT concept surely can be subsumed under the category of "systemic innovation concepts." It has to be noted, however, that the KT concept is not meant to supplant any of the aforementioned concepts, some of which have already found their way into policy strategies and documents and which may already be well-anchored in the STI policy of a country or in the strategy of an institution. Primarily, it may serve as a common frame for the analysis of different policy frameworks being used in different countries. In the policy approaches of some countries, KT is also used as an "umbrella framework" to include all other approaches.

In the following sections, we present and discuss (1) actors, (2) transfer mechanisms, and (3) policy paradigms related to and involved in the concept of the KT with an emphasis on the following main questions:

- *Which types of actors are engaged in the KT?*
- *What are the challenges in terms of governance approaches toward the links and interactions between the three corners of the triangle?*
- *What are the characteristics of the policies that may affect or support the design of the KT?*

In the final sections, we present some tentative conclusions regarding the usefulness of the KT concept as a policy tool, and as a socioeconomic model or guiding principle for the development of academic institutions.

3.2 Main Actors in the Knowledge Triangle

3.2.1 Higher Education Institutions

Higher education institutions (HEIs) are the backbone of the KT, first because they provide key inputs for each of the corners of the KT and second because they often institutionally incorporate the KT into their internal organization and mission, depending on their specific portfolio regarding the provision of education, research, and other activities related to innovation.

An assessment of HEIs' contribution to the different corners of the KT has to take into account the great variety of institutions in this sector. This should be done in terms of their mission to perform education and research, their ownership structure and institutional autonomy, their mandate to engage in third-mission activities beyond research and therefore their role in the national/regional innovation system.

In a broader definition, higher education institutions are typically classified as (1) universities, performing research and research-oriented education and (2) applied research universities or university colleges, typically providing education focused on a particular profession (in many cases, centered around a narrow speciality) and, typically in a limited amount, applied research. Other types of institutions in this vein include academies of science offering doctoral degrees and higher education institutions that serve specific professions, e.g., nursing schools, pedagogical colleges, or business schools, which may often focus on specific educational levels such as Bachelor's or Master's degrees. The importance of the different types of institutions varies between countries.[2] Variety does not exist only between different types of institutions, but also between similar institutions. For example, some key aspects of these differences include research and educational topics, endowment

[2]For example, see the European Tertiary Education Register (ETER): https://www.eter-project.com/about/eter.

with resources, the organizational structure, and the effectiveness of internal governance mechanisms as well as the interactions with other critical stakeholders such as institutions, companies, and society as a whole. Thus, recognizing this considerable degree of diversity in the higher education sector, it becomes clear that policies aimed at improving HEIs' engagement in the KT have to flexible enough to be calibrated to the individual characteristics of a given institution.

Compared with other types of higher education institutions, by their nature, universities tend to provide services feeding into at least two corners of the KT, tertiary education and research. They integrate these two spheres in line with a focus on research-oriented education. A change in the role of universities and an expansion in their range of activity are determined by several key trends:

- A trend toward the decentralization of governance and the greater autonomy of institutions, combined with shifts to funding schemes with a greater emphasis on performance and competition, has affected universities' ability to autonomously allocate resources, set strategic targets, and shape their unique profile in research and education;
- Increased international collaboration facilitates, on the one hand, the exchange of knowledge and experience in research activities and best educational practices, on the other, however, this leads to increased competition between institutions for research talent and students;
- The expansion of the types of key university activities beyond education and research has influenced innovation strategies, financing schemes, and relevant policies, as well as the realization of the "third mission" and the "entrepreneurial university."

Given the dual move toward increased autonomy and accountability for HEIs in most countries, many countries have deliberately acted to strengthen and formalize the image of HEIs as socially significant establishments engaged in the transfer of knowledge. In Sweden, for example, the "third mission" has been officially recognized in the Higher Education Act since 1997 (OECD 2015). The emerging importance of the knowledge-based economy also calls for a new understanding of the key tasks of universities. For example, Foss and Gibson (Foss and Gibson 2015) identify two major types of "entrepreneurial" activities of HEIs:

- *Entrepreneurial education* is understood as the fostering of an entrepreneurial spirit in students and graduates as part of the university's academic programs, e.g., by offering specific courses, joint labs, and platforms for co-creation with industry actors and the implementation of inter-sectoral exchange programs.
- *Entrepreneurial activities* involve the creation of spin-offs and academic start-ups, the production of intellectual property rights (IPRs) and engagement in collaborative research.
- *Academic entrepreneurship* involves the development of support structures for commercialization such as technology transfer offices (TTO) or industrial-liaison offices (ILO).

The concept of the entrepreneurial university serves as a basis for a partnership between the government, business, and academic sectors. An emphasis was placed on the idea that universities must consider entrepreneurialism a key value of their organization. This involves the transformation of universities' management and organizational structures and mechanisms, which leads to universities becoming autonomous and strategic actors in the innovation system. This institutional transformation includes three major pillars (Scott 2014):

- The regulative pillar involves the establishment of a legal framework, governance mechanisms, and a monitoring system;
- The normative pillar involves the realization of university functions in accordance with expectations placed on them, which is dominated by social values, the surrounding environment, conventions, and standards;
- The cultural-cognitive pillar involves rooting the entrepreneurial role of the university in the outlook of individual researchers and HEI teachers.

Thus, the increasing role of entrepreneurship in university activity depends on several institutional factors: institutional autonomy, the allocation of funding streams, governance mechanisms, and the surrounding entrepreneurial climate. Furthermore, a distinction can be made between the exogenous (top-down) and endogenous (bottom-up) factors that shape universities' transformations into entrepreneurial institutions (Etzkowitz et al. 2008). Exogenous factors include external shocks, such as the 2008 economic crisis and subsequent grand societal challenges, which then called for knowledge-based and sustainable solutions. This has endowed universities with the key role as partners in overcoming these challenges by creating these new solutions and innovations. The endogenous factors include internal transformations of the institutions themselves, e.g., of their organizational structure or strategic targets, or the bottom-up coordination of individual departments' provision of university services, such as conferences.

Given the diversity of exogenous and endogenous factors that affect university activities, it becomes clear that entrepreneurial universities can and do have a variety of characteristics. Bronstein and Reihlen (Bronstein and Reihlen 2014) developed a typology of these different characteristics based on a meta-analysis of the structural features of institutions, such as governance and organizational models, human resources, financial resources, infrastructure, missions, strategies, location, and environment. They identified four different university archetypes—*research-preneurial*, *techni-preneurial, inno-preneurial*, and *commerce-preneurial* (Table 3.2).

Though one might be able to identify examples that serve as perfectly fitting prototypes for each of these archetypes, most universities actually could be categorized as more than one type due to their mostly multifunctional roles stemming from path dependencies in their development, governance structures, environment, and culture.

Another important dimension that has recently gained traction places an emphasis on an extended understanding of HEIs' social role, resulting in “civic (or engaged)

Table 3.2 Classification of Entrepreneurial Universities

Orientation	Main characteristics	Examples
Research-preneurial	• Focus on the creation of new knowledge and research excellence • Traditional academic organizational structures (departments, faculties) • High degree of public funding (basic and competitive funding schemes) • Often host large research facilities • Strive to find external funding, which motivates these universities to implement socially oriented programs, the development of research and commercialization. Their resources include (joint) research centers and special divisions responsible for ILOs and TTOs.	• Stanford University, US • Technical University of Munich, Germany • University of California at Berkeley, US • Universidad Católica, Chile
Techni-preneurial	• Focus on applied research but still mostly publicly financed; • Strong ties to relevant industries, both at an institutional level and at the level of individual staff members, as direct providers of knowledge • Focus on inter-sectoral mobility (tailor-made academic programs in conjunction with businesses, entrepreneurship education, on-the-job training) • High degree of regional embeddedness	• University of Joensuu, Finland • University of Waterloo, Belgium • Hamburg University of Technology, Germany
Inno-preneurial	• Focus on innovative services and business solutions • Flexible structures that adapt to market characteristics; • High degree of private sponsoring, e.g., for professional schools • Incentive schemes emphasizing innovation and entrepreneurialism • Knowledge transfer and commercialization activities, including business and consultation services • Typically located in large urban areas and clusters	• University of Joensuu, Finland • University of Waterloo, Belgium • Hamburg University of Technology, Germany
Commerce-preneurial	• Focus on the commercialization of innovations and marketable products in specific high-tech sectors • Strong links with industry due to joint projects and joint ventures • Entrepreneurial facilities such as business units, incubators, and technology parks are core parts of university infrastructure • High importance of market-oriented project funding; • Managerial approach to governance • Emphasis on public relations and marketing	• Twente University, the Netherlands • Bandung University of Technology, Indonesia • Waseda University, Japan

Source: Compiled by the authors using Bronstein and Reihlen (2014)

Table 3.3 Civic Universities' Roles within the KT

KT axis	Description
Education—Research	Research-informed teaching that engages students in real, relevant research projects in the classroom based on the university's expertise in order to contribute to the solution of complex, comprehensive, and interconnected problems in cities or regions
Education—Innovation	Students' involvement in projects with real public or private clients, allowing them to apply their specialist skills and receive course credits for their work, while engaging in the teaching process, the wider community also reaps benefits from the student's work;
Research—Innovation	Focus on problem-solving, use-inspired research that makes a real impact on people's lives

Source: Compiled by the authors using Hazelkorn (2010)
One example in this vein is Finland's Technical University of Tampere. It hosts the "Open Innovation Platform Model," which strives to practically implement IT solutions and involves students and companies, secondly, the Campus Arena, which aims to engage companies and students in joint projects

universities" (see, e.g., Goddard 2009; Henke et al. 2015). The fundamental starting point here is that HEIs are seen as providers of public goods, hence the results of research and education should not solely be assessed in terms of quantity and excellence, but in terms of their social significance and relevance. This especially includes the potential to contribute to the solution of societal challenges such as ageing populations, sustainable energy production, smart mobility solutions, etc. Another core function of the civic-oriented model is the university's contribution to social inclusion by striving to provide equal educational opportunities to all strata of society. Typically the civic engagement of HEIs has a strong place-based dimension, with an emphasis on their direct impact on their regional environment (policy strategies based on location will be considered in a later section). Hazelkorn (Hazelkorn, 2010) provided some examples of how the "civic university" can contribute to the activity of all three axes of the KT (Table 3.3).

Both concepts of "entrepreneurial" and "civic" universities call for an extended understanding of the role of HEIs beyond research and teaching, which also requires relevant organizational transformations. Nevertheless, there are also contradictions between these two models given that the focus on entrepreneurship, modernization, and a pragmatic allocation of resources based on commercial results may lead to a breakdown of the university's social goals. These targets are often intangible in the short term. On the other hand, an innovative and flexible approach could include both the entrepreneurial and civic models, reaping additional benefits by using creative resources for the development of new solutions.

Table 3.4 Typology of Public Research Institutions (PRI)

Type	Characteristics	Main functions
Mission Oriented Centers (MOC)	Owned and sometimes run by government departments or ministries at the national or sub-national level (e.g., NASA, USA)	Perform public research in certain thematic areas; support public decision-making.
Public Research Centers and Councils (PRC)	Large multi-disciplinary organizations with a significant share of public R&D funding (e.g., Max-Planck-Gesellschaft, Germany)	Perform (and sometimes fund) public fundamental and/or applied research in several fields.
Research Technology Organizations (RTO)	Often in the semi-public sphere (although some are owned by governments); private non-profit organizations. Also known as industrial research institutes (e.g., Fraunhofer Gesellschaft, Germany; Netherlands Organization for Applied Scientific Research (TNO))	Provide links between public sector research and private innovation activity; knowledge transfer to business sector and society.
Independent Research Institutes (IRI)	Semi-public; exist in various legal forms with varying ownership structures (e.g., run by HEIs); often founded on a temporary basis at the boundary between public and private sector research (Competence Centers for Excellent Technologies (COMET), Austria)	Perform basic and applied research focused on specific issues or problems, research mostly performed under the aegis of joint HEI projects with the public and private sector.

Source: Adopted according to OECD (2011a)

3.3 The Role of Public Research Institutions (PRIs) in the Knowledge Triangle

In a number of countries, public research institutions (PRIs) are important actors in public sector research. Over the course of the last few decades, their share of domestic R&D spending has been on the decline in many OECD countries (OECD 2011b). However, they remain critical actors in some national innovation systems, as dedicated research providers of unique, niche research for commercial application. Together with companies, they perform research in specific fields or implement long-term strategic projects, such as those dedicated to space exploration. Due to the great diversity of institutional types among OECD countries, finite typologies of PRIs must be considered with care. The OECD Innovation Policy Platform provides a useful, but broad, characterization of the "ideal" types of PRIs (see Table 3.4).

This broad typology illustrates why PRIs must be considered critical actors in the KT. They act at the intersection between public HEIs and the private sector, performing specialized applied research and providing career opportunities for researchers from specific fields, sometimes beyond a given university's purview.

Table 3.5 Functions of PRIs

Function	Example of activities	Rationale/motivation
Fundamental/ strategic research	• Fundamental research in particular in strategically important areas, e.g., defense, security, nuclear energy, public health, etc. • Long-term research	• Improbability that enterprises or universities would undertake this work with a sufficient breadth/ depth of study, inter-disciplinarity, and appropriate continuity. • Need to combine basic and applied research to ensure "knowledge integration," i.e., bring together knowledge from one's own research and other sources • Complementarity with university research (link-function) • Scale of investments required for critical mass (personnel, facilities, equipment, etc.). • Public security interests (in strategic or sensitive areas). • Provision of specialized training and skills (perhaps a benefit rather than a motivating factor).
Technological support for economic development	• Contract research services for businesses • Collaborative research with industry • Long-term, foresight-oriented technological research (*speculative research*) • Technological "expansion": support diffusion and adoption of existing technologies • Market intelligence services, • Technology matching services	• To compensate market imperfections related to costs and risks • To accelerate, broaden, and expand technology diffusion.
Information support for public policy	• Fundamental and preventative research, focused on environmental policy, public health, food security and safety, sustainable development • Pre-emptive policy design and impact analysis • Monitoring of the implementation of policy concerning, e.g., pollution, seismic surveys • Expert assessments	• Impartiality (including the need to separate monitoring and control functions from advocacy functions) • Unbiased broker of policy alternatives • Need for resource-/time-intensive expertise (i.e., more than occasional or one-off expert assessments) • Responsibility and accountability
Technical norms, standards	• Pre-normative research • Implementation of monitoring, e.g., metrology	• Impartiality • Public security based on independence

(continued)

Table 3.5 (continued)

Function	Example of activities	Rationale/motivation
	• Certification of products (and accreditation of certifiers)	
Construction, operation, and maintenance of key facilities	• Large infrastructure (e.g., accelerators, research reactors, botanical gardens, large computing facilities). • Large, unique, and perhaps dangerous collections of research samples. • Large, long-term data collection	• Potential market failure: 'Cost beyond the resources of other players' • Security and safety (physical concentration of infrastructure, accountable management)

Source: Adopted according to EURAB (2005); Gulbrandsen (2011); EARTO (2005); Pielke (Pielke Jr 2007)

In addition, PRIs sponsor research that is not always market-oriented. Whereas Table 3.1 takes an *ownership* perspective in the classification of different types of PRIs, Table 3.5 considers more *functional* aspects of PRIs, highlighting several knowledge transfer channels. This concerns where PRIs might be engaged along the three axes of the KT, especially the ties between research and innovation, academic institutions and PRIs, and those between education and innovation, due to, for example, the mobility of researchers.

3.4 Private Companies and the Role of the Business Sector

The business or private sector as a component of the KT framework significantly differs from public institutions and innovation policymakers. It is commercial interest, rather than some other social or political vision, that is decisive in whether or not private companies might interact with the public and semi-public sectors (however, the notable impact of philanthropic activities from the private sector should not be overlooked).

These interactions can take place through different channels. First, a key factor is the mobility of skilled personnel with all levels of education, who make up the foundation upon which companies' innovation potential is built. Second, there is also research by either public universities or PRIs, which directly or (in the case of basic research) indirectly could be converted into innovations (see Jaffe 1986; Karlsson and Andersson 2005).

The way in which and the degree of the intensity with which private companies might engage in collaboration with the public research sector and universities determines the contribution companies make to education and R&D. Although the literature usually focuses on the contribution of HEIs to innovation and private sector activities, this overview highlights the various potential contributions and spillovers in both directions. Table 3.6 presents a list of some direct inputs and

Table 3.6 Spillovers from Private Sector to HEIs' Research and Educational Activity

Direct contributions to research	• The provision of funds for R&D and innovation projects of public institutions. Private funds are an increasing source in university budgets in many OECD countries, influencing university potential and shaping their profiles. Investments are made via competitive research grants and prizes, the hire of well-known professors, or through competitive programs, run either by the company itself or by intermediaries such as private foundations. • Co-financing or other involvement in government initiatives (joint R&D projects, clusters, etc.) • Participation in the basic funding of HEIs, e.g., via donations or investments in research infrastructure
Direct contributions to education	• Grants and scholarships for students • Collaboration with HEIs in terms of hosting students as part of their professional education, e.g., via internships, the co-supervision of research thesis papers, or part-time employment of young researchers on a collaborative basis as part of, for example, an industrial doctoral program, specialized colleges or European programs such as the Marie-Sklodowska Curie Actions • Involvement in the development of curricula • Guest lecturers • Participation in the basic funding or even foundation of HEIs, especially of universities of applied sciences or institutions with professional or technical colleges, according to specific needs of companies in a certain location (e.g., technical universities in the Netherlands or "new universities" in Sweden).
Indirect spillovers affecting research	• The creation of an entrepreneurial ecosystem around HEIs in which there are a dynamic variety of companies, either large multinationals or small and medium enterprises (SMEs), is crucial for the university's and individuals' attitude toward engaging in entrepreneurial activities. This is motivated by a kind of "entrepreneurial spirit," the existence of opportunities for the commercialization of know-how and the capitalization of start-ups, with an explicit or implicit focus on businesses' needs. • Companies' needs may implicitly influence the research profile of HEIs, i.e., by pointing toward specific challenges and future needs that demand solutions. • Companies act as an absorber and user of knowledge produced by the public sector, which may help them when justifying the need for public funds in R&D.
Indirect spillovers affecting education	• Demand on the labor market serves as indicator for the development and relevance of academic programs, • Some graduates may still be connected with their alma mater, e.g., via alumni associations or as donors, and serve as a starting point for the future networks of young graduates.

Source: Authors' compilation

indirect spillovers from the private sector, based on indicative examples from case studies carried out as part of this article.

3.5 State Authorities

Policymakers consider higher education institutions to be suppliers of competent specialists and participants in national and regional innovation systems. The term "Knowledge Triangle" gained importance especially as part of the European Commission's policy strategies, according to the targets formulated in the European Union's 2020 Strategy for Smart Sustainable Growth (European Council 2010). According to this strategy, effective links between research, education, and innovation are considered a key prerequisite for tackling societal challenges. In 2009, the Council of the European Union announced: "*. . . [the] need for improving the impact of investments in the three forms of activity—education, research and innovation—by systemic and continuous interaction*" (Council of the European Union 2009). Therefore, the KT is not a finite concept, but should serve rather as a guiding principle, directing the attention of actors to creating productive links between the education, research, and business sectors. Policies in line with this approach should promote the expansion of academic cultures beyond research excellence and teaching alone toward innovation and the development of solutions for socioeconomic challenges. Besides applied research and commercialization activities, universities should contribute to the formation of such assets as relevant and diverse competencies (including soft and entrepreneurial skills) and an innovative and entrepreneurial spirit. In their *Agenda for Europe's Higher Education Systems*, often referred to as the "modernization agenda," the European Commission calls for a greater variety of study models to provide flexible and personalized learning opportunities and the improvement of specialist training programs at all levels, including doctorate, so that graduates would be more in demand and ready to meet the needs of a dynamic and changing labor market (European Commission 2011a and 2011b).

Due to the great heterogeneity of the formal responsibilities of governmental and administrative entities, it is impossible to classify the role of public authorities in the KT in a single, all-encompassing framework. Differences exist, for example, in the governance and financing of higher education institutions, depending on whether this is anchored at the national or sub-national level (Germany and Spain can serve as examples of countries with a highly decentralized system). Other differences occur depending on the extent of institutional autonomy and the degree of automatism in funding schemes (according to the application of formula-based or contractual schemes, for more, see the next section).

Differences in approaches to innovation policy may emerge depending on whether or not innovation is among the formal responsibilities of a certain ministry or whether innovation is considered a guiding principle for coordinating various concepts, funding schemes, and institutional targets that are among the responsibilities of several ministries. This is increasingly relevant given the challenge-oriented approach to policy formulation. This type of policymaking takes a topic- or technology-oriented perspective (e.g., climate change, energy security, mobility, etc.) as opposed to the activity-related approach that is used in the KT framework (e.g., collaboration in research, personnel mobility, etc.). Earlier such concepts focused on technological sectors, while new horizontal approaches to determining priorities focus on social needs and challenges (e.g., the EU's formulation of the "grand societal challenges" and their integration into the current research framework program, HORIZON 2020). These mission- or challenge-oriented approaches call for the integration of actors and policies along defined priorities. Often, they focus on real educational issues, such as the need for a focus on math-information technology-natural sciences-technology (MINT) or the integration of innovations as a guiding principle for the provision of education at all levels (e.g., the Dutch Technology Pact). Hence, the KT will have different configurations depending on the institutional actors and responsible state authorities.

That said, in general, the state authorities (ministries, regional, and local administrations) fulfill the following roles in the KT:

- Provision of a legal and regulatory framework for public research, education, and innovation activity based on the delegation of duties to the relevant agencies and for the formulation of norms, standards, and regulations for businesses;
- Provision of funding for higher education, public sector and private sector R&D and innovation activities both directly and through funding intermediaries such as councils, state agencies, and foundations, they can also do this through indirect stimulus mechanisms like tax incentives (*supply side policies*);
- Encouragement and support of innovations by creating demand for them, i.e., innovation-oriented public procurement;
- Absorption and use of highly skilled human resources, research, and innovation outputs;
- Definition of thematic or technological priorities that serve as medium- to long-term guiding principles for funding and planning public and private sector activity (Mazzucato 2013).

In attempting to integrate activities within the KT, public sector administrations are confronted with a variety of challenges (Markkula 2013, p. 18):

- Embedding entrepreneurial culture throughout the higher education institution
- Involving students as co-creators of knowledge and as part of the innovation system
- Creating rich learning environments for talent development
- Quality assurance and recognition of the need to develop new skills and competencies
- Adopting an interdisciplinary approach to higher education research, and the development of policies targeting, for example, the EU's "grand societal challenges"
- Developing academic talent and skills
- Internationalization as a way of improving institutional practices
- Implementation of flexible management models
- Life-long learning, inter-sectoral mobility

- Embedding evaluation and monitoring systems to determine the impact of activities related to the KT in university strategy
- Smart specialization as a policy focus for KT activities
- Adopting a long-term vision for change at the institutional level
- Incentives and funding structures
- Engaging with the national policy environment across the areas of research, education, enterprise and innovation

The increasing internationalization of research as a consequence of the globalization of value chains for goods and services and the anticipation of challenges that call for global cooperation (climate change, energy production, and resource management) also calls for a new way of coordinating relevant and pressing policies across countries. This model is already used by the Knowledge and Innovation Communities (KIC) of the European Institute for Innovation and Technology (EIT).[3]

3.6 Governance Models and Policy Tools for the Support of Knowledge Triangle Activities

During the creation of industrial, educational, and innovation policy, economic needs are not always considered, which may cause "silo-thinking." The KT eliminates this shortfall, calling for an *integrated* approach to the three aforementioned spheres. We will consider the relevant mechanisms in educational policy, the tools for developing ties between research and industry, as well as those for performing expert evaluations as part of the KT in the following section.

3.6.1 Funding and Management of Higher Educational Institutions

As key actors in the KT, higher education institutions play a crucial role in shaping it. The design of governance structures and funding mechanisms is an important determinant as to how higher education institutions may position themselves within the KT, as they provide both incentives for and barriers to individual researchers as well as the institution as a whole. Several developments took place over the course of the past two decades in many OECD countries that directly impacted HEIs' engagement in KT activities. These developments include changes in the regulatory framework as well as shifts in the steering and funding mechanisms of the state authorities, namely:

- An increase in HEIs' institutional autonomy, regarding the distribution of funds, choice of research partners, recruiting & HR, the development of curricula, etc.;

[3] https://eit.europa.eu/.

- The introduction of performance-based funding schemes for the allocation of basic public funds including contracts, agreements, formula- and indicator-based schemes;
- An increase in external (competitive) funding from both public and private sources;
- Institutional cooperation and mergers.

These developments will be described in the following section.

3.6.2 University Autonomy and Performance-Based Funding

The rise in universities' autonomy, by means of legal and institutional independence from the state authorities, was accompanied by the introduction of performance-based elements in the allocation of basic public funds to universities in many OECD countries. *"Performance-based funding is to be understood as a type of funding where the (public) budget of a higher education institution varies with the performance of the institution."* (De Boer et al. 2015). Hicks (Hicks 2011) pointed out six major justifications for the rising importance of performance-based elements:

- The need to incentivize increased productivity
- The replacement of traditional command-and-control systems with market-like incentives
- Incentivizing a stronger focus on services
- Strengthening the administrative autonomy of higher education institutions
- Contracting services
- Raising accountability for results and outcomes

De Boer et al. (De Boer et al. 2015) found institutional profiling, i.e., a strategic diversification of the higher education systems based on individual institution's strengths, to be another important result of performance-based funding schemes. Several recent studies surveyed the structure of performance-based schemes in European and OECD countries (e.g., Pruvot et al. 2015; de Boer et al. 2015; Hicks 2011; Niederl et al. 2011) finding a great variety in design and targets. Instruments of performance-based funding include formula-based schemes, performance agreements and contracts as well as combinations of these elements. Furthermore, these instruments could differ depending on the point in time at which performance is measured.

Formula-based funding schemes typically use a result-based, retrospective approach, proceeding from past teaching and academic achievements, research and third-mission activity, which are assessed by a predetermined set of performance indicators. The productivity of research and third-mission activity is often evaluated using the amount of third-party funding or cooperation activities. According to the aforementioned studies, frequently used indicator dimensions cover: (1) the number of graduates, (2) the number of exams passed or credits earned by students,

(3) participation in research studies, (4) the social and demographic mix of students, (5) average study duration, (6) number of PhD graduates, (7) research productivity, (8) research performance in terms of shares in competitive projects, (9) third-party income, (10) university revenue from commercialization activities (patents, license income). In many countries, educational funding is typically provided on the basis of performance indicators (e.g., in Denmark, Sweden, Australia), whereas funding for research is often allocated on the basis of historical path dependencies and only to a smaller extent on performance indicators.

Unlike formula-based schemes, performance contracts or agreements set targets for future performance, usually on a negotiated basis between the relevant ministries and individual universities. These measures can be characterized as being *soft* or *hard* in terms of their effect on funding when targets could not be reached. Performance agreements typically allow for the setting of strategic targets for institutional development other than those that could be directly encapsulated by technical/numerical quality indicators. That is why performance agreements are especially useful tools for expanding HEIs' missions beyond research and teaching activities. Such targets may include: (1) the increase of HEIs' social outreach and engagement and the resolution of local problems, (2) the development of a unique institutional profile, (3) the improvement of ties with the business sector and participation in innovation activity, (4) the increase in the international connectivity of national R&D. The difference between the terms "agreement" and "contract" mostly refers to how legally binding a document is. In selecting either mechanism, the authorities decide whether to continue supporting a project and how this support may be extended when announced targets are not met. Although such mechanisms have been used recently in several countries, in most, they are supplements to formula- or historically-based schemes. This is due to their dedicated share of the budget (for most EU countries, between 1% and 7% of block grant allocation, according to (Pruvot et al. 2015), the power of sanction mechanisms, or the focus of those agreements only on specific fields.

Based on an analysis of universities' performance based on international rankings, such as the Shanghai ranking, and patenting activity, Aghion et al. (Aghion et al. 2009) showed that university autonomy and competitive funding mechanisms are positively correlated with university output at both European and U.S. public universities. However, the use of performance-based funding affects not only universities' research and teaching performance, but also determines their innovation potential and therefore their full integration into the KT.

The contributions of autonomy and performance-based funding are decisive for HEIs' participation in the KT in two ways. First, increased autonomy allows more freedom in allocating funds, setting a strategic agenda and developing an HEI's profile. Second, mechanisms for increasing productivity facilitate the development of innovative activity, the commercialization of developments, and other "third-mission" activities. However, depending on the calibration of such performance-based schemes (the alignment of priorities, financial resources), there is a risk of an imbalance in the support given to various university functions/departments for limited resources. So, a focus on research can lead to a decline in investments in teaching and vice versa. Polt et al. (Polt et al. 2015) in an in-depth analysis of the Danish and Swedish innovation systems observed that, although innovation is high on the government agenda, especially in Denmark, and despite the fact that there is a great deal of commitment to innovation from the university sector, many HEIs feel that this is not properly reflected in the funding made available as it is still focused on education and research excellence. The imbalance between universities' missions may be attributable to mechanisms such as the Swedish "professor's privilege," which allows professors a teaching exemption, permitting them to focus on research alone, while individual researchers are able to retain exclusive rights to intellectual property (Damsgaard and Thursby 2013).

3.7 Institutional Change of Higher Education Systems

Along with the increase of a university's autonomy and the introduction of performance-based funding schemes, there were efforts made to consolidate the public research sector through mergers of departments within HEIs themselves as well as mergers between HEIs and PRIs, especially in Northern Europe (e.g., Denmark, Finland) and in France. Such consolidation is thought to lower costs and increase efficiency. However, Pruvot et al. (Pruvot et al. 2015) demonstrated that this is of secondary importance while the goals to create "critical masses" in areas of research and education and, to strive for improvements in quality were identified as the main drivers of these developments. Another observed positive effect is the simplification of the public research system in terms of the number of institutions. The merger of the PRIs and universities could help companies improve their access to public research services due to the increased transparency of the institutional landscape and recognition of the great potential offered by ties to the corporate sector (Polt et al. 2015).

3.7.1 Competitive Funding for Higher Education Institutions

The change in universities' role in many countries may permit an increase in the share of third-party, i.e. external (non-governmental) funds, in universities' budgets. This, on the one hand, is attributable to the rising importance of competitive grants offered by the public sector and its intermediaries. On the other, with universities increasingly engaged in collaborative and contractual research activities, investments increasingly stem from the private sector.

Competitive funding from third parties has different implications depending on the source of the funds. For example, such schemes can increase excellence in a certain field or improve the link between research and industry. Therefore, they may influence the achievement of targets set down in performance-based basic funding schemes. Depending on the targets of competitive funding, there may be bottom-up or top-down oriented structures for defining thematic areas of fundamental or applied research. Another aspect of competitive public funding programs depends on the recipient, be it a particular project, individual, or be it for the development of institutional ties (e.g., partnership structures with the business sector such as joint labs, centers, etc.) or research infrastructure.

Third-party funds from private sources, especially from industry partners, are often used as indicators for a qualitative and quantitative assessment of the transfer taking place between the academic and private sectors. In some countries (such as Denmark, Sweden, or the USA), private foundations, owned by philanthropic investors or companies, also play an important role in funding R&D and tertiary education. In the framework of the KT, potential conflicts may occur given the different objectives of public and private funders. In some areas, as is the case. In the Danish life science sector (Polt et al. 2015), private money may be the dominant source of funds for university research and also education activities (especially for doctoral programs). Therefore, governments risk losing the authority to determine strategic areas, and, as a result, they have fewer opportunities to determine the research profiles of universities and therefore lose influence over the three spheres of the KT.

Another potential pitfall is that overhead costs connected with competitive funding from both public and private sources are seldom covered sufficiently. With the rise in external investments, a greater share of universities' basic budget becomes dependent on co-financing requirements. This leads to diminished opportunities for strategic action by university management, regardless of the extent of their formal legal independence in the allocation of funds (see, e.g., OECD 2016).

3.8 Research's Ties to Business and Knowledge Transfer

Recent studies have analyzed transfer channels, the freedom of interaction and policy instruments, providing for such knowledge exchanges between academic institutes as well as knowledge transfer from the academic sector to the social and business sectors (OECD 2013; Perkmann et al. 2012; Arundel et al. 2013; Mathieu 2011). Some channels are used by third-party actors, such as companies, for the transformation of the products of university research and educational activity into innovations, other channels are the result of entrepreneurial activity by the universities themselves (such as the creation of spin-offs, patenting, and other activity generally falling under the term "commercialization"). Furthermore, more informal linkages such as individual networks have also been identified as a key prerequisite for later, official cooperation. Table 3.7 gives an overview of those commonly identified transfer channels as well as related modes of their formalization and policy support structures.

The importance of these channels and the potential for participation in them are determined by the institutional characteristics of the research and educational sectors, the degree of autonomy and management capabilities of the institution, its departments, faculties and individuals as well as the characteristics of the surrounding environment, which is comprised of potential partner companies and institutions, public funding incentives and political, strategies.

Table 3.7 Knowledge transfer and commercialization channels and interaction modes

Transfer Channel	Mode of interaction and support instruments
Informal Outreach Activities	Conference participation
	Formation of social ties and networks
	Inter-sectoral mobility of students and researchers
	Publications
Research & Educational Collaboration	Cooperation in education: firms' participation in the development and implementation of academic programs (e.g., PhD programs, internships)
	Cooperation in research via joint activities and initiatives (research centers, labs, cluster programs, platforms, etc.)
	Research cooperation on a project-by-project basis
	Shared research facilities
	Academic consultancy services
	Joint publications
Commercialization and Entrepreneurial Activities	Patenting and licensing activities: TTOs
	Public research spin-offs and academic start-ups
Other	Joint development of norms and standards
	Joint provision of recommendations for state policy makers, for example, through research councils or consultations at the EU level (European University Association (EUA))

Source: Adopted based on OECD (2013); Mathieu (2011); Perkmann et al. (2012)

The enumerated modes of the transfer of knowledge to society at large usually operate independently from one another, whereas they are integrated in the KT. Thanks to this interconnectivity, there are spillover effects, allowing both the final consumer of research results and the universities themselves to benefit. Researchers or instructors with a background in contractual and collaborative research activities may share important know-how with their students, making a contribution to their further academic career. A vibrant start-up culture may be a key incentive for focusing on entrepreneurship in teaching curricula. Participation in joint activities may also improve universities' research reputation, signalling its high quality and reliability, which may lead to an increase in external financing and facilitate the procurement of academic talent. These are just a few examples, depending on the specific characteristics of individual universities' involvement in knowledge transfer and the incentives and potential of the surrounding ecosystem, this range may be much wider. Figure 3.2 gives an overview of human potential and the institutional environment on research productivity with account of externalities and spillover effects caused by active engagement in transfer activities by the performing institutions according to their status and potential (Unger et al. 2020).

When developing policy support measures for the KT, these interdependencies between transfer channels and the internal structures of universities have to be taken into account. The latter cannot be solely considered a positive effect from knowledge acquisition and rising potential, as it may cause conflicts in fulfilling teaching and research functions. In the context of the KT, businesses' links to research and

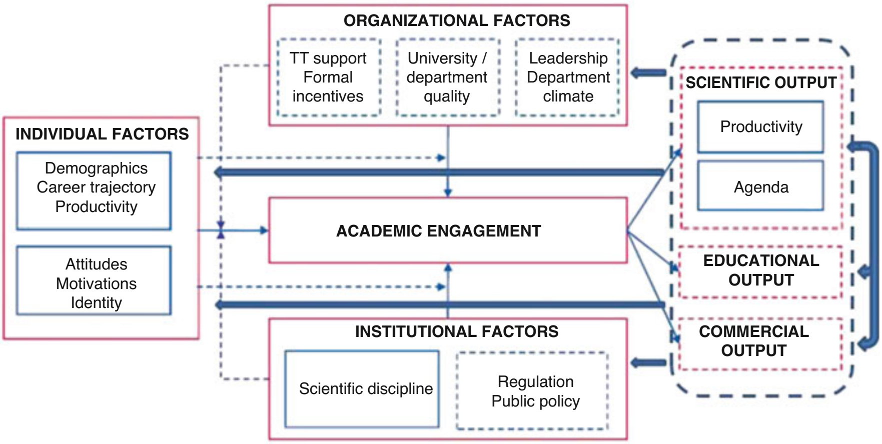

Fig. 3.2 Analytical framework for external engagement by academic researchers. (Source: Authors' adoption based on Perkmann et al. (2012))

transfer mechanisms must be viewed not only as unilateral and bilateral knowledge flows as part of certain projects but also as a process of creating an innovative environment and forming agendas, which would unite all three corners of the KT. These activities typically include medium- to long-term collaboration between universities and partners from both the public and private sector. Examples include excellence center schemes (best practices are demonstrated in Sweden or Austria), which aim to transform basic research outcomes into applied knowledge and solutions for companies. Other instruments, such as cluster programs or development and innovation platforms, put a greater emphasis on applied research and innovation. One can distinguish between them based on who initiates research projects with students and academics—either companies or the public sector.

3.9 Analysis of Policy Instruments and Measures Related to the Knowledge Triangle

To evaluate the efficacy of the KT activities is challenging because it is rarely addressed explicitly in institutional activity or national policy paradigms (with a few exceptions such as the strategic vision of Aalto University, see Markkula 2013). Any assessment of policy instruments and measures is usually carried out on the basis of the implicit structure of applied mechanisms, targets, and performance indicators. When evaluating research and innovation strategies, besides measurements of productivity, or the positive and negative effects of the adopted measures, one must consider the ties and interrelationships between these strategies.

During the evaluations of public programs, in particular, those aimed at developing ties between research and business or those aimed at transforming HEIs into centers of excellence, the effectiveness and productivity of such programs are analyzed, whether specific program goals or policy targets have been met is considered. Despite the fact that an evaluation and monitoring of trends and results can be tied to one another with the investment of funds or the imposition of sanctions depending on the extent of adherence to agreed-upon standards, they must be kept separate. Despite the fact that in many countries' higher education systems a holistic view of HEIs' functions is already used, their total contribution to research, education, and innovation is rarely measured. Monitoring systems, whether they apply numeric indicators or contracted milestones are typically focused on only one of the three KT axes, therefore, these systems suffer from difficulties in properly addressing spillover effects and externalities between the three spheres.

Acknowledging the difficulties of evaluation and the monitoring of systemic ties, the KT concept should not be treated as an independent subject of evaluation, but as a guiding principle for (1) measuring the productivity of institutions, policy measures, and programs and (2) an assessment of the level of outreach in research, education, and innovation policies, and (3) to uncover whether there is an excessive focus on any of them regarding funding, regulation, or rhetoric.

The most successful attempt to create such an evaluation system was made in Sweden, where, in line with a 2012 government initiative, measurements and incentives were developed and tested for assessing the involvement of local universities in the social context (Wise et al. 2016).

3.9.1 Place-based Policies and the Knowledge Triangle

Despite the increased global integration of research institutions, which was encouraged by developments in digitalization and transnational research cooperation, geographical proximity continues to be an important determinant for the engagement of HEIs in knowledge transfer activities. Several studies (e.g., OECD 2007; Veugelers and Del Rey 2014; Goddard and Puukka 2008; Unger et al. 2016) on universities' contributions to regional development allowed for developing a broad classification of transfer channels, which play a critical role especially in the regional context. The functions, as well as the readiness of companies to establish businesses in this or that region, are determined by the features of the local ecosystem (business climate, investment opportunities, the presence of business communities), which in turn affects a region's economic performance and competitiveness.

The typical instruments for formalizing and organizing knowledge transfer activities are by their nature tied to their region of location and cooperation with geographically close actors, these instruments include, for example, clusters, science parks, or incubators (Meissner 2018; Sarpong et al. (2017). A key factor in determining the attractiveness of a region is the presence of highly skilled specialists on the local labor market, and HEIs are responsible for educating these people. Companies quite often express their educational needs to HEIs by participating in the development of curricula or collaborative educational programs such as dedicated professorships or courses.

Furthermore, besides contributing to the competitiveness of a region within the global competitive space by bringing in companies, HEIs are decisive factors in shaping the social, demographic, and cultural structures of a region. A region's ability to bring in young, educated workers positively impacts the development of its infrastructure, including schools, kindergartens, and the hosting of cultural activities.

Additionally, HEIs provide direct economic stimuli for regions (1) as an employer (of not only academic personnel), (2) by the demand created by its students, (3) by expenditures and investments in the construction of infrastructure (Musil and Eder 2013), (4) by contributing to the "branding" of a region, some examples if this phenomenon include Oxford, Cambridge, Princeton, or Harvard, which may enhance a region's reputation as well as its attractiveness as a tourist destination.

HEIs are also affected not only by knowledge transfer but also by the local environment (Carayannis et al. 2018; Kergroach et al. 2018; Unger et al. 2020). The institutional, geographical, or ecological environment (including architecture, rivers, mountain ranges, fauna and flora) may become the starting point for the development of unique research and educational specializations and competencies at the local universities. An example is the research focus on the "Alpine Region" by the University of Innsbruck in Austria. In line with the changing principles of OECD regional policy, regional ecosystems are considered key factors in determining not only HEIs' activities but also the performance of the national innovation systems in general. Traditional cohesion policies, focusing on transfers to lagging regions, have increasingly been replaced over the past two decades by an integrated approach emphasizing innovations that arise from regional knowledge-based ecosystems. Universities and higher education institutions play a vital role in these new socio-economic models, first, because they are the central providers of knowledge and skills, second because they can support policymakers in the development, implementation, and evaluation of strategic concepts and policy measures.

The concept of *smart specialization* is directly tied to the coordination between regional actors in the KT. Smart specialization serves as a key paradigm for the formation of regional structures, combining several spheres of the KT as a driving factor in achieving sustainable, knowledge- and innovation-driven regional development (European Commission 2012; OECD 2014a, 2014b, 2014c, 2014d). Many countries, regions, or sub-regional administrative entities, such as cities and municipalities, to some extent participate in STI policy matters. Therefore, in Germany and Spain, regional administrations develop strategies supporting innovative infrastructure (clusters, etc.), participate in the formation of research, technological, and innovative policy. Depending on the constitutional status of regions in this or that country, the mechanisms for coordinating STI policy may vary. In Denmark, for example, the Regional Growth Forum is a legal entity and coordinates the actions of local scientific, economic, and political actors in a region. In the Netherlands, the so-called "triple-helix" structures have had a long tradition in facilitating the coordination of regional actors, who are often organized as jointly financed councils or associations, which in turn organize multilateral projects in which residents from other regions participate. The Swedish VINNVÄXT program serves as an example of a holistic, integrated approach. This program gives impetus to bottom-up initiatives for the identification of priority areas for action, contributing to knowledge-based regional development.

Involving HEIs in the life of a region is no easy task for politicians. Challenges for implementing and assessing policies in this vein arise especially due to differences in their teaching and education missions and the heterogeneity of the institutional landscape of regions. The management systems and financial state of universities, innovation policy, and regional development depend on the distribution of responsibilities between the federal and regional levels. Such a complex array of factors can lead to contradictions in the use of stimulus mechanisms. Consequently, the degree to which regional structures and innovation policy planning as well as implementation can address the entire KT varies greatly. Therefore, during the development of KT policy at the federal level, in particular, regarding the funding of HEIs, one must consider the role and potential of regional ecosystems.

While these structural differences create difficulties in assessing and benchmarking the regional engagement of HEIs, other difficulties stem from contradictions between HEIs' regional engagement and their aspiration to become competitive on a global scale through their research and ability to bring in talent. In some countries, the task of developing university ties with the surrounding region is formally proscribed in the agreements on research results. Despite this, universities must search for a balance between a focus on the location-based dimension and the tasks of effective educational and research activity and the commercialization of developments. This aspect is poorly reflected in monitoring schemes and performance indicators.

3.9.2 The KT as an Integrative Framework?

The KT concept was used throughout as a common analytical framework for the analysis of whole systems as well as for specific cases and institutions by the Working Group on Innovation and Technology Policy (TIP) under the OECD Committee for Scientific and Technological Policy (CSTP). The study stipulates the systemic cooperation between actors representing the spheres of education, (academic) research, knowledge creation, and innovation. Many of the interactions dealt within the KT framework also feature prominently (though from different angles and perspectives) in analytical frameworks such as the "triple helix," "entrepreneurial university," and other such schemes. So, in Sweden and Canada, many researchers and research departments at higher education institutions are not (yet) familiar with the KT concept, though they certainly engage in KT activities (knowledge transfer, cooperation with companies, education, etc.). Nevertheless, some universities explicitly address the "third mission," "entrepreneurial university," or "triple/quadruple helix" as part of their mission and in their strategy documents.

Although common patterns exist that determine the role, behavior, and organizational characteristics of universities, when deriving a general policy, one must be

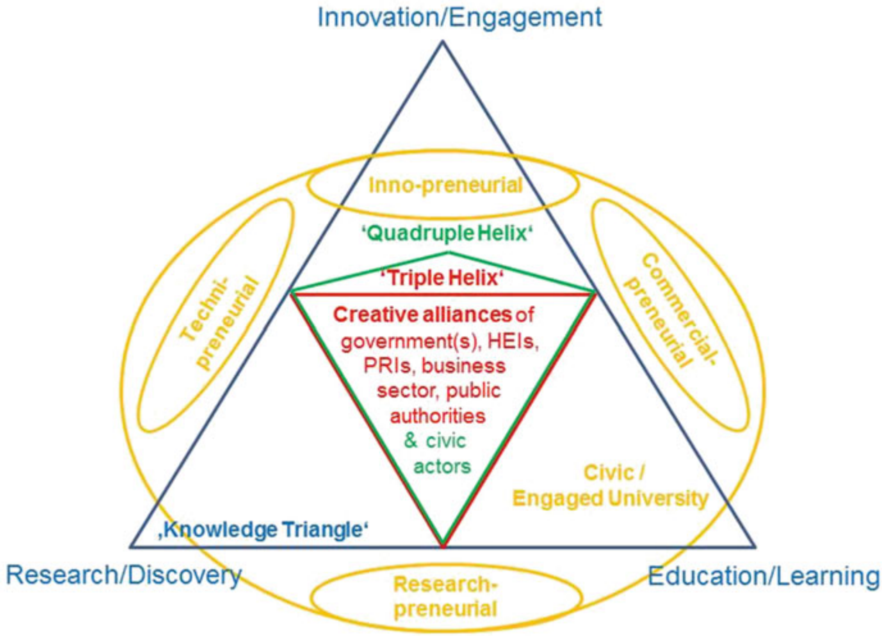

Fig. 3.3 The Knowledge Triangle as an Integrative Policy Framework. (Source: Authors' compilation)

careful given the great deal of institutional diversity and compare institutional facilities and challenges.

Figure 3.3 shows how the KT could serve as integrative framework for the variety of concepts discussed in this article that all refer to (though to varying degrees) a broader understanding of HEI's role in social and economic development. The KT serves as a guiding principle for the development of policies by anticipating the formation of ties between research, education, and innovation.

Irrespective of which concept is adopted (KT, "triple/quadruple helix," "civic or entrepreneurial university"), they all demand a policy or strategy that is aware of the interrelatedness of the activities, potential trade-offs, and the necessary differentiation between incentives and instruments in addressing different approaches and actors. Many HEI policy instruments still do not use an integrated approach to research, education, and innovation. They still focus on single issues, such as education, commercialization, research ties between the academic and business sectors, etc. Strategies for developing ties between the research and business sectors still underestimate the benefits derived by both parties from such interactions.

The logic of the KT places an emphasis on the ties between education, research, and innovation activity. In accordance with the concept, each policy that solely addresses one of these spheres automatically has an effect on the other corners of the KT. However, the term "KT policy" only includes those policies, measures, and instruments that explicitly address the integration of all three corners of the triangle.

Examples of this include Finland's open innovation platforms or centers of excellence/competence (e.g., Austria's COMET, Sweden's VINNVÄXT Excellence Centers and others).

The KT concept addresses several levels of policymaking, from local and municipal to regional and national as well as international authorities. The question of which vision prevails in the strategic interpretation of the KT therefore is dependent upon the focus of a national/regional innovation system and the country's STI governance system.

What could be derived from the several examples that were brought forth in this article is that the implementation of institutional transformations at higher education institutions and other organizations requires appropriate incentive mechanisms. These can include competitive public programs, national or regional strategies with dedicated budgets, specific measures for the allocation of public block grants, etc. Even small amounts of funds could have significant mobilization effects, especially when private funds are leveraged. The concept of the KT hence supports policymakers by providing a deeper understanding of the fact that investments in one corner of the KT tend to positively affect not only the other two corners, but also creates external effects, from enhancing the labor market and fostering structural economic change to improving society's standard of living. Thus, the KT should be first and foremost a practical policy framework, rather than simply a theoretical concept. Therefore, its success can and should be measured by its perceived usefulness for policymakers.

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Different Approaches to Regional Embeddedness and the Knowledge Triangle in Germany

4

Stephanie Daimer, Michael Rothgang, and Jochen Dehio

4.1 Introduction

The environment of Higher Education Institutions (HEIs) in Germany has changed substantially in recent years. These changes embrace different financing conditions and new demands by society regarding the roles HEIs (should) play in regional innovation environments. In fact, we witness HEIs adapting to these changing environments in very diverse ways. So the reasons for different directions of change and different role models universities aspire to must be multi-faceted. Against this background this paper discusses approaches used by different types of HEIs when they develop their patterns of regional embeddedness and address the functions that are outlined by the Knowledge Triangle (KT).

Undoubtedly, universities are acting in response to the requirements posed by their major income streams. Hence, with public universities (or more generally Higher Education Institutions (HEI)) being dependent to a large extent on public funding, a strong impact of HEI policies and governance on the development of HEIs can be expected. In the past 15 to 20 years, political framework conditions in

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Germany like in many other European countries have changed substantially due to the Bologna process, new public management, and more autonomy combined with a more indicator based steering process, or Centre of Excellence initiatives.

At the same time, processes of knowledge production have changed. Despite important differences between new modes of knowledge production, many of them share the feature of different types of actors taking part in an interactive co-construction-type of knowledge generation (e.g. Mode 2 (Gibbons et al. 1994), Triple Helix (Etzkowitz and Leydesdorff 2000), post-normal science (Funtowicz and Ravetz 1993), open innovation (Chesbrough 2003; Chesbrough 2006; Gassmann et al. 2010), or social innovation (Moulaert et al. 2013; Howald and Schwarz 2010)).

And, perhaps most importantly, the role of research and innovation for society has changed enormously, with the grand societal challenges posing new rationales for policy-making (Mowery et al. 2010; Foray et al. 2012; Steward 2012; Weber and Rohracher 2012; Kallerud et al. 2013; Kuhlmann and Rip 2014; Lindner et al. 2016). In STI policies, this means that societal needs have become influential shapers of research priorities. Linked to these developments, science–society relations are in a process of readjustment. This, in turn creates pressure on organizations like universities to change processes and structures, and redefine their mission and strategies (Mowery and Sampat 2005; Samarasekera 2009; Markkula 2011; Benneworth 2013).

The units of observation of our study are HEIs (universities and universities of applied sciences) in Germany and their development during the past ten years. In line with the conceptual approach of this volume we focus on the changing regional embeddedness as captured by the concept of "Knowledge Triangles (KT)" (Gokhberg, Kuzminov, Cervantes, Meissner, Schwaag Serger in this volume). In brief, the Knowledge Triangle stresses an integrated approach to research, education, and innovation with the aim to drive economic growth (Sjoer et al. 2012; Maassen and Stensaker 2011) or broader societal challenges.

We seek to answer these research questions:

1. Has the KT become a desired model and goal for university development in Germany?
2. Are the observed changes in strategies and activities de facto developments relevant to the KT (even if there are no explicit references to the KT)?
3. Which factors have triggered these change processes? What role do regional factors and national policies play?

Our study builds on a few previous studies about the societal and regional embeddedness of universities in Germany (Technopolis et al. 2012; Stifterverband 2013; Koschatzky et al. 2013b; Kroll et al. 2015; Rothgang et al. 2015; RWI and FCON 2015). To this current state of the literature, we add two explorative case studies. They address specific characteristics of the situation in Germany, where looking at interactions between different policy levels is crucial for understanding KT policies (as in fact institutional funding and HEI governance are in the competence of the federal states). Another specificity of the situation in Germany is that public research institutions (PRIs) such as the institutes of the Max-Planck-Society play an important role in the KT.

For the case studies, two HEIs were chosen that display the differences in Germany with respect to framework conditions such as location in different federal states and in different economic conditions, as well as different institutional policies, such as involvement in national excellence programmes or relationships with PRIs. The two cases are Heidelberg University and the University of Applied Sciences Bremen. For each case, we analysed information gathered from documents and webpages of the HEIs, secondary sources, and interviews with representatives from the selected HEIs, one related PRI and the responsible Länder ministries. While four interviews were conducted directly for the case studies, the analysis is based on a substantially higher number of interviews that had been conducted before (29 interviews in 2014 with representatives from HEIs, research institutes, intermediaries, and the administration, in the case of Bremen, seven in the case of Heidelberg between 2012 and 2014). The material from previous studies on the two cases provided a deeper insight also for this study on the KT. So, the additional interviews conducted in the course of this study served to deepen specific aspects of KT relevance.

4.2 The Situation in Germany: Policies, Different Types of HEIs, and Regional Diversity

In this section, we describe the situation in Germany in general terms with respect to the different roles played by HEIs in the regional innovation environments.

In Germany, the tasks of university education are split between the different kinds of public HEIs, primarily between universities and universities of applied sciences (UAS), while private universities play a minor role. As in other countries, there are differences between universities and UAS, but at the same time, the Bologna process has lead to a partial convergence of educational programmes. Other developments have lead to more differentiation within types: the federal excellence programme has lead to larger differentiation among universities, and the expectation of federal states' governments have triggered some UAS to respond to demand of regional industry by investing in their solution-oriented research profiles (Daimer et al. 2017).

In this diverse HEI landscape, different types of universities strive for excellence in basic research, application-oriented research, or in education, but organizational strategies rarely aim at an integrated KT vision, as this chapter will show.

Similarly, at the policy level, the interactions between all three KT angles have not been the major focus of policies or strategies. Nevertheless, the German High-Tech Strategy, which is a major innovation policy strategy at federal level, does define strong links between research and innovation as a major objective and addresses the need for a well-qualified workforce as a central task. There is also an explicit commitment to the third mission in the legal basis: The Framework Act for Higher Education defined "knowledge and technology transfer" as a third task for HEIs in 1998.

At the same time, policies with a focus on HEIs pursue a variety of objectives. From a KT perspective, it is important to note that the policies to foster the third mission of HEIs are based on an understanding that cannot simply be described as "technology transfer" (Carayannis et al. 2017; Kergroach et al. 2018). Rather than simply handing over academic knowledge to industry in collaborative research projects, the different policies aim at establishing formats for joint and mutual R&D processes between public research and industry that start in the early phases of knowledge generation and may last until market invention (like industrial collective research, see Rothgang et al. 2011). Moreover, these programmes aim to establish service structures supporting technology transfer and the entrepreneurial activities of HEIs (e.g. the EXIST programme) as well as raising awareness and triggering behavioural changes in academia towards third mission activities (e.g. pilot measure VIP). Alongside strengthening the third mission of HEIs, there is a focus on excellent research and a stronger link between research and education (e.g. with the Excellence Initiative and complementary policies at the Länder level), and place-based policies (e.g. the research campus models and cluster policies). Over the past ten years, these policies have been accompanied by a substantial increase of public investments in R&D (alongside an increase in private R&D funding). The share of institutional (block) funding as opposed to competitive, project-based funding for HEIs is still relatively high in Germany when compared to other countries. Nevertheless, the performance-based allocation of institutional funding has become more significant over the past ten to 15 years and is now an important aspect in the governance of HEIs by the responsible ministries at the level of the federal states (Länder) (Daimer et al. 2017).

Furthermore, different roles of HEIs in local innovation environments can be observed, depending on the economic structures in the regions. As it is to be expected, HEIs and students in Germany are concentrated in regions with major cities (urban districts) and other urban areas. This is the case for both universities and universities of applied sciences although the latter are also more likely in less metropolitan or more rural areas. This distribution reflects the demand for highly qualified labour, which is more concentrated in municipal areas. However, some rural regions also feature a substantial demand for highly qualified labour. It is a general feature of German industry that family-owned SMEs (but also large firms) have traditionally been successful, and a substantial number of these companies have also developed in more rural areas, especially in the south and in parts of North Rhine-Westphalia.

The focus of university activities has often been national or international with regard to their orientation towards research and education, while universities of applied sciences have addressed local demands to a greater extent (but not solely) (Back and Fürst 2011). Substantial regional orientation of HEI research remains the exception. However, there is a more recent tendency that regional embeddedness of universities becomes increasingly important, and there are examples of universities and universities of applied sciences trying to address local needs more intensively (Koschatzky et al. 2011; Koschatzky et al. 2013a).

Similar results can be seen for research cooperations, which are often national or international. Only, if there is a good match between the industrial structure of the regions and the research and qualification fields of the university, substantial regional anchoring of universities can evolve in metropolitan areas (as is the case, e.g. for the automobile industry in Stuttgart, or for biotechnology in the Munich area). Generally, interactions of HEIs with industry in research and innovation are intensive due to the strong industrial base in Germany. One indicator of this development is the share of HEI expenditure in R&D financed by industry. With 14% in 2012, it is considerably above the OECD average of 5.9% (OECD 2015).

4.3 Case Studies

4.3.1 Heidelberg University

Founded in 1386, the Heidelberg University is the oldest German university and among the most renowned in Europe. The university is a large, comprehensive university covering medicine, natural sciences, mathematics and computer sciences, social sciences, and humanities. It has more than 30,000 students. There is a strong focus on excellent research. Heidelberg was successful in both phases of the German Excellence Initiative with its institutional strategy (future concept), called "Heidelberg: Realising the Potential of a Comprehensive University". Heidelberg is—like the vast majority of German universities—a public institution and receives more than 60% of its budget from the state government of Baden-Wuerttemberg. More than one third of the budget is funded by competitively won R&D contracts. The absolute amount of third-party funding is fairly high at €250 million.

4.3.1.1 Institutional Policy to Support KT and the Third Mission

Heidelberg University is at the centre of a well-developed KT. However, the term KT as such is not explicitly used, but many aspects of the KT concept are present in the mission statement, strategy documents, the governance of the university, and various activities. The main angle is (excellent) research and there are strong links between research and education as well between research and innovation.

For example, the strategic future concept aims at a closer integration of research and education. Moreover, the mission statement accounts for the usefulness of research in a very broad sense when it describes two functions (among others) of the university as follows: ". . . to create and safeguard the conditions for comprehensive, interdisciplinary collaboration that will make possible essential contributions toward the solution of major issues facing humanity, society, and government in an increasingly changing world"; and ". . .to make research results available to society and encourage their utilisation in all sectors of public life" (Heidelberg University 2011).

Heidelberg University has established a specific structure to implement its institutional strategy. Besides the statutory organs of the university—the rectorate, senate, and university council—there are additional bodies involved in developing, implementing, and supervising the institutional strategy. With its Research Councils, the Commission for Research and Strategy, the Steering Committee, and the Academic Advisory Council, Heidelberg University has established a governance structure, which aims to integrate and coordinate formerly unconnected activities and units. In particular, the Research Councils integrate the views of different disciplines, junior and senior faculty, industry as well as representatives of (regional) PRI.

Heidelberg has a strong focus on (international) excellence. All activities with relevance for the education or innovation angles are developed from the research angle (Fig. 4.1). Third mission activities do not focus primarily on a direct contribution to industry-led innovation. Heidelberg's approach is better described as establishing strategic partnerships with research institutions and with industry, for example, in industry-on-campus models. The mission in the life sciences is to do translational research, which aims at making basic research results available for further R&D by partners or for (cancer) therapy in the university hospital. The strategy is to be locally anchored and globally visible. The university aims at (research) activities of an international standard that produce material and immaterial advantages for the region at the same time (Schnabl 2013; Power and Malmberg 2008).

4.3.1.2 Location of the HEI and Role of Regional Activities

Heidelberg (with 150,000 inhabitants) is located in a highly industrial and metropolitan region in the southern German federal state of Baden-Wuerttemberg. The university and other HEIs in the region together with a large number of PRIs provide an ideal backdrop for knowledge-intensive industries such as biomedical applications and other biotechnologies, chemical industry, ICT, plant and manufacturing, systems engineering, automotive industries, and energy technologies. The region is characterized by a population of large firms acting as patrons for the region.

The university, in particular the university hospital, is an important employer in the region. The university's expenditure in the region for personnel as well as for investment and tangible expenses amounts to 60% of its total expenditure (Schnabl 2013; Glückler and König 2011). The university partners with many other regional employers in a Dual Career Service in order to further increase the attractiveness of the region as a place to live and work, in particular for international researchers.

The reputation of the university contributes to the branding of the region, and the historical buildings add to the cultural and touristic attractiveness of Heidelberg. There are various other ways the University contributes to the cultural and social life of the region such as public lectures and discourse formats, seminars for children, and many forms of dedicated volunteerism.

Strategic partnerships with PRIs in the region are central activities to work towards the mission of excellent research at the international level. Probably the most important example of this aspect is the alliance between the university and the German Cancer Research Center DKFZ (Deutsches Krebsforschungszentrum). This

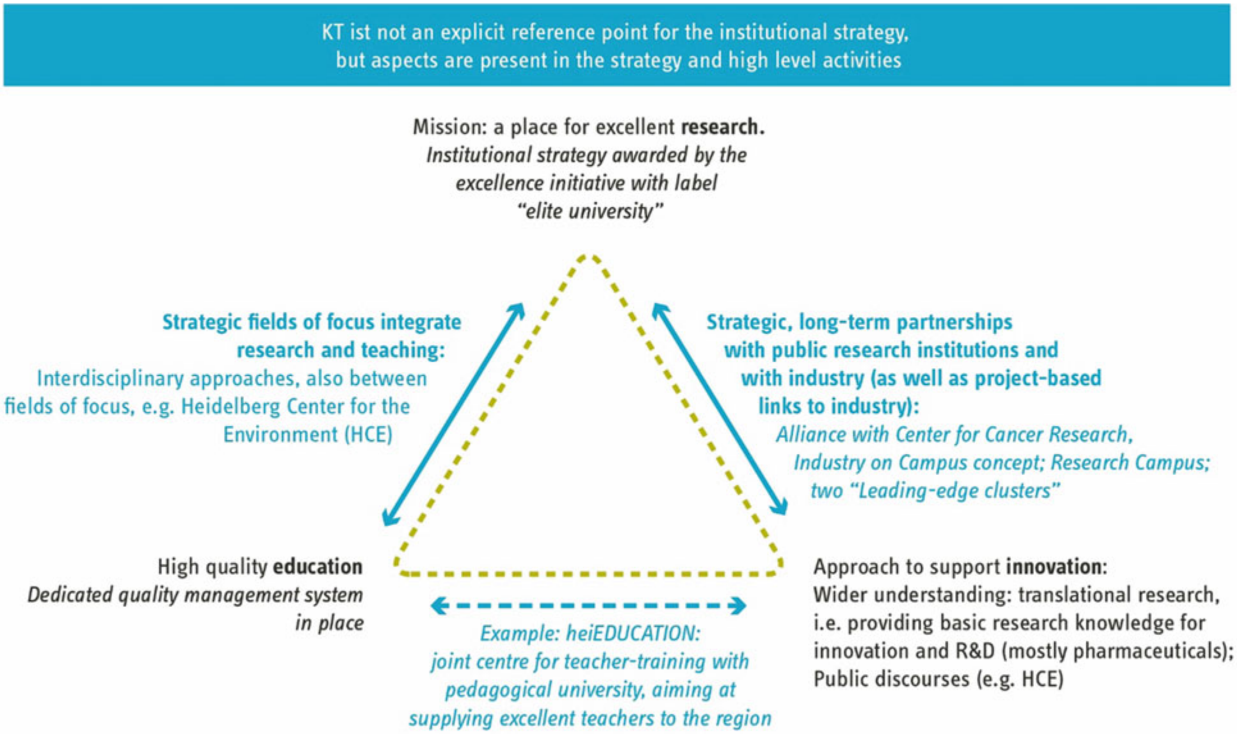

Fig. 4.1 Heidelberg University: Knowledge Triangle understanding and selected activities. (Source: Authors (Fraunhofer ISI))

cooperation makes it possible to focus on basic research and translational research at the same time.

Like other PRIs, the DKFZ is located on campus in Heidelberg. Hence, these actors have always existed in a physically "connate" relationship. Institutionally, the most important links are the bridge professorships, where DKFZ's principal investigators hold chairs at the Heidelberg University (and to a smaller extent also at other universities). The two institutions work closely together in education (master programmes and doctoral programmes) and in the qualification of early career researchers (post-doc stage). Joint research is developed both bottom-up and top-down. There is, for example, the strategic approach to joint basic research in the alliance between DKFZ and the Center for Molecular Biology (ZMBH) at Heidelberg University. The DKFZ, the University and a few other partners have set up the German National Center for Tumor Diseases (NCT). It translates basic research results into cancer therapy as quickly as possible. The DKFZ and the Heidelberg University are also involved in the German Consortium for Translational Research (DKTK), where more than 20 institutions and teaching hospitals come together in translational research centres at eight locations across Germany.

There is a long tradition of cooperation with innovative industry in the region, in particular with larger firms. Due to the focus of the University on excellence, the primary choice for cooperation is not proximity, but shared research interests. Many partnerships have evolved into long-term, institutionalized forms of cooperation (innovation eco-systems):

- **Industry-on-campus projects**: Heidelberg University can be seen as a pioneer among German universities with this approach (Schnabl 2013), where a university cooperates with industry and other partners in strategic basic research.
- **Leading-Edge clusters**: The university belongs to two excellent local cooperation networks designated by the Federal Ministry of Education and Research (BMBF) as Leading-Edge clusters in the framework of its High-Tech Strategy: "Biotech Cluster Rhine-Neckar (BioRN)" and "Forum Organic Electronics". In these networks, the University cooperates with PRIs and firms in R&D and other activities to pursue common technology and market-oriented strategies (Rothgang et al. 2015).
- **Research campus**: The M^2OLIE collaboration (Mannheim Molecular Intervention Environment) is a research campus funded by the Federal Ministry of Education and Research as a public-private partnership to foster innovation. It aims at the development of a molecular intervention environment for cancer treatment. The Medical Faculty of Heidelberg, which has been working in a close partnership with the Medical Faculty of Mannheim since 2006, is a partner in this activity.

4.3.1.3 Examples of Programmes, Initiatives, Or Centres That Explicitly Aim to Integrate Research, Education, and Innovation

There are many more activities with relevance for KT development. Most of these integrate two of the three dimensions, but often also have links to or implications for the third one.

The institutional strategy fosters collaboration and the integration of activities between different fields of focus. The **Heidelberg Center for the Environment (HCE)** is one example of such an activity. It is "located" in the research angle, but has important implications for (interdisciplinary) education as well as the third mission—in the sense of relevance for and engagement with society: "The HCE aims to develop scientific solutions to the existential challenges and ecological consequences of natural, technological and societal changes on humans. To reach its goal, the HCE embraces a broad spectrum of disciplines that includes geography, the geosciences, biodiversity research, environmental physics, the social, economic and legal sciences as well as pre- and protohistory and medieval studies. Furthermore, the centre integrates central aspects of environmental research into teaching and public discourse" (Heidelberg Center for the Environment n.d.).

The social sciences and humanities, which are traditionally strong in Heidelberg, also develop third mission activities. The **Centre for Social Investment (CSI)**, for example, "... is a central academic institute of the Heidelberg University cooperating with the economics, social science, law and theological faculties. Its mission is to improve the theoretical and practical understanding of social investment through research, teaching, networking and consulting" (Centre for Social Innovation n.d.). The centre receives about 80% of its funding from third parties (Schnabl 2013). Five industrial foundations act as the main donors, but the institute also does contract research for non-profit organizations, foundations, and companies (e.g. regarding corporate social responsibility).

The Excellence Initiative required universities to establish close links between research and teaching. One of many measures and activities in place to support this link is called "optimising the general conditions". This means establishing **research-oriented teaching** throughout all the phases of academic education. Measures and activities also address the management of diversity or the support of leaders of early career research groups.

This relationship between education and innovation is dominated by the "transfer via heads"—the education of a qualified workforce for the region. One very visible example is **heiEducation:** This joint centre for teacher-training with the pedagogical university aims at supplying excellent teachers to the region.

4.3.1.4 The Role of Policy

Policy plays a role in several respects of the KT activities at Heidelberg University. A few examples are: The first industry-on-campus project CaRLa emerged out of a Collaborative Research Centre funded by the DFG. The idea to apply for the Leading-Edge Cluster Competition with two cluster organizations from the region originated in the political bodies of the metropolitan region Rhine-Neckar. The University rector, who is represented in the organizational bodies of the

Rhine-Neckar region, committed the University to the strategies of the cluster organizations. While Heidelberg has a long tradition as a research university, participation in high-profile policy measures such as the Leading-Edge Cluster Competition and the Excellence Initiative has strengthened the strategic approach to university activities over the past few years (Schnabl 2013).

4.3.2 University of Applied Sciences Bremen

The Bremen University of Applied Sciences (Hochschule Bremen, HSB) was founded in 1982 during a period when the capacities of the Universities of Applied Sciences were increased in Germany following an initial phase beginning at the end of the 1960s when the government regulations were formulated for establishing this kind of university. The demands from the labour markets with firms searching intensively for a higher educated workforce also played an important role in setting up universities of applied sciences.

In Bremen, as in other places, one core task of these newly founded practice-oriented universities was to open up the university system to new groups that had not attended HEIs before. With about 9000 students, HSB is one of the larger universities of applied sciences, and belongs to the largest 15% of these universities (own calculations).

From the start, a clear focus of the HSB was on the international orientation of its activities. About half of the degree courses include an international semester, some also feature a double degree. More than 300 international cooperation agreements exist with other universities in about 70 countries. In the context of the internationalization strategy, an “International Graduate Center” (IGC) was founded in 2004.

The HSB has five schools, covering business and economics, architecture, social sciences, electrical engineering, and natural sciences. In addition, the HSB established six research clusters in 2012, which addressed regional demands, but also topics of the German High-Tech Strategy and the EU Framework Programme Horizon 2020. At the same time, HSB focused its research activities around these topics in order to create a clearer profile, increase technology transfer, and be more successful in attracting third-party funds (Willms 2013).

4.3.2.1 Institutional Policy to Support KT and the Third Mission

Like the Heidelberg University, HSB does not explicitly mention the KT in its strategy. At the same time, many aspects of the KT concept have been integrated into the goals and activities of the organization.

Figure 4.2 shows the position of HSB activities in the KT. As the mission of the university shows, a clear focus lies on the angle of education: providing the younger generation with an education to meet social challenges and pursue their individual paths. While research is application-oriented, obtaining impulses from firms, the overall approach towards the KT can be described as “triangulation”. That means that the different relevant actors are brought together (firms–students–scientists) in common activities. Therefore, research is often performed within internships and

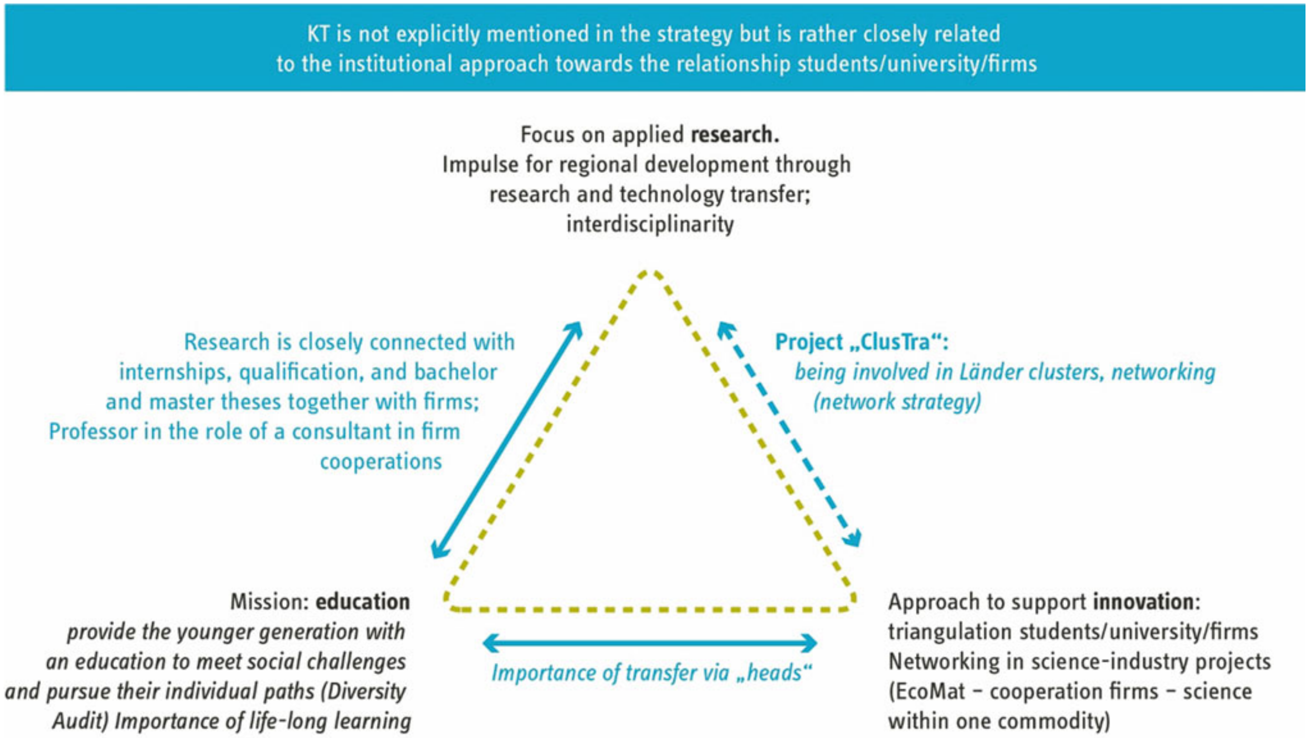

Fig. 4.2 HSB: Knowledge triangle understanding and selected activities. (Source: Own compilation (RWI))

bachelor and masters theses with the professor as a consultant, who supports the joint activities. The relationship between research and innovation is fostered by networking activities between HSB and business firms and HSB's participation in relevant firm clusters and networks (ClusTra is a programme with this goal, see below). In addition, HSB is engaged in regional activities aiming at industry–science cooperation like the Center for Eco-Efficient Materials and Technologies EcoMat, a technology centre, which aims at developing new material technologies in close cooperation between the local HEIs, PRIs, and firms. In respect of the relationship between education and innovation, HSB emphasizes the importance of knowledge transfer via heads.

This general orientation of HSB existed already from its foundation. In recent years, new initiatives were launched by both the university administration and local state policy that foster third mission activities. These initiatives focus among others on the networking of HSB with firms, integrating life-long learning into the curricula, and gearing both curricula and research towards the demands from the local economy even stronger than before.

Third mission- and KT-related activities have been fostered with individual projects in recent years, especially through increasing networking with local industry, and defining core research areas of HSB (research clusters).

At the same time, HSB understands its third mission activities not only in economic terms, but also as a contribution to civil society, because it is located in a multicultural district in Bremen. The goal is also to contribute to the development of the local society and to develop the competences of students beyond purely economic aspects. Examples are:

- The Bremen Diversity Award presented by HSB and Mercedes-Benz Bremen every year. Firms, organizations, and initiatives can apply that deal with diversity and foster equal opportunities. In 2014 an "International Café" received the award for the support and active integration of refugees.
- The Bremen Certificate for Intercultural Competence, a certificate of intercultural skills awarded by the Centre for Intercultural Management & Diversity. To obtain the certificate, the student partakes in a two-day intercultural training and complete two of three special elective subjects. Topics are the knowledge of different cultures, experiences with different nationalities, and awareness of diversity.
- In the project "Third Mission—Environmental Management System" according to EMAS (Eco-Management and Audit Scheme), a management system was developed that supports the university's ecological behaviour in the form of internal audits.

4.3.2.2 Location of the HEI and Role of Regional Activities

While Bremen was an important Hanseatic city with a long history in trade, the Metropolitan area of Bremen was and still is characterized by a substantial share of industry employment. The recent decades have been marked by a structural shift from shipbuilding to (at that time) new industries (like automobile, aircraft, and aerospace industries, and production of offshore wind solutions). The maritime economy (especially the port and the related logistics) was and still is an important economic factor and employer in the region. While some sectors like the aircraft and aerospace industry cooperate quite closely with HEIs, this is not the case to the same extent for some traditionally important sectors like the food industry. In general, there is potential to increase the cooperation between HEIs and firms (especially SMEs) and there are also important activities in this direction (RWI and FCON 2015).

The role of HSB in the local economy has to be understood within the context of the regional innovation system and the division of activities with other HEIs and research institutes in the region. The science system of the region has undergone a remarkable development. The University of Bremen (founded in 1971, 19,000 students), being the largest HEI in the region, has increased its reputation and focuses on scientific excellence. It is one of eleven German HEIs, which were successful in the third round of the federal government's Excellence Initiative with their institutional strategy. In total, there are four state HEIs and three private HEIs in the region. In addition, Bremen has a high number of public research institutions (the highest number in Germany when related to the number of inhabitants).

In this innovation system, where many activities are focused on scientific excellence, the HSB has an important complementary role that is characterized by a strong focus on the regional economy and high regional interconnectedness. Education programmes are oriented towards the local economy. In designing and developing further study programmes, the differentiated demands of local industries like aircraft have been taken into account. Over the past few years, this focus on impulses for regional development and knowledge transfer has been intensified. In addition, one activity of HSB has been to promote local spin-offs. In recent years, about 30 spin-offs were observed (Willms 2013).

4.3.2.3 Examples of Programmes, Initiatives, Or Centres That Explicitly Aim to Integrate Research, Education, and Innovation

There are many activities of HSB that do not target a specific side of the KT, but are related to the KT in general. For example, HSB actively participates in the cluster and network activities in Bremen in order to (1) create a research profile by focusing on future topics, (2) intensify technology transfer through better visibility of the research competences (3) create innovative solutions through interdisciplinary cooperation, (4) develop synergies (5) increase the success of attracting third-party funding by focusing competences, (6) foster education of students and combine research and education within master programmes (Willms 2013: 74 f.).

An example of one such activity is the **ClusTra** project. This project, which was funded until 2014 by the business development agency in Bremen (Wirtschaftsförderung Bremen), aimed at firm-oriented technology transfer into the innovation clusters in Bremen. This project established a central contact point for firms to pose research questions. Together with the firms involved, 18 projects and activities were developed. These included a website where projects would be collected, the development of dual degree courses, a newsletter for firms featuring ongoing HEI projects, the promotion of spin-offs from HSB, seminars and trainee programmes, career services to prepare students for their professional lives, and the development of a transfer office. This lead to an intensification of the contact between firms and HSB, while at the same time new requirements resulted for HSB regarding applied research and third-party funding projects.

HSB participates in several activities in Bremen in order to foster the relationship between research and innovation:

- There are several initiatives to foster spin-offs from HSB like the university initiative BRIDGE, which aims to support potential and promising ideas through consultation, workshops/seminars about business start-ups, competitions. There is also close cooperation with business incubators such as "Gründerzentrum Airport" (GZA), "Bremer Innovations- und Technologiezentrum" (BITZ) and "u-institut für unternehmerisches Denken und Handeln".
- One other example is HSB's participation as a partner in the "Center for Eco-efficient Material and Technologies" (EcoMat). This technology centre, which is situated close to Bremen Airport and other industrial partners, aims to concentrate industrial and scientific expertise on innovative material and surface technologies and enable cooperation between science and industry.

While the overall strategy of HSB is to bring the different angles of the KT together, individual projects also target the relationship between education and research. The project "KBB trans" trains technology transfer mediators, who then coordinate research and enterprise experts in the development of feasible and practical innovative solutions. The project is funded by the EU's Lifelong Learning Programme.

There are complementarities between education, on the one hand, and innovation on the other. As bachelors' and masters' theses often develop together with firms and on topics that are relevant for them, education and technology transfer are in fact combined. As HSB aims at networking with businesses and participating in common activities, many opportunities for such cooperation arise. KT connections between education and innovation are also addressed within regular educational programmes through (i) dual study programmes that combine education at the HSB with practical experience (partly with the opportunity to obtain an official degree for the vocational training), (ii) continuing training, e.g. for firm employees which represents one key area of HSB activities.

4.3.2.4 The Role of Policy

In general, the policy in Bremen is influenced by the view that scientific excellence and economic impact are in principle complementary and that firms profit from first class research. This notion has a strong influence on policy geared towards the university and research institutes. At the same time, innovation policy also promotes the cooperation between firms and HEIs/research institutes. The main policy focus with respect to HSB is on increasing its contribution to meeting the demands of local industry in respect to both education and research.

The Science Plan 2020 for Bremen, which was enacted in 2014, required HSB to consolidate its degree courses and orient itself even more towards the demands from the local economy (Senatorin für Bildung und Wissenschaft in Bremen 2015). The Science Plan, which aims at a rather detailed level of steering, is important in coordinating targets between local state policy and the HSB (as well as other HEIs). The target and performance agreements made between the federal state of Bremen and the HSB are oriented towards political targets. At the same time, HSB has the opportunity to bring certain topics into the discussion (e.g. creating new vocational courses and formats for employees in life-long learning).

4.4 Discussion and Conclusion

The findings of our analysis of the two case studies show five distinct features in respect of the regional embeddedness of HEIs in Germany and the approaches that HEIs choose in that respect:

Firstly, Knowledge Triangle is used neither as a term nor as a concept in German HEIs. The concept does not play an explicit role in the strategic development of activities in either of the HEIs, which were studied in depth, the University of Applied Sciences Bremen and the Heidelberg University. This also holds true for other German HEIs as is shown by the study (Koschatzky et al. 2013b), which provides evidence for another eight cases covering a broad range of universities and universities of applied sciences from different German regions. None of them uses the term KT. To the authors' knowledge, there is only one exception in Germany: the Karlsruhe Institute of Technology (KIT) has used the term explicitly in its mission statement since the merger of its teaching and research institutions in 2009. It claims that the merger puts the new KIT in a better position to integrate the three angles of education, research, and innovation (Technopolis et al. 2012).

Secondly, we find that HEIs have developed quite different profiles and strategies over the past ten to 15 years, whereas many developments have implicit KT relevance. Our case studies show that activities which implicitly relate to the KT are important to both HEIs, but their main activities and strategies are located at different angles of the KT. Thus, the mission of Heidelberg University has excellent research at its core, while the strategy of Bremen University of Applied Sciences centres on education and life-long learning. Policy has had an impact on the developments in HEIs. This is not only true for Heidelberg and Bremen, but also for other HEIs (Koschatzky et al. 2013b). Besides place-based instruments such as cluster policies and the promotion of research campus models, there are dedicated supportive research policies (at the level of the federal state) for research infrastructures and a strong intermediary system (as in the case of Karlsruhe, see Technopolis et al. 2012), or the embedding of HEI policies in a broader regional policy approach (as in the case of Bremen, and similarly in Berlin). In addition, the national Excellence Initiative has left clear marks on the HEI landscape and has influenced HEI strategies and strategic capabilities in particular (e.g. in Heidelberg, Aachen, Dresden, Göttingen, and many more).

Thirdly, we find that KT models, in particular third mission activities, are highly diverse and do not serve the single purpose of generating economic impact. Bremen

University of Applied Sciences focuses on the "transfer via heads"—the education of a skilled workforce tailored to the needs of the region. Moreover, it has developed a societal mission with its diversity policy that aims to open up academic education to students from socially disadvantaged groups. Cooperation with local industry in R&D projects is an aspect of the third mission, too, but not the central one. Heidelberg University is characterized by the translational research approach: basic research contributes to innovation research, while there is less weight on "classical" transfer channels such as patents. Knowledge transfer is founded on long-term strategic partnerships and networks such as the industry-on-campus activities and Leading-Edge clusters. The social sciences and humanities, which are traditionally strong in Heidelberg, have also developed third mission activities. Looking at the broader evidence from other case studies (e.g. Koschatzky et al. 2013b), it is clear that in regions with unique potential for cooperation with industry, the HEIs try to exploit this potential. Aachen University, for example, has an approach which is similar to Heidelberg when it engages in long-term strategic relationships like industry-on-campus projects or research campus models. Historical patterns and the disciplinary strengths of HEIs often dominate third mission activities too.

Our fourth observation is that the location of the HEIs matters for the role they can play and for the effects they can have on the region. The local focus in the HEIs examined varies strongly: The role played by Bremen University of Applied Sciences has been influenced by the features of the regional innovation system and Länder policy that addressed these features, but also by the university's strategy. In the federal state of Bremen, the University of Bremen aims at scientific excellent research. At the same time, the innovation system is characterized by a substantial number of PRIs that perform excellent research. In this framework, Bremen University of Applied Sciences specially addresses the demands of local industries. For HSB, activities that address non-economic aspects are also important. One example is the focus on diversity, because it is part of a diverse district of Bremen, and giving impulses for societal development in individual projects. In comparison, Heidelberg University has always been a top-performer in research in many disciplines and a focal point in regional, national, and international terms. Regional integration is seen as an enrichment to national and international activities and strategies. The university has developed strong strategic partnerships with firms and PRIs in the region. The focus of these partnerships is on research excellence. While there is little specific focus on regional demands, many regional activities and indirect impacts can be found. The university is an important regional employer, its reputation contributes to the branding of the region, and the historical buildings add to the cultural and touristic attractiveness of Heidelberg. Other examples confirm our observation (see the history of Leuphana University in Lüneburg (Koschatzky et al. 2013b)). At the same time, the effects of HEIs on their regions vary depending on the location of the HEI and the characteristics of its regional economy (industry structure, unemployment, economic strength (Stifterverband 2013)).

Our fifth finding was that in recent years, both standard and non-standard national or institutional policies and strategies have played an important role in shaping regional embeddedness of HEIs in Germany. Although the Excellence Initiative is oriented towards a rather “standard” objective of HEI policies, it seems to have indirectly triggered KT relevant developments in the applicant institutions. Many institutional strategies and measures contribute to the integration of at least two dimensions of the KT, primarily research and education. The Technical University of Dresden has been successful in the Excellence Initiative with an unusual concept that addresses the third mission beyond the implications of excellent research: non-economic aspects of regional development and the inclusion of society. Overall, universities have developed more strategic capacities in response to the Excellence Initiative and other “standard” HEI policies such as steering by performance contracts or more (financial) autonomy for HEIs. Beside the dominant excellence paradigm there are quite a number of examples of policies allowing for place-based, more contextualized approaches to HEI development. Place-based instruments such as cluster policies and the research campus models have proven highly attractive to HEIs. Also dedicated supportive research policies (at the level of the federal state) for research infrastructures and a strong intermediary system have been identified as successful KT policies (as in the case of Karlsruhe). Similarly positive results could be observed from efforts to embed HEI policies in a broader regional policy approach (as in the case of Bremen, and similarly in Berlin and Lüneburg).

To conclude our observations of the factors influencing different degrees of embeddednsss in the two HEIs we discussed, we find that the different approaches toward the KT and regional embeddedness are partly caused by the fact that Heidelberg and Bremen represent two different types of HEIs in Germany (general universities, which have stronger research profiles than universities of applied sciences which often focus on education). However, we see that other factors also play an important role in the positioning of HEIs in the KT. These are (1) historical developments and the structure of the innovation system (what firms, other HEIs, or PRIs are in the region?), (2) Länder policies and strategies that foster certain HEI development paths in and with their regions, (3) strategies and perceptions of the acting persons in the relevant Länder ministries and the HEIs; and (4) HEI policies at the federal level (e.g. the Excellence Initiative). As our analysis further shows, there is also a complementarity between universities and universities of applied science, with both kinds of HEIs addressing different aspects of the KT and the demands of the local economies in a different manner. This indicates that knowledge triangles might not only emerge from a single university (or other type of HEI) in a region, but might rest on a small set of core institutions, which complement each other. In the German case such a set of core institutions might be a general university and a university of applied sciences or a university and one or several large public research institutes.

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5 Technology Upgrading and Knowledge Triangle in Brazil

Bruno Fischer, Paola Rücker Schaeffer, and Nicholas Vonortas

5.1 Introduction

A striking challenge for most developing economies concerns the structural barriers embroiled in middle-income traps (Im and Rosenblatt 2013). Catching up with advanced countries depends on multiple aspects related to innovation systems' functioning. One approach to explaining these dynamics has been recently put forward as Technology Upgrading, a term that can be straightforwardly defined as "*a gradual shift from lower to higher value-added activities*" (Radosevic and Yoruk 2016). While not entirely a new concept—akin to the concept of "structural change"—it involves a complex array of vectors of interest, it is closely connected to the diversification in the knowledge portfolio of nations (Lee 2013). These approaches to innovation in catching up economies stress that closing the

The chapter builds on a previously published paper by the authors (Fischer, B. B., Schaeffer, P. R., & Vonortas, N. S. (2019). Evolution of university-industry collaboration in Brazil from a technology upgrading perspective. Technological forecasting and social change, 145, 330–340.). The chapter is a further development based on the prior work.

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technological gap with advanced economies is not the same as exploring new knowledge frontiers.

Within this context, the knowledge infrastructure stands as a key element of technology upgrading. The relationship between scientific and technological development has long been recognized as a pillar of innovation systems' development and of the competitive capabilities in knowledge-based societies (Etzkowitz and Leydesdorff 2000). If anything, this relationship has become more deeply entrenched in productive structures in modern times and in multiplayer settings (Leydesdorf and Meyer 2007). Accordingly, the modern university is viewed as a central agent of the knowledge infrastructure on which innovation dynamics rely (Mazzoleni and Nelson 2007).

The acknowledgment of this role for academia has given rise to institutional changes aiming at promoting a closer connection between universities and markets (Caraça et al. 2009), which intensifies the need to further explore the relationship between the science base and technological and industrial knowledge (Radosevic and Yoruk 2014). The idea of universities as core agents in the education–research–innovation relationship has gained recent attention in the formulation of the Knowledge Triangle concept (OECD 2016; Unger and Polt 2017). The strategic importance of Higher Education Institutions goes well beyond its role as a supplier of qualified human capital and scientific research—the main contribution of these agents lies within the interactions of its different missions (Meissner and Shmatko 2017). In this regard, bidirectional flows of knowledge occupy a critical position. For instance, we can illustrate this rationale by stating: (1) the relationship between education and innovation through the promotion of entrepreneurial activity; and (2) the inverse relationship, i.e., impacts of innovation on education like the introduction of faculty with industrial experience in academic environments (Cervantes 2017). This is critical for emerging and transition countries—those in search for technology upgrading. These economies often lack adequate knowledge infrastructures able to feed the economic system with skills and ideas necessary to attain higher levels of productivity.

Aiming at contributing to this debate from a new perspective, this chapter addresses the evolution of universities' embeddedness within the innovation system of an emerging economy. We explore the evolution of academic patenting and linkages to industry—a cornerstone of connections innovation and research spheres of the knowledge triangle—over the past decades and how these dynamics may fit into technology upgrading processes in an emerging economy: Brazil. As it is known, the role played by universities within National Innovation Systems varies over time and across countries at different stages of development (Kruss et al. 2015), making such an approach a fundamental step in understanding the trajectory of the Brazilian Innovation System—as well as drawing implications for countries in similar stages of development.

5.2 Technology Upgrading and Knowledge Triangle

Middle-income traps consist of a state of growth decelerations following periods of sustained increases in per capita income (Gill et al. 2007). This situation is a function of the exhaustion of imitative strategy opportunities and low value-added production. As income levels rise, international price-based competitiveness decreases. A key aspect in this discussion concerns the inability of middle-income countries to generate sufficient levels of innovative capabilities and product differentiation in international markets. Eventually, gains from the exploitation of low-cost resources (typically labor and natural resources) and imitation of foreign technologies are exhausted, requiring a productive shift toward high value-added activities for sustaining growth (Perez-Sebastian 2007).

In this regard, technological knowledge from advanced economies represents a strategic asset for emerging economies' evolutionary trajectories (Gerschenkron 1962). However, traditional approaches have rarely emphasized the barriers faced by developing countries in the generation of technological capabilities (Lall 1992). This implies that innovations generated in advanced nations should be appropriated in developing economies at low costs and that some level of convergence should be attained over the long run. But a closer look at catching-up processes reveals that convergence is conditional on the capability of absorbing and diffusing frontier technologies from advanced markets (Abramovitz 1986). In order for these conditions to materialize, catching-up economies must be able to promote the development of learning capabilities (Dahlman et al. 1987).

Distinct analytical approaches have been directed toward the catching-up processes of developing and emerging nations. Key items of interest include participation in Global Value Chains as a transmission channel of knowledge (Ernst and Kim 2002), complexity of economic structures (Hidalgo and Hausmann 2009; Krüger 2008), dynamic specialization toward emerging technologies (Radosevic and Yoruk 2014), and sequential upgrading based on leading sectors (Ozawa 2009), among others. Jindra et al. (2015) have summed up these arguments in three dimensions of technology upgrading processes in order to address the evolution of value-added within emerging economies:

(a) *Intensity of Technology Upgrading*: A vector of technology acquisition strategies conditional upon countries' current technological capabilities.
(b) *Breadth of Technology Upgrading*: Structural factors connected to the dynamics of technology upgrading, such as infrastructure, structural features of productive systems, and firm-level capabilities.
(c) *Interaction with the Global Economy*: International interconnectedness that is embedded in knowledge flows, highlighting interdependencies across different nations and technological systems.

The overarching argument behind these dimensions resides in technological capabilities and human capital (Stokey 2015). The reasoning is that human capital, along with broader structural changes, influences innovation rates, and driving up sophistication of production and exports. As previously outlined, a socioeconomic environment that tackles these challenges comprises several distinct elements. One of the key players in these dynamics is the academic system (Mazzoleni and Nelson 2007). The next section discusses how and to what extent universities can influence technology upgrading trajectories as a means for catching-up.

5.2.1 Universities as Agents of Technology Upgrading

From a systems perspective, several organizations interact with one another to contribute to the construction of technological capabilities (Bergek et al. 2008; Cohen et al. 2002; Nelson 1993; Yoon 2015). Academic institutions are central agents in these evolutionary processes due to their ability to create and deploy knowledge (Bercovitz and Feldman 2006). This is mainly a function of the fact that universities operate as sources of aggregate industrial competitiveness and brokers' of international knowledge to domestic industries (Rosenberg and Nelson 1994).

A traditional pillar of this knowledge transmission comes in the form of human capital. Tertiary education has been perceived as a strategic vector of developing countries' growth trajectories, supplying economic systems with advanced skills (Bercovitz and Feldman 2006). Education, however, provides a limited interpretation on how universities interact with innovation systems and disseminate capabilities. The role of the university as a supplier of human resources has been extended to include joint R&D projects and other forms of technology transfer (Etzkowitz and Leydesdorff 2000), such as spin-offs, patents, licenses, and consulting activities (Mazzoleni and Nelson 2007; Kergroach et al. 2018, Meissner et al. 2018).

These mechanisms of technology and knowledge transfer are key components of the Knowledge Triangle analytical framework (Unger and Polt 2017; Cervantes and Meissner 2014). However, they should not be taken as independent, separate dimensions, but rather as parts of a holistic perspective in terms of policy goals at both the national and the institutional levels—the target being one of building platforms to promote a closer integration between education, research, and innovation (OECD 2016). Examples coming from Germany, Sweden, and Norway highlight how these three missions are increasingly embedded in governmental discourse and academic practices.

A successful case of these dynamics taking place in a catch-up context is that of the Taiwanese chip industry, where universities acted as strategic patenting and licensing agents (Lee and Yoon 2010). Also, increasing levels of collaboration between academia and industry have been identified as a mechanism to enhance the productivity of the Chinese innovation system and help it develop the necessary capabilities to move past the middle-income status (Liu et al. 2017).

While this discussion is also of interest to developed economies, we argue herein for the critical importance to emerging nations. First, universities form part of innovation systems, being able to influence rates of catching-up in developing country firms (Lee and Malerba 2017). Second, considering the incipient nature of innovation systems in these countries (Albuquerque 1999), universities play a critical role in shaping overall firm capabilities (Suzigan et al. 2009). Dahlman et al. (1987) have proposed that institutions dedicated to research, education, and training can play the role of specialized technological agents in developing countries' evolutionary processes. In the same vein, universities in emerging economies can function as "antennae" for scientific and technological evolutions created in leading innovation systems (Kruss et al. 2015). Therefore, outcomes of academic research—coupled with stronger incentives for university R&D—can assist in reducing domestic dependence on foreign sources of technology and promoting the development of domestic capabilities (Chang et al. 2016).

Nevertheless, recent evidence (Fischer et al. 2017) points out that developing countries demonstrate weak participation of universities in the economic structure, indicating barriers for technology upgrading and to build an effective knowledge triangle. This implies that the mere presence of key agents in innovation systems is insufficient and that systemic interactions matter. The nature, the quality, and the content of relationships involving education, research, and innovation ultimately determine systems' performance (OECD 2016). This feature underscores the importance of such relationships and the existence of bidirectional flows of knowledge among different agents of the Knowledge Triangle (Cervantes 2017; Sjoer et al. 2016). Still, there is insufficient knowledge on how universities in emerging nations are connected to developing countries' productive systems (Suzigan et al. 2009). This provides the motivation for the present analysis.

5.3 Analytical Approach

We analyze university–industry interactions in Brazil, focusing on the technological activity of the twelve most distinguished research-oriented Higher Education Institutions (HEIs) in the country. Since research quality significantly affects the university's ability to engage with nonuniversity actors (Laursen et al. 2011), dealing with the leading academic institutions is appropriate for assessing university–industry interaction patterns.

Next, we turn to university patenting activity. Even though patents have definite limitations as proxies of catch-up conditions, they represent a useful analytical tool. The top-12 Brazilian universities in terms of academic excellence are responsible for the bulk of academic patents in the country. Restraining the sample to the more usual "top-10" approach would lead to the exclusion of two relevant universities in terms of patenting activity. Other universities not included in our sample presented only marginal contributions to the overall picture of technological development.

In order to develop a description of the participation of Brazilian universities to technological upgrading intensity, breadth, and interaction with the global economy, we assess: (1) domestic and international patents, (2) field and technological domains, and (3) networks of assignee/applicant. Data were obtained from Orbit Intelligence. A total of 807 patent applications with participation of at least one of the twelve focal institutions were analyzed for three periods: 1994, 2004, and 2014. Searches were performed for each individual university taking into account application assignees. For each patent, we collected information on the office of application, IPC (International Patent Classification), and co-assignees. Table 5.1 summarizes the overall quantity of patent applications for each university/year of interest. It is worth noticing the substantial increment over the years in terms of patent

Table 5.1 Patent applications for each University/Year

University	Acronym	1994	2004	2014
University of São Paulo	USP	3	39	112
University of Campinas	UNICAMP	8	73	83
Federal University of Rio de Janeiro	UFRJ	0	35	35
State University of São Paulo	UNESP	1	9	42
Federal University of Rio Grande do Sul	UFRGS	0	13	47
Federal University of Minas Gerais	UFMG	0	26	89
Federal University of São Paulo	UNIFESP	0	1	0
Federal University of Santa Catarina	UFSC	0	3	20
Federal University of Paraná	UFPR	0	6	65
Federal University of Pernambuco	UFPE	0	7	26
Federal University of São Carlos	UFSCAR	0	7	30
University of Brasília	UnB	0	1	26
	Total	12	220	575

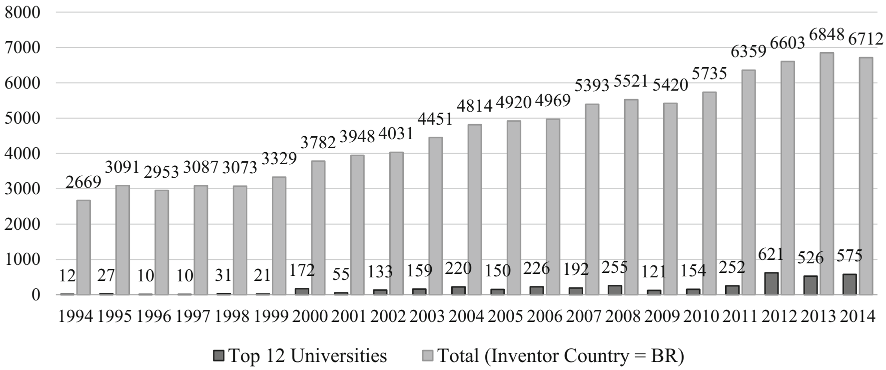
applications from academic units included in the sample (with the exception of the Federal University of São Paulo).

The next step in our exploratory exercise consisted of schematizing the obtained dataset for university–industry interactions, a measure of academic embeddedness in domestic productive structures and international knowledge networks. We use Social Network Analysis (SNA) for this purpose, focusing on co-patenting data as proxy of interactions between universities and industry (a vector of both knowledge creation and dissemination within the productive system). Co-patenting refers to patents applied for by two or more agents. Generally, this is a sign of cooperative innovative activity. Our panel data consists of cross-section across twelve universities and longitudinal for years 1994, 2004, and 2014, allowing for structural trends and shifts in social ties related to co-patenting over the last decades.

Lastly, we cast the discussion of findings within the evolving institutional context of the Brazilian innovation system during the 20-year period (1994–2014) to address how it affects university embeddedness in technology upgrading dynamics. We also extend our argument to the larger population of Brazilian firms, and how they perceive the participation of academic institutions within the innovation environment. To do so we use descriptive statistics from the Brazilian Innovation Survey (PINTEC).

5.4 Empirical Evidence

The first step in our assessment develops a closer look at the top twelve research-oriented universities in Brazil with particular emphasis on the evolution of their patenting activity over the 20 years period. The purpose is to detect behavioral patterns concerning the extent to which these institutions participate in processes



Graph 5.1 Participation of top 12 Brazilian universities in total patenting activity (1994–2014)

related to knowledge generation and deployment. Correspondingly, we look into academic patenting and university–industry co-patenting indicators.

A first description of the sample is offered in Graph 5.1, presenting the weight of the top 12 Brazilian universities in total patenting activity (domestic and international applications) with at least one Brazilian resident on the list of inventors. There are clear indications that the most preeminent research-oriented universities in Brazil are responsible for a substantial amount of patenting activity in the country. According to the Brazilian Patent Office (INPI), six among the ten most active players in terms of patent generation are universities. The top 12 academic institutions have enhanced their share of patenting from 0.45% in 1994 to 8.57% in 2014 (patents with at least one Brazilian inventor). To put this in perspective, the participation of the total population of universities in patenting activity in the European Union is around 4%, while in the United States this number goes up to 6% (Malerba et al. 2016). Hence, the analysis of the Brazilian sample of key institutions reveals a different picture in terms of academic weight in total patenting activity. This feature corroborates with the expectation that universities in Brazil are strategic agents in the technology upgrading process.

5.4.1 Brazilian Universities and the Dimensions of Technology Upgrading

The next step in our analysis consists in organizing the top twelve Brazilian universities' data on patents according to the established measures of technology upgrading (Jindra et al. 2015). We look at domestic and international patents, technology fields, and networks of inventors. Table 5.2 provides an introductory description of these dimensions.

The patenting behavior of the twelve top-ranked research universities in Brazil indicates a rather domestic-oriented focus. Academic co-patenting is also strongly inward oriented, lacking connections with agents abroad and with multinational

Table 5.2 Top 12 university patenting: technology fields, international engagement

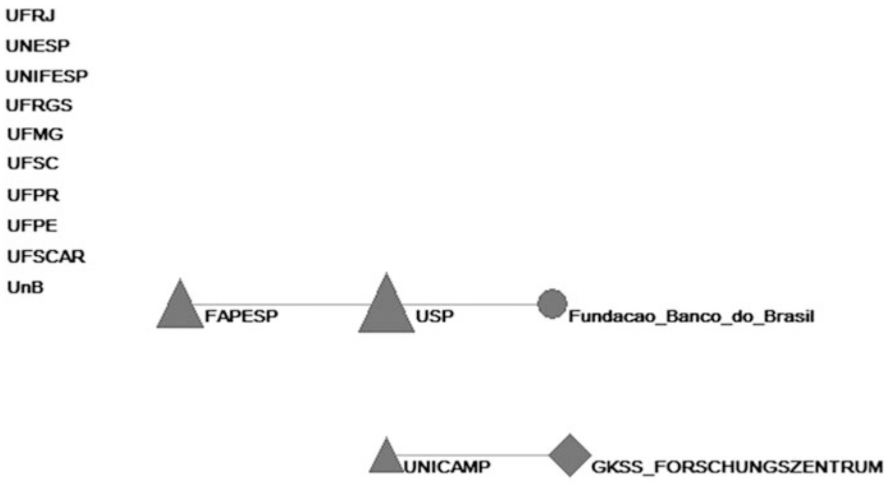
Technology upgrading	1994	2004	2014
Intensity of technology upgrading			
Domestic	11	200	494
International	1	20	81
Breadth of technology upgrading			
Field and technological domains (IPC-code)[a]			
Human necessities	5	93	258
Performing operations, transporting	1	27	92
Chemistry, metallurgy	5	98	214
Textiles, paper	1	2	7
Fixed constructions	0	6	11
Mechanical engineering, lighting, heating, weapons, blasting	0	3	6
Physics	1	35	81
Electricity	0	19	29
Herfindahl-Hirschman Index (HHI)[ba]	0.796	0.181	0.178
Interactions with the global economy			
Co-patents	3	47	203
International co-patents[c]	1	7	21

Notes: [a]Some patents do not have information on technological domains, while others are assigned to more than one area of knowledge
[b]HHI was calculated based on the subfield of technological domains containing the 23 subareas with patenting activity for our sample
[c]This indicator represents only how many co-patents were deposited with international partners. However, the number of interactions may differ from this data because each application could consist in multiple interactions

enterprises with subsidiaries in the country. These are capped with a low degree of diversification in the application of patents. Inventions are concentrated in only two broad technological domains: Human Necessities and Chemistry and Metallurgy. However, when technological subareas are introduced in the analysis, the Herfindahl-Hirschman Index demonstrates a relative deconcentration process in patenting activity: technological concentration reduces from 0.796 in 1994 to 0.178 in 2014. We see here indications of slow pace of improvement of technological activity, relatively low levels of interaction with the global economy, and gradual deconcentration in terms of technology fields, a picture of the struggle to engage in catching-up processes (Lee 2013).

5.4.2 A Social Network Perspective on Academic Patenting in Brazil

The next step consists in social network analysis of co-patenting relationships involving our focal group of Brazilian universities. Emphasis here resides in the characteristics of connections, i.e., the nature of agents (companies, other universities, research institutes, and research support institutions) and their

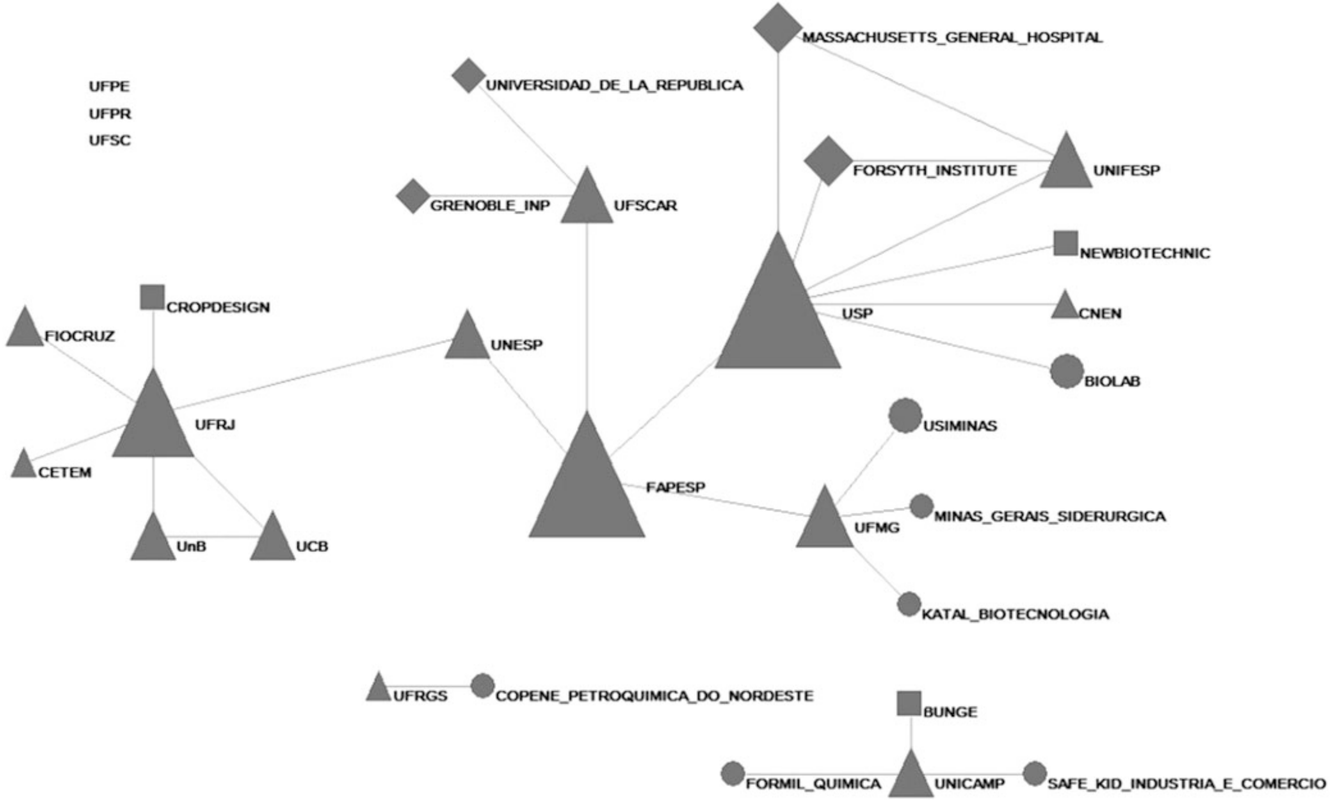


Graph 5.2 Network of patent collaborations established by the top 12 Brazilian universities—1994. (Note: Triangles comprehend domestic Universities and Research Foundations & Institutions. Diamonds identify these same agents that are located abroad. Circles represent Brazilian firms. Boxes stand for multinational companies with subsidiaries in Brazil and foreign corporations)

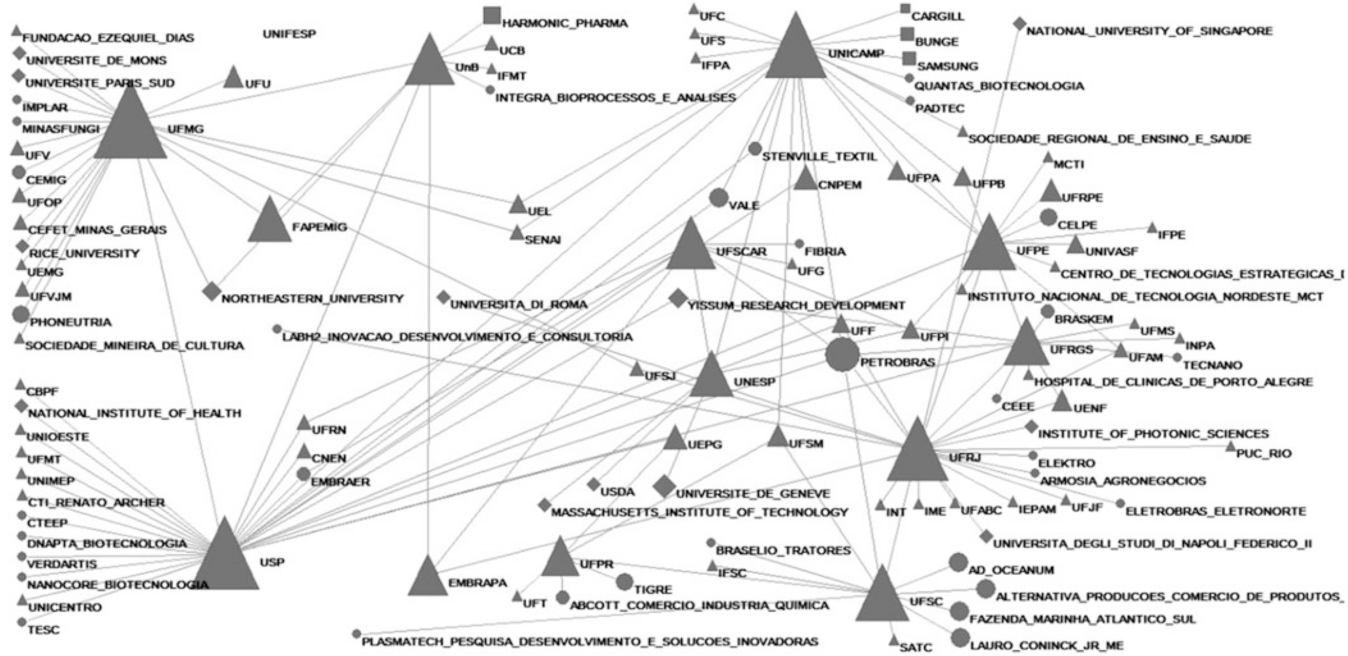
respective origin (domestic, multinational subsidiaries, or foreign entities). In the following representation of networks, the size of symbols reflects the degree centrality of each agent (absolute number of collaboration in patent applications for each agent).

The dataset reveals that Brazilian universities have increased the level of interaction with industry over time, albeit starting from a very low level (Graphs 5.2, 5.3, and 5.4). There is a growing level of embeddedness of these institutions into patenting networks involving firms over the specific time period. Back in 1994 U–I co-patenting networks barely existed, reflecting the small numbers in overall patents with university applicants that year (twelve in total). The only institutions among the top 12 academic units examined were the University of São Paulo (USP) and the University of Campinas (UNICAMP). The latter was the sole agent to engage in transnational patenting activity.

Ten years later (2004), we observe that only three of the twelve institutions are left out of co-patenting activity. Still, even if this network appears to be denser, interactions with multinational companies and other agents located abroad are marginal: three Multinationals and four Universities and Research Foundations and Institutions located abroad are included in Graph 5.3. The central role played by the São Paulo Research Foundation (FAPESP) must be highlighted, interacting not only with universities from its own state (São Paulo) but also with the Federal University of Minas Gerais (UFMG). This foundation is the institution responsible for financial support for science, technology, and innovation in the State of São Paulo, acting as a key player in sustaining high-quality research in several



Graph 5.3 Network of patent collaborations established by the top 12 Brazilian universities—2004. (Note: Triangles comprehend domestic Universities and Research Foundations & Institutions. Diamonds identify these same agents that are located abroad. Circles represent Brazilian firms. Boxes stand for multinational companies with subsidiaries in Brazil and foreign corporations)



Graph 5.4 Network of patent collaborations established by the top 12 Brazilian universities—2014. (Note: Triangles comprehend domestic Universities and Research Foundations & Institutions. Diamonds identify these same agents that are located abroad. Circles represent Brazilian firms. Boxes stand for multinational companies with subsidiaries in Brazil and foreign corporations)

universities across the Southeast region. As its budget is dependent on value-added taxes of the richest state in Brazil, FAPESP has a substantial amount of resources to invest, thus shaping a rich environment for academic institutions in the State of São Paulo. Five out of our twelve focal institutions are located in this particular State.

The 2014 network is clearly much denser than what was observed for previous periods. Only one university (UNIFESP) in our sample did not involve in co-patenting activity that year. Over the past couple of decades, then, the role of Brazilian academic institutions as central agents in processes involved in the production and deployment of knowledge has advanced significantly. The University of São Paulo (USP), the University of Campinas (UNICAMP), the Federal University of Rio de Janeiro (UFRJ), and the Federal University of Minas Gerais (UFMG) stand out in terms of interactions in patenting activity. However, only 25 out of 268 identified collaborations are related to multinational corporations or other foreign entities. The remaining 243 interactions are with domestic agents. This is a manifestation of the domestic orientation of Brazilian academia, underscoring its difficulty in participating in international knowledge flows—particularly those originating in advanced economies.

5.5 Understanding the Institutional Framework

The institutional context can help clarify the empirical appraisal of data. A key point of interest concerns the evolving institutional framework for university–industry (U–I) linkages in Brazil, a central issue in the discussion of the necessary settings for technology upgrading (Lee and Malerba 2017). Our assessment (1994, 2004, and 2014) covers a rich period of changes in the Brazilian innovation policy landscape. A first institutional landmark concerns a major revision of the intellectual property law in 1996 (Law 9279/96). The improved regulatory mechanism enhanced the institutional stability for filing patents in Brazil by incorporating issues contained in the TRIPS agreement and created a stronger appropriability regime that benefitted technology markets in the country (Ryan 2010). Better intellectual property protection has been associated in the literature with positive incentives to collaborate in research.

As Ryan (2010; p. 1084) puts it, "*Brazilian technocrats in science and technology funding agencies and research universities recall that in the 1990s they realized that Brazil had great science but little technology innovation*." Albuquerque (1999) found in this situation signs of immaturity of the National Innovation System. In the late 1990s, FAPESP started providing financial support for collaborative R&D between academic institutions and firms (Alves et al. 2015). Known for its pioneering initiatives, FAPESP functioned as a benchmark for funding agencies across the country. But it was not until 2004 that the Federal Government included University–Industry linkages as a pillar for innovation policy. Since that year, industrial policies have prioritized closer interaction between academia and the private sector. This approach was embraced by the Industrial, Technological, and Trade Policy (PITCE 2004–2008), and it remains a core axis of the current National

Strategy for Science, Technology, and Innovation (2016–2022). In practical terms, this has resulted in several initiatives that facilitated the approximation of companies to the S&T infrastructure.

In a similar vein, and inspired by the Bayh-Dole Act in the United States, the Brazilian Innovation Act of 2004 set the regulatory framework to guide technology transfer processes from academia. This regulatory framework also includes the creation of research infrastructure in public universities that can be shared with companies in collaborative projects with universities (Santos and Torkomian 2013). Positive effects of the Innovation Act of 2004 in terms of overall academic patenting (Santos and Mello 2009) and for U–I cooperation, leading to stronger innovative capabilities in companies, have been reported (Dewes et al. 2015). This is not to say that all challenges have been resolved, including institutional weaknesses in U–I agreements mainly a function of inexperienced governance of university technology transfer offices (TTOs) (Alves et al. 2015) and high levels of bureaucratic barriers in public universities and research institutes (Freitas et al. 2013). This situation perpetuates informal agreements (Dewes et al. 2015). Such “teething” problems are not unique to Brazil, of course. In its first decade, the Bayh-Dole Act did not generate significant results in terms of getting academia closer to industry, except for some specific “superstar” outliers (Nelsen 2004). The system was also underlined by deep mistrust between the two sides (Hertzfeld et al. 2006).

Subsequent discussions between government, academia, and industry over a period of five years led to updates of the Innovation Act of 2004 via a new institutional framework in 2016 (Law 13,243/2016, also known as STI Legal Framework) to further facilitate linkages between academia and industry. The new legal framework further regulates the participation of academics in firms’ in-house projects, as well as the use of university laboratories and facilities by industry. It also adds flexibility to the ownership of IP rights. According to the Innovation Act of 2004, these assets belonged to universities and they could only license it via public bids. Impacts of these new regulations should be felt in upcoming years.

Several additional programs directed toward fostering linkages between universities and firms are also worth mentioning. Law 11.196/2005—commonly referred to as *Lei do Bem* (Good Law)—instituted R&D tax deductions for companies, also including joint projects with universities. Launched in 2007, the Brazilian Technology System (Sibratec) aims at coordinating relationships between academia, research institutes, and firms through collaborative innovation centers and subsidies for joint technological development. Embrapii (Brazilian National Association for Industrial Research and Innovation), a public enterprise, was created in 2013 to foster innovation-oriented U–I collaborative projects. Embrapii’s current structure consists of 28 research centers, 23 of which are located in the same regional ecosystems of the majority of our 12 universities (South/Southeast). Main expectations involve technology transfer as a means to generate and strengthen innovative capabilities in firms.

Lastly, we can mention the National Funds for Science and Technology Development (FNDCT). These funds were originally established in the period 1999–2002 to foster competitiveness in Brazilian firms by financing projects that bring together universities, research institutes, and firms (Cimoli et al. 2005). Thus, as the implementation of these funds involves academia and industry, the structure of FNDCT promotes proximity among these different agents of the Brazilian innovation system. The budget relies on federal taxes, compulsory contributions from firms benefitted by fiscal incentives, royalties from exploitation of public infrastructure and natural resources, donations, and loans. These funds involve priority sectors and transversal actions. Priority sectors are oil and gas, agribusiness, aeronautics, shipbuilding, biotechnology, water resources, ICT, mining, health, and land transportation. Among the transversal actions, the Green-Yellow Fund, established in 2000, deserves attention. It is exclusively oriented toward fomenting U–I linkages. As a general overview, these sectoral and transversal funds provide financial stability for the innovation system, setting the stage for stronger connections between firms and academia.

Two further issues deserve attention regarding U–I linkages in Brazil. The first concerns the apparent short-termism of research projects which tend to focus on solving the immediate technical problems of the industrial partners. The second concerns that such projects are concentrated in low and medium-tech sectors (Albuquerque et al. 2015). An explanation for the lack of long-term projects may be the predominance of multinational companies in high-tech sectors in Brazil which are primarily interested in adapting their products and processes to the local market while remaining only marginally involved in longer-term innovation activities locally. Another explanation may be that, with some notable exceptions, domestic companies that have significant resources for research tend to be in mature industries with slow-moving technological trajectories.

Despite the institutional evolution of the innovation system in Brazil in the direction of strengthening the interaction between university and industry, universities are still regarded as marginally important by the private sector regarding its innovative processes. On the upside, data from the Brazilian Innovation Survey (PINTEC) shows an intensification of U–I interactions (Table 5.3).

Nonetheless, the share of firms developing joint R&D-oriented activities—instead of technical, training, and consulting forms of cooperation—has not increased. More troubling is that the large majority of firms involved in collaborative processes view Brazilian universities as of low relevance for their innovative strategies (a constant trend over time). As a result, the persistent chasm between academia and industry hampers a faster diffusion of knowledge in the country, arguably affecting technology upgrading processes (Britto et al. 2015).

5.6 Concluding Remarks

Starting from the proposition that universities play a strategic role in technology upgrading dynamics, this chapter has addressed the embeddedness of higher education institutions in the Brazilian National Innovation System. Implications of this analysis should help to guiding institutional adjustments that promote the integration of a broader spectrum of research-oriented universities into national and global value

Table 5.3 Brazilian Innovation Survey (PINTEC): UIC trends in Brazil from companies' perspective

PINTEC	Total companies in the survey	Innovative companies	Companies with collaborative processes	Companies with UIC	UIC Object(only companies with UIC)		UIC importance (companies with collaborative processes)		
					R&D activities	Others	High	Medium	Low/No relevan.
2003	84,262	28,036	1052 (3.76%)	551 (1.96%)	360 (65.3%)	191 (34.7%)	188 (17.9%)	124 (11.8%)	740 (70.3%)
2005	91,055	30,377	2194 (7.22%)	777 (2.56%)	341 (43.9%)	436 (56.1%)	432 (19.7%)	256 (11.7%)	1506 (68.6%)
2008	106,822	41,223	4248 (10.31%)	1759 (4.27%)	1028 (58.4%)	732 (41.6%)	829 (19.5%)	477 (11.2%)	2942 (69.3%)
2011	128,699	45,950	7694 (16.74%)	3405 (7.41%)	1850 (54.3%)	1555 (45.7%)	1431 (18.6%)	826 (10.7%)	5437 (70.7%)
2014	132,529	47,693	7299 (15.30%)	3432 (7.20%)	1882 (54.8%)	1551 (45.2%)	1098 (15.0%)	840 (11.5%)	5361 (73.5%)

chains. Closer interaction of academia with productive systems is anticipated to boost the intensity and breadth of technology upgrading and innovative activity (Caraça et al. 2009; Cohen et al. 2002). In turn, universities may disseminate this knowledge back to industry via improved education and human capital better attuned to technology transfer activities as highlighted in the knowledge triangle framework.

As shown by the patent data in this paper, the evolution of the Brazilian regulatory system over time toward closer U–I cooperation has not yet been translated into extensive integration of the two parties. Despite the rate of improvement, connections with international value chains are especially lacking. To conclude our analysis, we propose the following remarks:

(a) **Reaching the next level is not a straightforward process that happens mechanically**: Technology upgrading takes place slowly and depends on adequate market and institutional settings (Radosevic and Yoruk 2014). To include universities as central agents in this process can be a strategic step for innovation policy, but it involves systemic coordination and paradigm shifts in the way academia is perceived (by itself and by external agents) in Brazil and other developing economies.

(b) **The predominance of firms with weak technological competences in the country increases the strategic importance of universities.** Based on studies of successful cases, previous assessments have related academic institutions in Brazil to the development of new technologies and knowledge transfer to firms (Mazzoleni and Nelson 2007; Suzigan and Albuquerque 2011; Suzigan et al. 2009). A typical case in point is the emergence of Embraer in Brazil and its long-term reliance on close collaboration with universities and public research centers (Mazzoleni and Nelson 2007). Another is the profound success of the agricultural sector during the past few decades and its extensive reliance on public agencies like EMBRAPA as well as a very extensive network of public research institutes and university departments around the country dedicated to its efforts for technological upgrading. A third example is the extensive international presence of the country in food processing and extractive industries where very significant technological advancement has taken place. Yet, as observed by Lee (2013), there remains a relative disconnect between academia in industry in Brazil compared to other catching-up countries, contributing to lower levels of STI development and economic growth (Santos and Torkomian 2013).

(c) **On a positive note, a lot has happened in the two decades since** Albuquerque (1999) **characterized the Brazilian innovation system as immature.** Research-oriented universities have involved more extensively in technology upgrading processes, strengthening linkages with the private sector, and responding to the call for national efforts to close the gap with more developed economies.

(d) **The new STI regulatory framework in Brazil does not include any topic on the Knowledge Triangle approach**. Despite the inclusion of the Knowledge Triangle as a cornerstone in innovation policies in Europe—and the empirical evidence showing this approximation between academic research and innovation capabilities, the Knowledge Triangle perspective is lacking from the Brazilian regulatory framework proposed in 2016. The three components of the KT approach—education, research, and innovation—are still assessed separately by the institutional structure. More than that, relationships and connections between such dimensions are absent from policy directives.

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6 Knowledge Triangles in Dutch Entrepreneurial Ecosystems

Monique Roso, Erik Stam, Georges Romme, and Jan Peter van den Toren

6.1 Introduction

In knowledge-based economies, long-term wealth generation depends not only on human capital and research as separate resources but also on the complementarity between research and human capital in the creation of innovation (Cohen and Levinthal 1990; Qian and Acs 2013) and the feedback effects of innovation into the economy (Aghion et al. 2009). The interaction between education, research and innovation has gained prominence with the "Knowledge Triangle" concept (OECD 2015). In this chapter, we present an explorative study of knowledge triangles of research-education-innovation within Dutch entrepreneurial ecosystems (based on Stam et al. 2016). Knowledge Triangles do not evolve in a vacuum but are part of a

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broader set of interdependent actors and factors that, if coordinated in an adequate way, might enable entrepreneurship within a particular territory. We focus on the role of regional governance (i.e. networks and leadership) in the knowledge triangle and the entrepreneurial ecosystem more broadly. This is reflected in the main question addressed in this chapter: How is the interaction between research [knowledge] and education [talent] coordinated [by networks and leadership] to promote entrepreneurship in regional ecosystems in the Netherlands?

6.2 Theoretical Framework

How do education, research and innovation interact to generate wealth? The generation of knowledge and accumulation of human capital does not automatically lead to innovation. The knowledge spill over theory of entrepreneurship (KSTE) suggests that entrepreneurship provides a crucial mechanism in translating knowledge into new value, and ultimately economic growth (Acs et al. 2005; Audretsch et al. 2006). Entrepreneurship necessarily involves individuals and their response to economic opportunities (Eckhardt and Shane 2003). Not only is the source of opportunities important (knowledge created in organizations), but so is the individual recognizing and commercializing these opportunities. Entrepreneurial opportunities are not exogenously given, but rather endogenously and systematically created under certain conditions; they are the outcome of investments in new knowledge and ideas (Schumpeter 1942; Audretsch et al. 2006) on the one hand, and the accumulation of knowledge in individuals (Shane 2000) and firms (Cohen and Levinthal 1989; Cohen and Levinthal 1990) on the other hand. Prior knowledge enables certain entrepreneurs to be alert to new opportunities (Shane 2000; Kirzner 1973). Both education and experience are therefore needed to absorb the knowledge that can serve as input for the entrepreneurial process (Shane 2000; Qian and Acs 2013). In addition, leadership experience (Stam and Wennberg 2009), the recruitment of talented students (Mian 1996) and experienced personnel (Audretsch and Stephan 1996; Audretsch and Lehmann 2006) are needed to scale up new firms and ventures. Talent, knowledge and experience are thus important resources for entrepreneurial activity in a knowledge-based economy. To accomplish economic growth, the interaction between these elements is critical. The systemic nature of these interactions is captured in two emerging concepts: the knowledge triangle and the entrepreneurial ecosystem.

The knowledge triangle has recently gained prominence in innovation policy thinking of the OECD and the European Commission. The OECD (2015) defines a knowledge triangle as "the interaction of education, research and innovation." The central idea is that creating new knowledge from research and high-quality education in themselves are not enough to gain prosperity and economic growth. New knowledge and talented people need to be linked to innovation. Moreover, the knowledge circulation between these elements (resulting in a learning economy (WRR 2013)) increases their ultimate impact on prosperity. Even though innovation is a multi-player game, a system with a large set of agents involved beyond the focal organization, it ultimately depends on individual action by entrepreneurs. Entrepreneurial action is needed to experiment and reduce the uncertainties arising from the long-term cycle of innovation (Stam and Nooteboom 2011). Different types of entrepreneurship are involved, from entrepreneurs forging radical new combinations to entrepreneurs that realize the first successful applications of these new combinations and entrepreneurs who scale up these initial successes. Further along the cycle of innovation, entrepreneurs are needed to transfer and adapt these innovations to new contexts, potentially leading to radical innovations again.

Each region has a specific context to organize the knowledge triangle. This variety, its causes and consequences can be analyzed by adopting an entrepreneurial ecosystem perspective (Stam 2015). The entrepreneurial ecosystem perspective is related to the innovation system approach, which argues that the quality and interaction of the elements of innovation systems (knowledge, producers, finance, demand) determines the innovation output of the system (Nelson 1993; Edquist 1997; Cooke 2001; Nooteboom and Stam 2008).

Both the entrepreneurial ecosystem and innovation system approach emphasize the systemic nature of innovation. However, agency and especially entrepreneurial action is more central to the entrepreneurial ecosystem approach. An entrepreneurial ecosystem is a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory (Stam and Spigel 2018). Productive entrepreneurship here refers to entrepreneurs creating and exploiting opportunities for innovation in ways that lead to (significant) new value for society.

In this study, we focus on the regional governance of knowledge triangles: interorganizational knowledge networks and leadership via regional economic boards. The knowledge networks are mechanisms for providing connection, whereas leadership involves a mechanism for giving direction. We address these questions of governance in three case studies of the most binding constraints within the ecosystem and the commitment among key stakeholders to invest in projects with collective and long-term returns.

6.3 Case Studies

In researching the functioning of the knowledge triangle in the context of entrepreneurial ecosystems, we selected three cases. Elsewhere, we provide an extensive rationale for the selection of these cases and also describe the data collected for each case study (Stam et al. 2016). The three case studies are: Brainport Eindhoven, Metropolitan Region Amsterdam (MRA), and Twente.

6.3.1 Brainport Eindhoven

The Eindhoven area is one of the most industrialized regions in the Netherlands and has been the home base of multinationals like Philips (electronics), ASML (lithography systems), NXP (semiconductors) and DAF (automotive). Until the end of the nineteenth century, this area was dominated by agriculture. Multinational corporation Royal Philips (founded in 1892 as a light bulb producer) played a very important role in the development of Eindhoven, creating a company town with a tight network of technical suppliers in the region (Engstrand and Stam 2002; Havermans et al. 2008). The concentration of specialized knowledge, labour force and experience provided fertile soil for new technological ventures, like the Philips-ASM International joint venture ASML (founded in 1984). The scaling down of Philips in the 1990s and early 2000s led to divestments which in their own right provided the foundation for many new companies in the high-tech systems sector. The high-tech expertise of the region has led to the area being dubbed "Brainport," as a juxtaposition to the traditional main ports (Rotterdam Seaport and Schiphol Airport) as key assets of the Dutch economy.

In the 1990s, cooperation between industry, government and HEIs intensified due to the possible collapse of the industrial base. Car manufacturer DAF went bankrupt, and Philips had to scale down rapidly. Ten years of cooperation between leaders within government, industry and HEIs led to programmes that were able to revive large parts of the regional manufacturing base by creating new horizons, including new matches between design and technology (Horlings 2014; Schaap and Van Ostaaijen 2015). This culminated in the formal establishment of the Brainport Foundation in 2006.

The Brainport region has a rich history of place-based policies for knowledge development and innovation with a large portfolio of physical campuses: science parks associated with either HEIs (TU/e Science Park), multinationals (ASML), or research institutes (Automotive Campus), but also privately owned locations characterized by open innovation (High Tech Campus Eindhoven, Strijp S). Leading companies—ASML, NXP and Philips—all have a large number of innovation projects in their portfolio and are major players in the national innovation system.

The largest university in the region is Eindhoven University of Technology (5500 bachelor students, 3200 master students, 1500 doctoral students, 2000 academic staff members). The Fontys University of Applied Sciences is the other large higher education institute in the region (44,000 students, of which 15,000 in the Brainport region, 4400 employees). Vocational education and training (VET) is provided by three colleges (21,000 students). When looking at the characteristics of knowledge networks, in the Brainport region, two large OEMs, as well as two HEIs, are central players in the project-based innovation networks.

Dutch regions have a complex layering of coalitions and networks, and Brainport is no exception. The 21 municipalities in the region are organized in the all-government Metropolitan Region Eindhoven (MRE). The board of Brainport Foundation currently includes representatives of (1) all the major higher education institutes and vocational schools in the region, (2) the municipalities, (3) the province, and (4) large firms and industry associations. The board is chaired by the mayor of Eindhoven. Brainport Foundation in 2015 formulated a so-called "adaptive strategy," which does not contain any quantitative long-term objectives but rather aims at continually identifying opportunities to increase the competitive advantage of the region and being flexible enough to exploit them (Brainport 2015).

The Brainport Foundation has an executive organization named Brainport Development, responsible for the international communication strategy of the economic interests of the region, the international human capital agenda, the technology portfolio, and the creation of a favourable investment climate. The organization is funded by each of the stakeholders represented in the board, either in cash or in kind. Brainport Development has organized its initiatives along the lines of societal challenges (like transitions in energy, health and safety): a thematic focus instead of a sectoral focus to create new perspectives for the high-tech sector. The interviewees emphasize that Brainport Development is considered a neutral party, and therefore Brainport managers are often called upon to bring different public and private organizations together.

The Brainport Network seeks to reinforce its collaborative efforts and ambitions with eight other regional development boards elsewhere in the provinces of Noord-Brabant and Limburg. Brainport Industries is a network organization that unites around 300 first, second, and third tier suppliers of original equipment manufacturers (OEMs) in the region to provide its members with one strong voice as well as promote collaboration in order to improve the innovativeness of the companies. A major funding organization for the region is the Brabant Development Agency (BOM), which provides public funds for long-term investment schemes.

All the HEIs have solid ties with technology-driven companies inside and outside the region. At the level of VET, companies help revise the qualifications for their field and provide internships and lecturers for the school. Cooperation is institutionalized in Centres of Expertise (UAS), Centres for Innovative Craftmanship (VET), and academic research programmes, and aligned with the regional strategy. Both types of Centres are temporarily funded (by industry, HEIs, government).

The international companies based in the Brainport region are committed to the functioning of the ecosystem, and all have the capacity for a long-term strategy agenda. They need a continual influx of new knowledge and high-level suppliers. The international OEMs in the region are all high-tech firms, but mostly not direct competitors, which facilitates cooperation. Although they have high standards in terms of business climate, almost all have a long history with the region, making it easier for government and HEIs to come to long-term agreements with the private sector. One interviewee noted that “there seems to be a common goal to keep labour and knowledge beneficial for the region.” Another interviewee noted that “speed is the determinant for success in this sector and since most firms are specialists, collaboration is essential for survival.”

Additionally, the corporate culture of the large specialized suppliers in the region is rather cooperative in nature. Several interviewees noted a revival of this cooperative stance that has cropped during the recent financial crises, which has resulted in the region weathering the recession with minimal losses. This culture fosters many informal meeting moments between private sector leaders in the region, which adds to the quality of the network.

Overall, the governance of the Brainport ecosystem and knowledge triangle entails:

An orchestrating university that through its students, resources and research actively transfers knowledge to firms in the region and initiates, facilitates and completes projects that aim to improve the knowledge triangle.
An active network organization that facilitates the collaboration between public and private parties and aligns initiatives with the strengths of the region, but deliberately spins out these initiatives (if they are viable) to new or existing organizations.
A tightly knit high-tech community of OEMs and specialized suppliers that are willing to collaborate with competitors and partners in their value chains.

The organizations within the Brainport region perceive several constraints in the further development of the ecosystem:

The development speed in the high-tech sector far outpaces the renewal of educational qualifications, creating a larger gap between education and professional requirements.
A growing shortage of engineers and developers, who also prefer jobs at large OEMs instead of SMEs.
International enterprises in the region place higher demands on infrastructure, which is currently underdeveloped for the future.
The ecosystem is very dependent on a small number of large manufacturers.
Research and innovation funding becomes increasingly complex and tight for HEIs and companies alike.
The public–private partnerships that have been established by HEIs, such as Centres of Expertise, have yet to find a sustainable business model and meanwhile continue to lean on government funding.

6.3.2 Metropolitan Region Amsterdam (MRA)

The economic strength and diversity of the Amsterdam region go back to the sixteenth century, when international trade, finance and transport (shipping) intertwined to create the base for prosperity. The city of Amsterdam enjoyed strong economic recovery during the last twenty years, following a decline in inhabitants and economic growth during the 1960s and 1970s. The economic structure of the city of Amsterdam largely depends on professional services (including financial services, marketing agencies, IT-services), transport, wholesale and creative industries. The larger MRA has a more diversified economic structure, including food processing industry, steel manufacturing, manufacturing of metal products and machinery, logistics, broadcasting and high-tech horticulture (Metropoolregio Amsterdam 2016).

The MRA has an abundance of business locations with a strong signature, including central business districts, creative campuses and start-up hotspots. Academic campuses and campuses for applied research are scattered around the city.

The ecosystem in the MRA includes a large number of institutes for higher education. The most important institutes are the University of Amsterdam (30,000 students), the Free University 23,000 students) and the Amsterdam University of Applied Science (50,000 students). The second University of Applied Science is InHolland, with four locations in the MRA (15,000 students). The largest institute for vocational education and training is the ROC of Amsterdam (36,000 students). The Amsterdam HEIs count more than 100,000 students (which is 12% of all Dutch students at universities for applied science and 22% of all Dutch university students). It is the largest concentration of students in the Netherlands. The formal knowledge networks in Amsterdam are dominated by a larger set of HEIs.

The MRA includes 36 municipalities, two provinces and the regional authority. The coordination of regional economic policy is executed by the all-government Platform Regional Economic Structure (PRES). PRES oversees several organizations dedicated to separate tasks: IAmsterdam (international marketing), Amsterdam in Business (foreign direct investment), Plabeka (Platform for the planning of business and office locations), and the Amsterdam Economic Board (triple helix collaboration for innovation).

The Amsterdam Economic Board (AEB) was established in 2010, as the offspring of the Kenniskring Amsterdam (1994) and the Amsterdam Innovation Motor (2004). As a form of triple helix cooperation, the AEB aimed to invigorate the competitiveness of seven (and later eight) industrial clusters in the metropolitan area and guarantee future competitive advantages for the Amsterdam region. The AEB has 20 members and is chaired by the mayor of the City of Amsterdam. The AEB has been able to build upon existing networks and social capital. Part of the structure of AEB is the Amsterdam Network Council (paid membership, uniting nearly 150 influencers from large corporations, governments and knowledge institutes), and Young on Board (functioning as a liaison between young professionals and AEB).

There are different perspectives on the level of commitment of leading firms. Key actors from regional industrial clusters (like logistics, horticulture) are active members of the AEB. Financial services, an important sector in the Amsterdam economy, are not represented directly. The connections between the start-up community and the AEB is indirect. One interviewee observed that “for start-ups there appear to be other focal points like [the accelerators] Rockstart and StartupBootcamp.” It has turned out to be difficult to connect with and get the commitment of SMEs in all sectors stretching from creative industries to manufacturing. There are different levels of commitment of HEIs as well. Amsterdam universities have less staff engaged in business interaction and knowledge transfer than other European universities that have excelled in these areas (BiGGAR Economics 2014). Representatives from knowledge-intensive new industries, like fintech, have identified large gaps between HEIs and their community in terms of quality of education, the development of new, interdisciplinary knowledge and understanding the needs of new industries. The presence of two universities enhances competition, even where collaboration to set up new programmes would be more appropriate and efficient. Interviewees from HEIs and SMEs share the opinion that research universities and universities of applied science should bridge their different views on education to provide better programmes for both students and industry. The broadly supported Human Capital Agenda aims to reduce the lack of efficiency in vocational education and turn competition between institutes into more tailor-made education in Amsterdam and its surroundings.

There is a strong commitment of local and regional governments to the AEB. At the start, the AEB could build upon the fundament of the seasoned all-government platform PRES. The AEB extended this cooperation to HEIs and enterprises. There is consensus on the importance of the City of Amsterdam, for example with regard to funding and staffing: "without the City of Amsterdam, the AEB would not have existed." Also, the energy and commitment of individual members of the Amsterdam city council are widely praised. The human capital agenda is a successful example of a broadly supported, promising and collective policy agenda for a better match of supply and demand on the labour market. On the other hand, there are several programmes that have been initiated by the City of Amsterdam but are not part of the agenda of the AEB, like the local start-up policy programme Start-up Amsterdam.

The AEB has recently seen a major change in strategy, organization and approach. The industrial cluster approach has been abandoned. Instead, five societal challenges have been formulated to mobilize SMEs, corporates, HEIs and governments into joint action. As a consequence, also the aim to remove institutional obstacles for industrial cluster development and business development more broadly (one of the initial goals of the AEB) has been transferred to other parties (municipalities and industry organizations). Initiatives and projects will be judged on "semi-commercial" criteria (feasibility, scalability, competitive advantage). A relevant barrier to overcome, is the lack of commitment of partners, within and close to the Board, to actively take the lead in projects and programmes. A new strategy has been crafted to address this problem. When looking at the dominant industries in the MRA, the question might be to what extent HEIs add to innovation in these sectors beyond the (one-way) delivery of human capital. In this sense, the conclusion of the OECD (2010) in 2010 still stands: "To reach its potential Amsterdam can and should make better use of the two legs it has to stand on: a strong knowledge base and strong businesses. Amsterdam's problem is that it has too many strengths." The results from the network analyses on innovation projects confirm this statement (Stam et al. 2016). The large set of HEIs in Amsterdam provides a strong base in terms of the scale of both human capital and knowledge, but at the same time, it appears difficult to align the HEIs to the needs of the highly diversified business community.

Overall, the governance of the MRA has to deal with a highly diversified economic structure and strong entrepreneurial dynamics:

The governance appears to have become increasingly adapted to the diverse structure of the regional economy, moving its focus from industrial clusters to societal challenges, a turn that paves the way to cross-sectoral innovations and open innovation strategies.

The ecosystem seems to be largely driven by self-organization, without firm guidance or steering by the AEB.

The board has especially been successful in making sense of a shared vision on the ecosystem and providing a platform for collective action in particular niches.

The most binding constraints of this governance system appear to be:

The lack of connections of start-up communities with the AEB and the ensuing limited entrepreneurial leadership in the entrepreneurial ecosystem.

The lack of entrepreneurial leadership might also be an obstacle in the necessary adaptation of educational programmes—although there are some good examples of industry-led educational changes.

The wide variety of governmental actors (municipalities, regional authorities, two provinces) carries the risk of slowing down effective governance and collective action. In that sense, the recent collective policy agenda for the MRA might be considered a milestone.

However, the MRA region appears to have a well-developed capacity for bottom-up self-organization, enabled by the density of entrepreneurial individuals and the density and diversity of ventures, skills and human talent. As a result, the constraints previously listed might not be very binding for the performance of the region.

6.3.3 Twente

The region of Twente is located on the eastern border with Germany. Until the first half of the twentieth century, the textile and related industries (machine manufacturing, construction) constituted the primary economic pillar of the Twente region. As of the 1950s, however, the textile industry in Twente suffered from a structural decline. This led to a decrease of 80% in employment in the textile industry in the period 1955–1980, a loss of about 40,000 jobs (Sijgers et al. 2005). Therefore, key agents from industry and local government started lobbying for academic education, which resulted in the establishment of the new University of Twente in 1964. As of the 1980s, investments in higher education, as well as substantial support from European funds, helped the Twente region to somewhat recover from its decline in preceding decades. But overall, the economic structure of Twente is still relatively weak in terms of the educational level of its population as well as R&D and innovation expenditures.

The Twente ecosystem includes two institutes of higher education: the University of Twente (10,000 students) and Saxion University of Applied Sciences (26,000 students). All intermediate vocational education is offered by the ROC Twente (18,000 students).

Important agents and bodies in Twente's ecosystem are the City of Enschede; Region of Twente (all-government platform with 14 municipalities); Province of Overijssel; Technologie Kring Twente (informal business network uniting 150 high-tech companies); Twente Board (triple helix platform); and Kennispark Twente (joint initiative of the University of Twente and Saxion University of Applied Sciences, the City of Enschede, the Region of Twente and the province). Kennispark Twente is considered a key orchestrator of Twente's knowledge triangle, rooted in its mission to further develop a climate of innovative entrepreneurship in the region of Twente, with incubator-like programmes, programmes stimulating industrial innovation and provision of business locations.

In formal collaborative innovation networks in Twente, the two HEIs are most central, also due to the absence of large Dutch corporations. Compared to knowledge networks in the other regions, Twente has the highest average number of partnerships, the highest density, the highest connectedness, and the lowest average distance between nodes (Stam et al. 2016).

In the last fifteen years, the Twente region has set up various regional bodies, such as a Regional Innovation Platform, later followed by a Strategy Board. The latter was transformed into the Twente Board in 2014. At the regional level, the Twente Board operates as a collaborative body, set up to stimulate Twente's economic development, with a focus on the top sector High-Tech Systems and Materials (HTSM). The Twente Board consists of 10 representatives from the triple helix and is chaired by an independent chairman. The first action undertaken by the Twente Board in 2014 was to assess the state and strategy of the Twente region. The audit confirmed that Twente needed to maintain its unique expertise in high-tech systems and materials but also had to develop entrepreneurship in new industries. The report of the visitation committee led the Twente Board to develop an activity agenda "Twente Werkt" ("Twente Works") in 2015. The chair of the Twente Board thus observed that "we have moved towards one shared agenda, with clear targets such as 5000 new jobs in Twente and 500 new jobs at the German side of the border (. . .) and objectives such as increasing the participation rate and the regional gross domestic product." Another key initiative taken by the Twente Board is to visit 100 enterprises in the region, of which 75 visits have been completed in the Board's first year. The Twente Board has adopted a rather lean operational structure. The members of the Twente Board turn to their own staff (e.g. at the University of Twente, Saxion, Twente region, or province Overijssel) to actually run the projects. In this respect, the chairman of the Twente Board believes "it is important in Twente to avoid further institutionalization, and instead focus on making connections with the key actors and their initiatives."

The university is the driving force behind the knowledge triangle, as one interviewee states: "There are hardly any large firms that can fulfil this role, but instead many start-ups and SME's. We have had a few fast-growing companies, but they often relocate outside the region when they become too big for the local labour market." The key role of the University of Twente is also evident in Kennispark

Twente, of which the University of Twente is the key occupant and (majority) owner. The stable governance system of Kennispark Twente appears to have contributed to its successful performance as an incubator of new firms; its historical track record in terms of spinoff creation is still unmatched in the Netherlands and has also long been a benchmark in Europe (Benneworth and Charles 2005; Benneworth et al. 2010).

The public ownership and control of Kennispark Twente imply that local industry is not represented in its management and governance. Several interviewees observed this governance approach helps the board of Kennispark to steer away from any possible conflicts of (business) interest. The flipside is that there are no private investors in the knowledge infrastructure. Kennispark Twente is under-financed, also as a result of the budgetary constraints of the University of Twente and the University of Applied Sciences Saxion.

Overall, we observe a strong commitment of the two leading educational organizations and three local government levels (cities, region, and province) to the knowledge triangle in terms of both investment and governance. The large population of small and medium-sized firms mainly contributes to developing and sustaining the regional ecosystem via representatives in formal bodies (such as Twente Board) as well as via informal settings and meetings (such as in Technologiekring Twente).

The Twente ecosystem has gradually evolved into a “start-up region” par excellence, with a well-developed governance system around Kennispark Twente. The recently established Twente Board can potentially offer orchestrator capability that complements the public ownership and governance of Kennispark Twente. However, as several interviewees observed, the Twente Board still operates rather loosely, and in the next few years, it will have to demonstrate that it can effectuate this capability.

The research also suggests that the Twente region continually adds new bodies and initiatives to an already dense network of taskforces, cluster organizations, and agencies, thus further enhancing institutional complexity. Several interviewees observed that (representatives of) most municipalities tend to prioritize the interests of their own municipality above those of the region.

A recurrent theme in the interviews with representatives from the Twente ecosystem is the shared perception of Twente being (geographically) distant from the heart of the Netherlands, which would reduce access to national funds and programmes. External observers have recently argued that the Twente region is in need of a new connector, or group of connectors, that would reduce its current dependence on the University of Twente (including Kennispark) as the main connector (Van Agtmael and Bakker 2016).

Overall, the governance system of the Twente knowledge triangle appears to entail:

A well-functioning Kennispark system, with a stable configuration of public owners and investors.

A relatively new Twente Board that still has to establish itself and demonstrate its capability and added value (especially relative to Kennispark Twente) to orchestrate and facilitate the economic growth of the region.
A tendency to further increase the institutional complexity of the region, by continually adding new initiatives, teams and taskforces to the existing landscape of collaborative bodies.

The most binding constraints of this governance system are:

Its (perceived) distant location relative to more densely populated regions in both the Netherlands (e.g. Randstad) and Germany (e.g. Ruhr region).
The historical demise of most (home-grown) large industrial firms, which has made the region largely dependent on the University of Twente and Saxion as primary orchestrators of the knowledge infrastructure (supported by several layers of local government).
The relatively small stock of human and financial resources that new start-ups, as well as SMEs and large corporations, have access to, given limitations arising from the local labour market.
A regional profile around "High Tech Systems and Materials" that in the longer run may not be sufficiently distinctive to attract new investors, companies and knowledge institutes.

In Twente the HEIs have a dominant position both in knowledge networks and in the governance of the knowledge triangle. In Brainport these positions are being filled by the closely collaborating OEMs and HEIs. However, in Amsterdam the HEIs—dominant in formal collaborative projects—are weakly connected to the other segments in the knowledge triangle. It seems that the larger and more diversified the economic structure, the more complex the governance of the knowledge triangle and entrepreneurial ecosystem at large.

6.4 Conclusions

In this chapter, we focussed on the entrepreneurial ecosystem context of knowledge triangles and, in particular, on two elements of the regional governance of the knowledge triangle: inter-organizational knowledge networks and leadership via regional economic boards. The knowledge networks are mechanisms for providing connection, whereas leadership involves a mechanism for giving direction. Connections between education, research and entrepreneurial actors are at the heart of the knowledge triangle, while the direction is needed to target the most binding constraints in the ecosystem and to facilitate collective action in tackling key socio-economic challenges in the region.

Overall, the regional economic boards in all three case study regions aim to make HEIs and other educational institutes more relevant for their regional ecosystem and share a triple helix-based approach in which key stakeholders are frequently consulted. Even though the regional economic boards in all three regions have adopted a regional governance approach centred around an ongoing dialogue between key agents in the region, they differ substantially in several key domains. We mention three of them:

6.4.1 The Ability to Prepare the Region for the Future

The Brainport region faces the huge challenge to make its successful high-tech industries "recipe" more future-proof by enabling more bottom-up new economic activities in order to make the region more resilient and less dependent on a limited number of high-tech OEMs. The Amsterdam region competes with metropolitan areas like London and Berlin in attracting foreign firms and high-level professionals. The growing collaboration between HEIs in the MRA region and (emerging) business activities may facilitate the development of new knowledge (networks) and thus make it more competitive compared to these metropolitan areas. However, most of these collaborations are both fluid and fragile: good for flexibility, but a lack of commitment may also be harmful to large-scale changes. The Twente region has an excellent track record in new business incubation and creation, but its capacity to nurture and retain fast-growing firms is relatively low. This illustrates that regions differ significantly in how they (as an entrepreneurial ecosystem) are configured, and therefore also face fundamentally different challenges in terms of economic growth and competitiveness.

6.4.2 The Coordination of and Emphasis on Industrial Clusters

The three regions studied are distinct in their place-based strategies and policies. The Twente region has a well-established Kennispark, entirely governed by public agents. The Brainport region has deliberately developed a larger portfolio of campuses, some initiated by public agents and others by private agents. The MRA can draw on a large number of attractive locations, even in the absence of a regional strategy for industrial clusters. This suggests that a collective sense of urgency about the local economic situation (e.g. in Twente and Eindhoven in the 1980s, respectively 1990s) may be a critical condition for any regional leadership to initiate a strategy for industrial clusters. In the MRA, the scattered pattern of locations with each its own strategy and client base did not hinder the emergence and growth of start-ups.

6.4.3 The Balance Between Top-Down Steering and Bottom-Up Leadership

In regions with a relatively homogenous and interwoven economic base and knowledge network, like Brainport, effective collective action is more probable due to the shared understanding of how economic value is created in the region. MRA's diversity in industries and knowledge institutes and its almost autonomous economic development constrain the ability of a regional board to steer it. In this type of highly distributed settings, bottom-up leadership in emerging niches might be much more effective.

Regarding the ability to guide a region in a particular direction, targeted industrial policies seem to have become a remnant of the past. All three regions in this explorative study followed, until recently, an industrial cluster strategy: backing strong sectors. Two of the regional boards in the Dutch regions are now moving away from this type of industrial policy in favour of an approach aimed at grand societal challenges (societal outcomes). In the Brainport ecosystem, there is consensus that shaping an industrial portfolio is less productive than making the region more adaptive towards yet unknown circumstances. This suggests each region has a unique history in shaping collective action and has also been developing a (region-specific) balance between top-down steering and bottom-up leadership.

In contrast to the expectations of the recent entrepreneurial ecosystem literature, none of the economic boards includes entrepreneurs that (sufficiently) represent the community of (potential) scale-ups. This omission may be a significant constraint on improving the conditions for productive entrepreneurship that has been recognized to be of major importance for the regional economy.

6.4.4 Relation with Government

All three regions have gradually been moving towards a triple helix mode of collaboration. Even the Twente region, where the local industry has for a long time not been directly involved in the governance of Kennispark Twente, has recently established a tripartite Twente Board. The Twente Board, as it currently operates, is highly dependent on the administrative support and project management capacity offered by governmental agencies. This may create tension between the intentions and policies developed in the tripartite constellation of the board itself and the capability to make these intentions and policies work. When it was first established, the Amsterdam Economic Board was for a major part, dependent on staffing and collective funding by nearly 40 local governments. Business partners and HEIs were member of the board but not financing it and were merely financially participating at the level of programmes and projects. With AEB's recent strategic change, the financial commitment will be redistributed to all partners in the triple helix. The Brainport board, by contrast, has its own support staff and budget for project management, which may enable it to operate more independently between all stakeholders of the knowledge triangle. The latter model, as such, may therefore better enable business leaders to participate in and contribute to regional governance in the context of a regional board that co-creates conditions for enhancing the viability of the region. Overall, there are substantial differences between regional boards with regard to their ability to choose where, when and how to act—especially as a result of how they are funded and organized.

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Part III

Knowledge Triangle in Higher Education Institutes and Public Research Organizations

7 Developing Research Organisations Towards Knowledge Triangle with Project Funding Instruments: An Example from Estonia

Kadri Ukrainski, Hanna Kanep, and Kadi Timpmann

7.1 Introduction

Competitive mechanisms for funding have been introduced by governments to steer the research behaviour of researchers and organisations, to achieve better efficiency in the distribution of funds, to encourage a wider set of research ideas and to make researchers more responsive to the needs of society or policy-makers. Considering long-term trends, the importance of project funding has grown in both old and new EU member states (Lepori et al. 2007, 2009; van Steen 2012). According to Eurostat, in some smaller EU countries like Ireland, it has grown over 60%. However, in Estonia and Slovenia, the project funding shares have been raised to 70–90% of the total research funding (Masso and Ukrainski 2009). These developments have motivated discussions in these countries about how to accomplish strategic development in such a funding environment and the sustainability of the universities as well as how to achieve broader goals universities have towards society, such as education, research, innovation function, and their integration.

Discussing the role of competitive project-based research funding vis-à-vis other funding instruments first requires an explanation of the wider context of the changing missions of universities. It also requires an overview of the ways institutional level strategies are translated into the level of research groups and vice versa. Research groups in this context can be analysed as quasi-firms whose main difference from real companies is their lack of direct profit orientation (Etzkowitz 2003; Scuotto et al. 2017; Carayannis et al. 2017). At the same time, there is a strong motivation for leading researchers to preserve the existence of the research group as

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such and their leadership in it. Such motives might be in conflict but also in line with the overall institutional goals of the universities. The results of studies (Muscio et al. 2013; Grimpe 2012) suggest that the success of achieving the desired change in researchers' responsiveness might not lie within the design of one specific instrument but rather the combination of instruments available for researchers overall.

This chapter aims to explain the challenges in research funding and governance mechanisms in achieving the broader strategic aims of universities in the context of an environment of extremely high project funding. The Estonian experience is relevant for other countries as well, as it reveals some important limitations of using this kind of funding mode for achieving knowledge triangle aims more broadly.

The chapter begins by conceptually discussing the interplay of the researcher and the university level in different funding modes. Thereafter, the Estonian research funding system and the reforms and developments that have led to very high project orientation are reviewed. In the last part of the chapter, outcomes on the university level are discussed in terms of strategic and operational governance mechanisms. The final section concludes.

7.2 Project Funding as the Interplay of the Goals of Researchers, Universities and the Government

Project funding as one research-funding mode depends upon the competition for recognition among scientists, and this feature is employed by governments to efficiently motivate scientific effort among researchers. Reputation has become the central asset in science, and success in acquiring grants has become a determinant of the 'value' of a scientist within the science system (Braun 2003). Scientists work within the credibility cycle (Rip 1994), and it is found that the introduction of competitive allocation mechanisms for funding enhances competitive behaviour among initially inactive individual researchers (Liefner 2003). But it is also discussed in the literature that researchers are, in general, oriented to exploit and strengthen the particular structures of the system (Morris and Rip 2006).

It can be argued that typically project rewards and publications (citations) are complementary stimuli in the science system. However (Ukrainski et al. 2016) discuss how narrowly determined incentives within the still transforming science systems of Estonia and Ukraine lead to the very different behaviour of scientists 'maximising' scholarly articles in the first case and utility model applications in the second case. Different funding sources may play different roles in a scientist's credibility cycle. For example, if competitive funding is associated with an increase in ex-post publications, then industry funding is found to decrease the marginal utility of public funding by lowering the publication and citation rate increases associated with public grants (Hottenrott and Lawson 2013). It is therefore extremely relevant which incentives the funding system creates for individual researchers when strategically balancing different aims and roles within the science system.

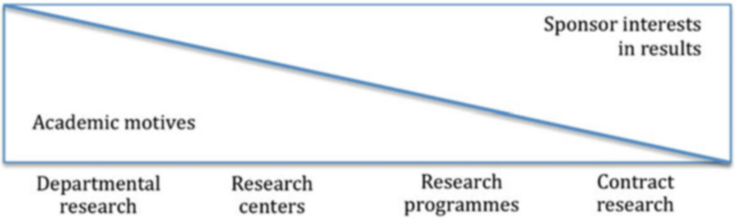


Fig. 7.1 The continuum of research by funding type and motives. (Source: Geiger 1990: 9)

Still, the role of the universities in balancing and coordinating the activities of individual researchers is very important, as (Geiger 1990) has argued in analysing the case of the American post-war success of science. Besides historical reasons and funding expansion by the government, success was determined by the capabilities of universities to accommodate 'organised' research as well as how this type of research balanced the knowledge demand of society (or sponsors) with the existing and evolving capabilities of research performers in universities. This programme-based research was not content based (which was largely controlled by researchers), but rather aim based and determined by the funding arrangement or organisation of the research; this was by no means related to the basic-applied nexus.

By applying this discussion to the contemporary European context, one would argue that departmental research (that is not related to competitive project-funding) emerging from the paradigms of a particular science discipline and dominated by academic motives lies on one end of the continuum of research motives, and sponsored (or alternatively, project-based) research on the other end (Fig. 7.1). As intermediary cases, research centres, which are somewhat more distanced from university departments, and research programmes, designed to meet somewhat more narrowly the funders' needs, can be considered.

This continuum of motives may still vary in different funding environments. Laudel (2006) showed through interviews with researchers from various science systems how other factors besides research quality determine the outcome or success of project funding applications and hence the ability of research groups to respond to societal or business needs. These factors include the existence of 'free resources' for writing project applications as well as research field specifics, a researcher's track record and the general availability of research funding in the system.

On the level of research organisation (but these arguments are also valid on the system level) Hornbostel (2001) suggests that external fund acquisition can be applied as a research performance indicator only, when in the particular research field external fund acquisition is typical (e.g. it is not common in law sciences); when there is a competitive system and grant proposals are reviewed by qualified peers; when competition exists but it is not disastrous; when there is a mix of different funding sources; and as a precondition, infrastructure exists, enabling the research.

The available mix of financial resources shapes the environment, where the universities operate strategically and operationally in funding their teaching, research and innovation activities. It is clear that when institutional funding

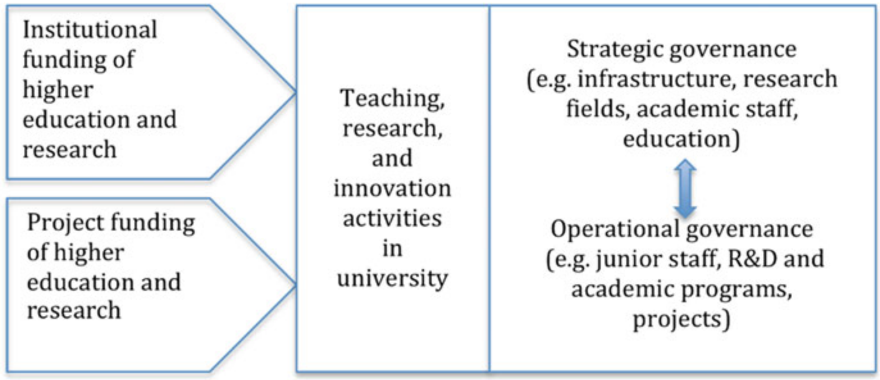


Fig. 7.2 Types of funding, research, teaching and innovation activities in universities, and strategic and operational governance. (Source: Horta et al. 2008: 151)

mechanisms dominate the budget of the university, the strategic governance mechanisms can be more easily used. If the project funding mechanisms dominate, the aims of funders must be followed in short time horizons (stemming from the very definition of project research) and the university must adapt its operational plans respectively (Fig. 7.2). Additionally, the agency conflicts, which arise between institutional goals and individual or departmental goals, depend on the dynamics of the internal balance of power shaped by the internal governance arrangements.

The state plays an important role as a buyer of the university's services by determining the conditions for institutional funding, but also by establishing incentives for project-based competitive research. In most OECD countries the institutional funding represents typically a larger portion of overall funding and is thus critical in providing support for the salaries of the faculty and administrative staff as well as support services, such as libraries, the student administration, human resource departments, etc. (Horta et al. 2008). It is therefore found that competitive funding gives universities the opportunity for a more diversified product portfolio because they can choose between the fields of science and a balance of research and teaching activities.

Lepori (2011) explains that the project funding type of measure is potentially an efficient allocation mode because it promotes competition and the strategic behaviour of research groups. By deciding the overall location of resources, competition and reputation issues in this process depend on peers' perception of differences in the quality of the applications and therefore are also shaped by the level of funding and policy targets (Garcia and Sanz-Menéndez 2004). Those targets can be expressed on the basis of thematic allocation decisions, which make the competition between and within financing schemes rather diverse, involving several or only a few players (for example, because of collusive behaviour by research organisations to exclude potential competitors (Elzinga 2003) or the Matthew effect at the institutional level (Arora and Gambardella 1997). For sound competition to work, a substantial number of competitors are needed on the market, ensuring a wide supply of high-quality research proposals.

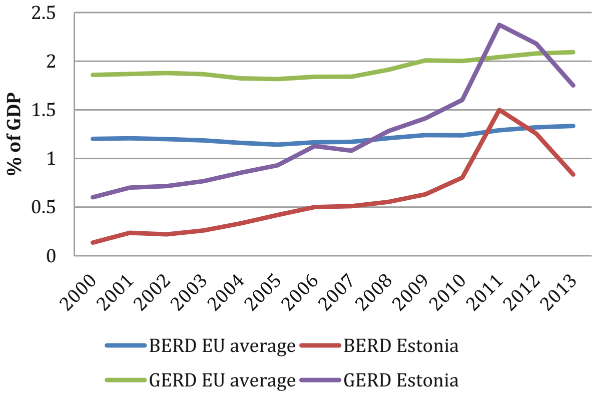
Low competition may force the funding agencies to fund projects not fully matching their goals, and high competition may bias the selection towards past performance and thereby reduce the acceptance of innovative proposals (Lepori et al. 2009; Geuna 2001; Laudel 2006). It cannot be taken for granted that a large share of competitive project funding alone can ensure an effective allocation of research funding. Research performers' decisions about the development of funding are based on expected funding, and some stability of funding over time might be needed to foster investments in research capacity (Liefner 2003; Echeverría 1998). Under the conditions of tight public budgets for science, project funding becomes more competitive and unstable over time for a particular institution; projects with higher risk are not carried out and the variety of research and innovation decreases (Geuna 2001). Institutional funding implies lower implementation costs of allocation for the government but also allows for more long-term commitments and strategic planning for the institutions (Lepori 2011). However, it might also help to maintain the diversity of research and innovation, which can be especially relevant in small countries, where ensuring the variety of the research in the long term is necessary (Carayannis et al. 2016; Meissner et al. 2018).

7.3 The Position of the Higher Education (HE) Sector in the Knowledge Triangle

Several authors have pointed to the general fragmentation of the Estonian innovation system with low connectivity and functionality for achieving economic outcomes (Glänzel and Schlemmer 2007; Ukrainski 2015). Looking at the reasons behind this problem, one discovers the limited capabilities of the actors and the institutional dynamics behind the HE sector in general. The only actor group among higher education institutions (HEIs) that has been relatively stable for a long period is public universities. Although the universities have also undergone several reforms, including legal reforms granting substantial autonomy as well as organisational reforms, targeted at quality assurance for research and education, and incorporation of the research institutes of the Academy of Sciences, etc., they have kept their core identities in the KT.

The other actors have been very dynamic. For example, the number of private universities has grown out of dissatisfaction with the quality and variety of higher education in general: this number rose as high as ten universities in 2001 and decreased later to only one, the Estonian Business School today. The binary divide of universities and of institutions of vocational higher education (now professional higher education) and/or vocational schools providing higher education, has been considered as the main characteristic of the contemporary HEI sector in Estonia (Tomusk 2001). However, despite the aims and considerable investments towards more attractive vocational education popularising contemporary technologies/ industries, its success can be questioned as the proportion of academic track students

Fig. 7.3 R&D expenditure as %-share of GDP. (Source: EUROSTAT 2016)



is currently slightly over 60% of all HE participants and has remained quite stable in recent years (Tõnisson 2011). The consolidation of different actors and reduction of duplicate activities in research and higher education, thus maintaining quality standards, has been the main aim of reforms in recently made HEI policy (Okk 2015).

One of the characteristics of the Estonian innovation system is hence the concentration of higher education and research into public universities. This change was initiated at the beginning of the transformation by dismantling the old Soviet-style Academy of Science and merging its institutes with universities, thus giving the latter greater responsibility and autonomy (Masso and Ukrainski 2008). This move was strengthened during the last strategic planning period of EU Structural Funds. Although by and large these reforms were carried out earlier and are still to be finalised in coming years, the shift has still been remarkable, especially when compared with greater stability in other countries (see also OECD 2013). One reason is that the universities, which generally are larger and more successful in grant funding schemes, have become even stronger via the Matthew effect in the process of high competitive project funding shares and extremely low baseline funding for research (Masso and Ukrainski 2009). In institutions of higher education, the average level of R&D investments has been 75.9% of the total investments within the public sector during the 2007–2013 period and has even grown to 82.6% in 2014. The consolidation will continue in the coming years.

In Estonia and other countries at a similar development stage, the impulses from academia as central to the KT relations are emphasised (Molas-Gallart and Davies 2006; Tiits et al. 2008). To some extent it is understandable as in such phase development is driven by investment rather than innovation and the firms' capability to become an important pull factor for KT activities is rather limited. The question of how to improve the innovative capabilities of firms is critical, as is the one about how to lower barriers for deepening cooperation with universities, thus increasing the demand side of R&D. It has to be noted that R&D expenditure financed by the business sector grew remarkably in 2011–2012 but shrunk afterwards (Fig. 7.3).

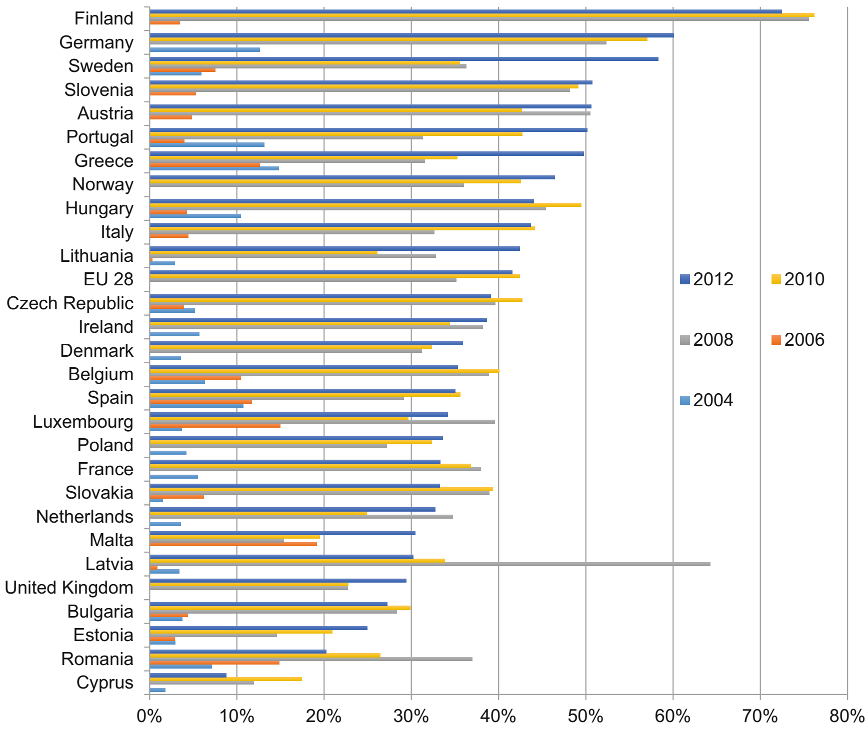


Fig. 7.4 The percentage of companies that have engaged in innovation cooperation with universities and HEIs as a share of the number of innovative companies that were engaged in any type of cooperation. (Source: EUROSTAT Community Innovation Survey Data 2016)

R&D activities of firms were highly concentrated during the observed period. In international comparison, it has been pointed out that it is difficult for Estonia to be successful as a knowledge-based economy if only 10% of businesses are involved in R&D (European Commission 2012). The concentration of business R&D has increased over time, when in 2009, expenditures of the 50 largest companies totalled 30%; in 2012 it was 85% of total R&D expenditure (Ukrainski and Varblane 2015). The investments of a few companies were behind the rapid increase in business R&D expenditure. Low relevance of universities for Estonian firms' innovation cooperation is reflected in Fig. 7.4. It was found that in the case of SMEs this kind of cooperation has even decreased and that leveraging business activities in general does not proportionally increase the added value and R&D (Kaarna et al. 2015). Therefore, the demand for knowledge for innovation remains restricted in the business sector.

In the framework of innovation policy governance and design, actors see the KT relationships very narrowly and mostly as contractual research between academia and industry or the government. For universities, the level of contractual research (judged by the respective shares in budgets) is comparable to other countries (even in comparison to top-level universities) (Karo et al. 2014). However, for SMEs, consulting, training and practice-based activities, etc. (more 'soft' activities) are more relevant. By and large, these activities are not reflected in any strategy-level indicators and are therefore difficult to assess. This is controversial as integration via educational cooperation was addressed in the Sustainable Estonia strategy (2005: 23), but this has not become an active interaction channel. Furthermore, if it is used, it is seen by enterprises as providing practice places for students. So far curricula development in HEIs has not actively involved external stakeholders either, although formally programme committees include external members.

The overall strategic focus within KT has been more on R&D than on higher education (Jürgenson et al. 2011). As these systems overlap in the case of Estonia to a great extent, this focus represents a kind of positioning within the sector. The European Paradox identified by Bonaccorsi (2007) (revealing the fact that European countries specialise in science fields with low search activities and dynamics) is not overly true in the case of Estonia as the dynamic fields that were stressed in the argumentation (life sciences, computer sciences and material sciences) are relatively well developed. In Estonia, the mid-term evaluation of the use of EU Structural Funds (Jürgenson et al. 2011) is rather indicative of the fact that strategic concentration on those new key areas has weakened the basic science fields (e.g. physics, chemistry) on which the new fields are resting, and it is doubtful that this approach is sustainable in the long run. One characteristic of Estonia's small economy is its very diverse and fragmented economic structure with few strong clusters, making it hard to form a supply-side science specialisation with critical mass. In addition, the institutional framework of funding contributes to the creation of research 'silos' for science fields and low complementarity in addressing societal challenges (e.g. the formal distribution of funding measures by field of science, e.g. Centres of Excellence, institutional and personal research grants, etc.).

7.4 The Funding of Research and Education

The largest reform in research funding creating a path for project-funding instruments was conducted in 1997, when two project funding measures were launched: targeted financing and research grants, both of which were based on competitive procedures. At that time, the creation of such project-based funding measures was estimated to be rather significant as it introduced competitive funding to the system (Heinaru 2000). Before that, the Estonian Science Foundation (currently the Estonian Science Agency) distributed the funds between the research institutions via institutional core funding. Several research institutes (more oriented to applied science) were left without targeted financing as a result of the reform.

The targeted financing was distributed to R&D institutions accredited beforehand with the aim to insure a high level of quality and continuity of the research activities (Masso and Ukrainski 2008). Both grant types were allocated through open competition for the implementation of a specific research project either in basic or applied research. Although the funding was based on competitive procedures, it was agreed

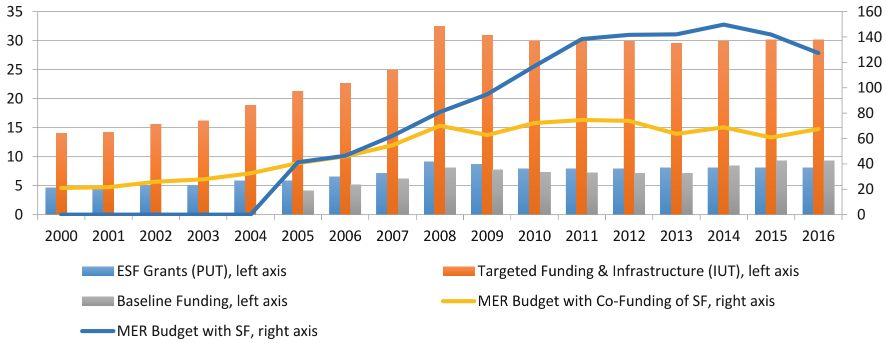


Fig. 7.5 Development of research funding measures in the Ministry of Education and Research (MER) budget. (Source: MER 2016)

that the relative shares of broad scientific fields would remain roughly the same throughout the years and this agreement has been put in practice ever since.

Since the establishment, both funding instruments have grown in volume, but not as fast as the total funding of research (Fig. 7.5). For example, if in the beginning phase of this measure, the targeted funding amounted to 50% of the budget of the Ministry of Education and Research, thin in 2014 it decreased to about 30% (without considering EU funding from Structural Funds, hereinafter SF). After the economic crisis in 2008, the growth of the funding measures outside SF stopped and actually even decreased a little. At the same time, the research system grew remarkably in terms of total funding as well as researchers. However, it meant that the administrative procedures of distributing SF started to dominate the developments in research funding.

Since 2012–2013, some additional institutional criteria have been incorporated into the allocation process. The change in the name of the instrument of targeted financing has also since become institutional research funding (hereinafter IUT). The additional institutional criteria means that an institution can improve the standing of some priority applications by giving additional points to the ones given by experts. At the same time, it was determined that the institution's funding in the new application round should not fall below 80% of that in the previous period. These decisions were made as a response to growing competition for funding and due to the fact that several research institutions were dependent on this particular funding instrument as a kind of substitute for institutional baseline funding. While the project funding logic is still implemented in the application and granting procedures, it implied that the experts in the peer-review committee must decide about the sustainability of some research organisations or groups. Universities were not affected very much; the analysis of the budget data shows that the funding from this instrument has been very stable in universities and has even grown over time.

As the duration of the projects has generally been 6 years, the funding of this measure has a kind of competition cycle. The average size in terms of the number of researchers and the funding amount per project has grown over the years. As in the years of 2004–2009, the funding volumes applied and granted corresponded similarly, the changing situation in 2010 meant that several research groups were not granted any more funding (as the total funding remained nominally stable). Therefore, it was decided to add more institutional criteria to the allocation procedures, to remediate the adverse outcomes for research institutions.

Based on the description above, one can see that the project-funding instruments that seemed appropriate in stable conditions failed when the system grew and competition intensified. As a temporary solution towards more institutional allocation criteria is probably not sufficient, the reform of the whole funding system is necessary. Some steps have already been taken to increase the baseline funding for ensuring the sustainability of research organisations. However, in the process, the mergers of smaller research organisations with larger ones would also be justified in this funding environment.

An international comparison of the share of project-based funding instruments is not available for Estonia based on the methodology of Eurostat, but data on the institutional level show that it is extremely high in Estonia (over 90%). Only one instrument is used (baseline funding), which is not project based but is still competitive. Compared to Finnish counterparts, it is also high (there the highest shares remain around 70%). As in Estonia, some R&D institutes are 100% project funded, we have found that the growing number of institutes within the University of Tartu, the largest research performer in Estonia, also fund their research this way (Ukrainski et al. 2015a).

7.5 Stimuli in the Funding Instruments for the KT Activities

Competitive funding instruments create stimuli for applicants through the criteria used for the evaluation of the project applications and indicators, which are incorporated into funding formulas. These indicators and criteria can reward researchers and institutions either directly (in the case of formulas) or indirectly through increasing the probability of being successful at the application process. Three core national research funding instruments in Estonia use rather similar criteria for allocation decisions.

These could be classified into:

- The past performance of researchers (both individually and collectively), which could be expressed via several indicators, like the record of publications or research contracts
- The scientific quality of the proposals
- The level of the existing research environment
- Alignment with the strategies either at the national or institutional level

The overwhelmingly strongest criteria used directly in the baseline funding formula as well as indirectly through the assessment of research teams' qualification and past experience in the case of the grant schemas of both PUT and IUT is past

Table 7.1 Relative importance of the criteria within core funding instruments

Domain of the criteria	Funding instrument			Share of the criteria within core funding instruments	Share of the criteria within MER research budget
	Baseline funding	IUT (former Targeted Funding)	PUT (former ESF Grants)		
Past performance	21%	16%	9%	46%	14%
Quality of the proposal		16%	9%	25%	7%
Existing research environment		9%	4%	13%	4%
Strategic relevance (national)	1%	9%		11%	3%
Strategic relevance (institutional)		6%		6%	2%
Total	22%	57%	21%	100%	30%

Source: Authors' compilation based on grant regulations and funding volumes in 2015

performance, which includes the number of publications, monographs and PhD students supervised. The volume of patents and income from R&D grants and contracts with both private and public partners is used as well, but only for the base funding instrument. The scientific quality of the proposal delivered is also rewarded strongly, which further magnifies the effect of individual researchers and research groups as they initiate and develop proposals in both grant schemas. Strategic research choices at the institutional as well as the national level are the least rewording criteria used, and alignment to national-level strategies is also weak (Table 7.1). Past performance and the quality of proposals are the main criteria used to evaluate SF projects.

Main sources of funding in higher education are funds allocated through the state budget, revenue received from students to reimburse study costs and revenue from the provision of services for a charge, e.g. courses of continuing education. Public funding from the state budget is largely based on one single funding instrument—activity support, which is allocated to both public universities and institutions of professional higher education in a similar fashion—on the bases of a 3-year contract and annual performance agreements. Most of the activity support (currently 75%, but this will vary) is distributed through a common formula and a smaller share is for targeted and/or institution-specific funding related to instruction. The funding formula takes into account several scale- and performance-related indicators, based on which shares of funding for individual institutions are calculated. Within this funding instrument, connections of funding to KT interactions could possibly be made through a share of specifically earmarked funding. There is, however, little experience of such practice.

Both a 3-year contract and a 1-year performance contract contain general and institution-specific goals. According to the funding model, a certain percentage of funding is allocated to institutions based on their accomplishment with respect to these goals. There is no direct funding connection to each and every goal; instead, an overall evaluation of contract fulfilment is carried out by the MER. According to 2016–2018 contracts, for example, all universities are expected to report on their main activities towards:

- Incorporating wider societal expectations and labour market needs in their activities as well as increasing public awareness of the university's activities
- Supporting lifelong learning and widening access to higher education opportunities, considering the needs of different groups in society
- Enhancing cooperation between educational institutions, businesses, employers, alumni and other relevant partners in teaching, research and development activities

Regulations for public and private funding for higher education were changed in 2012 (implemented from the study year 2013/2014), limiting the possibility to provide study programmes with the tuition fee and thus reducing the importance of private funding in the higher education funding mix. Currently, universities can charge a tuition fee only for part-time studies and studies based on curricula taught in foreign languages (mostly in English). Full-time studies are free of charge if the student completes the study load prescribed in the curriculum. Higher education institutions are entitled to demand partial reimbursement of study costs from students who fail to complete the study load. Still, upper limits per uncompleted ECTS are fixed by Government regulations (Kõrgharidustaseme 2016).

One possible channel for funding specifically KT-related activities is via SF. Multiple project-based instruments have been created, for example, for the development of the cooperation of HEIs and enterprises or innovations in HEIs, etc. All of these programmes are short-term and non-systematic support structures.

External evaluation of HEIs is needed to obtain the license to teach and open up programmes for new study groups as well as to receive baseline funding. The system of evaluation consists of two types of evaluation—institutional accreditation and quality assessment of study programme groups. Evaluation committees are, as a rule, international and include member(s) outside the HE sector. Institutional accreditation is built upon four areas, for which evaluation, feedback and recommendations are given, for organisational management and performance; teaching and learning; research, development and/or other creative activity; and service to society. Within each of these areas, a list of indicators is given (as an example) for the evaluators to look at, including, among others, rates of alumni employment, patent applications, patents, system development solutions, product development solutions, environmental solutions, contracts with enterprises, spin-off firms, the proportion of supervisors (including co-supervisors) from outside of the higher education institution, including from foreign countries, etc. So evaluation/accreditation involves a wide set of indicators that could potentially increase university stimuli for KT activities compared to the funding instruments, which are much more narrowly concentrated. Results of these evaluations are not an integral part of performance-based funding; however, some of the recommendations made by evaluation committees may become part of the performance contract.

7.6 Research Funding and KT Policies and Practices in Selected Universities

Estonian universities are very autonomous in terms of academic, organisational and financial matters as well as staffing compared to their European counterparts (Estermann et al. 2011). Three universities with different profiles were selected: the University of Tartu, UT; Tallinn Technical University, TUT; the Estonian University of Life Sciences, EULS (see Table 7.2). UT represents a comprehensive example, while TUT represents a technical example and EULS a regional university example.

It has to be noted that as the number of students has remained relatively stable, the revenues of universities have grown remarkably in 2006–2014. The bulk of these revenues went to the modernisation of research infrastructure. The share of funds for education has remained at about a third of total revenues. Teaching revenues per student have been different directly because of field specialisation (medicine in UT and veterinary medicine in EULS being the most expensive study fields) included in the funding formula of study places up till 2013 through specific coefficients and since then indirectly through the percentage of historic funding retained. However, clearly, UT has relied somewhat less on education funding in its funding mix.

Based on these cases one can say that in terms of governance there is no systematic approach integrating all of the aspects of KT. This means that the main activities and decisions are decentralised to the faculties and research groups. Although strategic documents (especially UT and TUT, less in EULS) emphasise the need and aims for integrating the fields of research, education and innovation, it remains rather fragmented even there, and the examples of integration are in many cases based on the initiative of faculties. This is also one outcome of the project-based funding system, as the availability of strategic funds on the university level is restricted.

There are examples in all case universities of KT integration attempts where, for the most part, two out of three KT pillars are targeted (e.g. research and teaching, research and innovation or teaching and innovation) (Table 2). The example of TUT with the creation of Mektory is perhaps one example of the broadest coverage; however, while it cannot be considered to powerfully integrate the respective activities of TUT, it supports strong research actors without forcing the weaker/ more passive ones to become active in KT relationships. There is a recent initiative involving all universities, a web-based platform called Adapter, through which companies can contact all the universities for their specific services through one channel.

Table 7.2 Summary of the profiles of selected universities

University	UT	TUT	EULS
General mission	A comprehensive university offering a traditional variety of science fields (including medicine), founded in 1632, location in Tartu (Southern Estonia). Has the role of a 'national university' with the mission of preserving natural heritage, culture and language.	A technical university, created in 1920 as a higher education institution focusing on technical education. However, in recent decades has been focusing more on social sciences.	An agricultural university and a regional university with 68% of its students from Southern Estonia. Created in 1951 by separating three agricultural faculties from UT. Specialises in rural life, the economy and in areas related to the sustainable use of natural resources.
Students (2014)	Contracted in recent years, about 14,000. The largest part of students is in social sciences as well as health, natural sciences, humanities and educational science, less in services and technical fields.	Expanded, about 13,000, technical fields, but also has a major bulk of students in social sciences and natural sciences, less in services.	Stable, about 4000, agricultural fields as well as technical science, social sciences and services.
Research output (2011)	Strong research focus: 873 papers indexed in WoS, 0.59 papers per academic staff	355 papers in WoS; 0.39 per academic staff	137 papers in WoS; 0.38 per academic staff
Revenues 2014	Total: €158.5 million; academic: 28%, €3053 per student; research: €60.3 million, 95% project funding.	Total: €95.5 million; academic: 32%, €2750 per student; research: €41 million, 95% project funding.	Total €33.1 million, academic: 32%, €2425 per student, research: €7.5 million, 93% project funding.
Governance of baseline funding	28% overhead, 23% R&D support, 43% faculties (formula based), 7% infrastructure.	42% R&D support, 36% faculties (formula based), 22% university level ('strategic') projects	About 55% R&D support, 40% faculties (formula based), the rest is the prize fund.
Pulling up the KT	Reached top 1% citation rate in the world in nine disciplines.	–	Reached top 1% citation rate in the world in two disciplines.
Broadening of the KT	The ratio of students in continuing education to number of students (2010:1.38; 2011:1.67; 2012:1.96). Colleges in Viljandi, Narva and Pärnu.	The ratio of students in continuing education to number of students (2010:0.72; 2011:1.12; 2012:1.18), College in Kohtla-Järve.	The ratio of students in continuing education to number of students (2010:0.62; 2011:0.51; 2012:0.57).
Examples of KT initiatives	Career Unit, Lifelong Learning Center, Idea Lab, Center of	Mectory, NBO Prototron, Development	Joosep Toots Fund, Applied Sciences Award, Science

(continued)

Table 7.2 (continued)

University	UT	TUT	EULS
	Entrepreneurship, Tartu Science Park, Tartu University Hospital.	Fund, Career and Counselling Office.	Communication Award, green university initiative.

Source: Authors' compilations based on legislative acts on universities, annual reports of the universities (Tina, Riisalu 2015, MER, ESA 2015, Allik 2015)

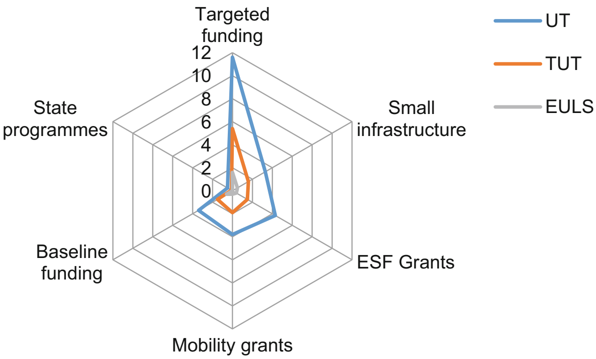


Fig. 7.6 Research revenues in mill eur in 2012. (Source: Tina and Riisalu 2013: 96)

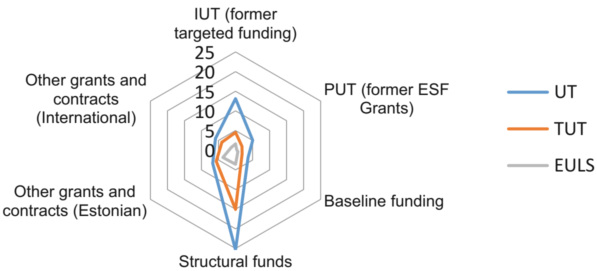


Fig. 7.7 Research revenues in mill eur in 2014 (Universities Estonia). (Source: Tina and Riisalu 2013: 96)

Summarising the cases by their empirical profiles, one can say that the universities have quite different specialisations in KT. It seems that most universities are relatively stronger in two aspects out of three: UT and EULS in research, EULS and TUT in education (perhaps also UT here; its disadvantage lies mostly in its student numbers, but it is significantly more involved in lifelong learning) and TUT and UT in innovation.

The absolute size, and to some extent the sources of funds in the research budget are quite different among the case universities, being highest in UT. However, it is remarkable how similarly distributed public science-funding instruments are (Fig. 7.6), with UT receiving at least double from every instrument compared to TUT. As all these instruments are competitive, it accurately reflects the position of institutions on the 'research markets'. Since the criteria are based overwhelmingly on past performance, the size differences also remained proportionally the same in 2014 (Fig. 7.7). However, UT and EULS have gained in IUT due to their relatively stronger position in scientific research. One can identify the dynamic Mathew effect, but more interestingly it is evident that this kind of research funding makes the research budget composition across universities quite similar. Universities compete on different 'markets' for grants, infrastructure support and even for baseline funding, and the differentiation of funding that would correspond to the specialisation of the universities is not reflected in their research budgets. The MER project-funding portfolio is only mirrored in the university budgets in its overall spectrum.

The different systems for allocation of education funding and research funding means that in universities budgeting involves two systems: top down in the case of education funds and bottom up in the case of research (Raudla et al. 2015). As this situation has been considered relevant for sustaining the autonomy of research institutes within universities it significantly limits the opportunities for central administrations to steer and develop universities strategically. It creates additional problems of funding central or indirect costs and of how to arrange multi-level governance of education and research matters. As in some universities, research funding has been extensive, disruptions in financial flows are quite common on the institutional level and the central administration has developed practices offering a stabilising mechanism (sometimes with the help of short-term loans) (Ibid).

7.7 Conclusions and Discussion

Several earlier studies (Masso and Ukrainski 2009; Christensen et al. 2012) and a more recent reform proposal (Okk 2015) have pointed out that the practices of competitive funding which are used in Estonia and follow different examples of developed countries are not suitably adapted to the local research setting. Research funding policy has increasingly concentrated resources towards basic rather than the applied type of research and guided research activities and fields through research groups' past excellence, international visibility and scientific curiosity. The criteria directing research towards solving socioeconomic development problems are marginal. This chapter also highlights that in current debates the role of universities in the KT is seen as 'service provider' instead of what it could be, where every university actively shapes its environment and society by having an understanding about as well as actively considering the local labour market needs and, at the same time, being a local centre of lifelong learning, etc.

Clear focuses (strengths) of the case universities in the KT relationships can be profiled, the research focus being strongest in UT and EULS, the innovation focus in TUT and UT, and the teaching focus in all three (although UT is losing students but increasing the number of learners in continuing education). Therefore, the strengthening needs (which are also recognised in strategic documents) are, in the case of UT, in education and innovation (perhaps here the most relevant are the governance issues of how to find a proper form for governing more diverse and numerous business relationships). In the case of TUT, the need to strengthen the research aspect and diversify business contracts to foreign firms is relevant. The EU funding and defended PhD numbers in TUT are lower in the Estonian and international comparison, and the quality and outreach of research group leaders are critical in improving the situation. In the case of EULS, the innovation link needs to be developed further both locally and internationally, which is a challenge as the university is very small.

On the country level, it can be concluded that an understanding of universities as important players in KT has gradually reached the managements and governing bodies of universities. However, universities are struggling in balancing their new roles with traditional academic ones and have difficulty enforcing the new roles in their internal policies and procedures. It has been argued that many R&D institutions of Estonia are simply not ready or not motivated to change their procedures, way of thinking or the culture of their organisations (Okk 2015). However, the funding system also contributes to this resistance because the stimuli concentrate on past academic performance and offer little room for strategic management.

As universities are relatively small though opening up to global competition, their capabilities and resources for creating high-quality knowledge transfer mechanisms are very limited both financially and in terms of competences. Here greater cooperation is needed, which, via Adapter, has only begun. Here the high dependence on project-based research and innovation (but increasingly education as well) funding comes into play as an additional factor that does not support competence building at the university level and further inhibits the development of KT relationships and the development of longer-term capabilities according to the main specialisations of the universities.

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Incorporating Knowledge Triangle in University Management System: The Case of the Higher School of Economics, Russia

8

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8.1 Introduction

During the last decade the Knowledge Triangle (KT) has received significant attention in terms of practical application by policy makers in the science, technology, and innovation (STI) policy domain resulting in broad range of policy initiatives around the world which aim at directing universities more to fulfilling the missions outlined in the KT, namely education, research, and innovation (OECD 2017; Unger and Polt 2017; Cervantes 2018; Unger et al. 2020) within a broader framework of well-known national innovation system (NIS) theory (Lundvall 2007a, b; Nelson 1993; OECD 1999, 2002). Since a "classical" university realises its three missions (education, science, and the "third mission") in line with the three KT domains, it reproduces the knowledge triangle internally at the level of own functions, processes, organisational structure, assets, and outputs. An approach known as the "entrepreneurial university" is an effective framework for theoretical discussion and applied modelling of best practices considering multidimensional university models (Etzkowitz and Leydesdorff 2000; Etzkowitz 2004a, b).

This chapter is devoted to the case of the National Research University Higher School of Economics (HSE) in Russia as a large-scale "classical" and "entrepreneurial" university performing the full range of activities regarding "external" and "internal" KT elements. An important feature of HSE is its constant evolution toward more competitive forms. The current state of the university is the outcome of three decades of transition and, therefore cannot be regarded as a "recipe" for creating a new higher education institution (HEI). On the other hand, it is a relevant example of stepwise strategic modernisation for mature organisations with a considerable resource base. The chapter starts with the general profile of HSE. The main part consists of three sections, describing the main education, research, and third

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mission trends at the university. The final section is devoted to a discussion of the provided details and respective conclusions.

8.2 Higher School of Economics: A Brief Portrait

The National Research University Higher School of Economics was initially established in 1992 as an international-style institute for education and research in economics and related disciplines. Since then, it has developed into a comprehensive university with total enrolment over 47,000 students (and more than a thousand of PhD students) and about 7000 academic staff. Ranked as one of Russia's top universities in key global rankings including Shanghai Ranking, QS, and THE, HSE demonstrates its leadership in social sciences, humanities, mathematics, computer science, and beyond.

HSE has an extensive governance structure that balances the interests of the different actors. The central executive body includes Rector, President, Academic Supervisor, Vice Rectors, and Faculty Deans. Rector, elected by a conference of university staff and approved by the Government, oversees the direct administration of activities at the University and manages it with complete authority and is personally responsible for the quality of education at the university and its financial activities. An advisory body (the so-called rectorate) functions underneath the Rector for collegial decision-taking on key current issues related to the university operation. The HSE President represents the University to government bodies, non-governmental organisations, professional and business associations, and unions. The HSE Academic Supervisor heads HSE academic activities, represents the university in research organisations, and supervises the university strategic development programme. Vice Rectors are responsible for various areas of university operation. Faculty deans oversee the activities of their faculties. In each faculty, an academic council is elected to serve as the faculty's representative body.

Collective management bodies include the Supervisory Council (this body provides recommendations on amendments to HSE's Charter, the establishment of branches and representative offices, approval of plans for HSE financial and economic activity and audit procedures, etc.), the Academic Council (a representative body elected by a conference of academic and other staff and students and responsible for the general administration of HSE), the Conference of University Staff and Students (takes place every five years to approve HSE's Charter and/or any amendments therein, to elect the University's Academic Council and to approve the HSE development programme), and a Board of Tenured Professors (a purely advisory independent body, addressing strategic issues relating to HSE's academic and educational mission; supports the implementation of HSE development strategy goals as stated in the University Charter). The Collective Advisory bodies include the Board of Trustees (supervises HSE development in short- and long-term and use of additional financial resources to support priority activities), Supervisory Council of the HSE Development Programme, and the International Advisory Committee.

The latter monitors and measures the University progress towards improving its competitiveness globally.

Students at HSE have their own voice and it is heard by university management. The HSE Student Council members hold a consultative vote and may participate as full-fledged members at meetings of the HSE rectorate and Academic Council, to express the opinions and concerns of students. The council includes representatives of faculty student councils, international student associations, and dormitory boards. Moreover, every year the HSE Student Ombudsman is elected to represent students' opinions on various issues and to defend their rights as well as to facilitate the best and most comfortable conditions for their time at the University. The ombudsman also plays the role of arbitrator in case of a conflict between students, student organisations, and student councils, and/or between student governing bodies.

Initially the primary aim of HSE was to renew the training of the Russian business and academic communities in economics as the Soviet Union's teaching of political economy was dominated by an outdated ideology and could not meet the international standards of a market economy. Soon after its foundation, the HSE received the status of a university in 1995 and in 2009 the status of a National Research University (NRU) moving a year before from being under the Russian Ministry of Economic Development supervision to being a Russian Government institution. In late 2010 and early 2011, HSE opened its first international research laboratories jointly headed by renowned international scholars and leading HSE researchers. The laboratories became part of the university strategy to create and develop its research, teaching, and staff potential. In 2014, major internal reforms began at HSE with the creation of "big faculties", which are responsible for implementing educational programmes. On September 1, 2015, the first HSE online courses opened on the National Open Education Platform. That same month, HSE received about 35,000 applications from 13,000 potential students to open optional courses. These and some other milestones are mentioned in the following sections. They form the path of the HSE to a fundamentally new level of development and role in the NIS.

A strategically important shift was made in 2013 when HSE entered the so-called Academic Excellence Project "5-100" (Gokhberg and Kuznetsova 2016). Within the group of 15 universities supported by the "5-100" project, HSE was among the leaders and is the only university to maintain a leading position throughout the entire course of the initiative. Since 2020 HSE has taken part in the National Project "Science" (revised in 2021 as NP "Science and Universities"), promoting its competitive positions in the Russian university sector. By the end of 2010s, the Higher School of Economics took the first-second positions among the leading Russian universities by the following indicators:

- Headcount of full-time students enrolled in bachelor's, specialist's, master's programmes (31,600, 2nd place)
- Headcount of master's students (8900, 1st)
- Headcount of students enrolled as olympiad winners (over 1000, 1st)
- Total intramural expenditure on R&D (4.7 billion RUR, 2nd)
- Non-budgetary revenues (10.3 billion RUR, 1st)

- Average salary of teaching and R&D staff (190,000 RUR, 1st)
- Number of positions in top-100 rankings by QS, THE, ARWU (6, 2nd)

In early 2019, HSE held a conference for its staff and students to consider the new university's development strategy until 2030 and the election of the new Academic Council. The actual HSE development strategy promotes a leadership model responding to national and global challenges. It includes an innovative market-oriented education basis, research excellence framework, and an extended "third mission" concept. Strategic goals are based on a diversified financial plan, efficient contract approach, and smart digitalisation of education and research (the latter began to be developed before 2020, but the COVID-19 crisis boosted its implementation greatly). The next sections discuss these elements one by one in order to represent the case as a knowledge triangle phenomenon.

8.3 Educational Policies and Strategies

The main vector for education activities in 2020–2030 extends the trends started at HSE in the late 2010s. It is based on geographical, formal, and disciplinary expansion. For instance, student enrollment will be increased outside Moscow and central regions; foreign students will raise their share up to 16–20%. Traditional full-time courses will be expanded very moderately; however, it is planned to multiply the headcount of online students as well as network education programmes and professional training enrollment. This transition should be enabled by a new educational model based upon open programmes, "real life" orientation, and student-centred planning. Open educational programmes in this framework are equipped with such tools as a single pool of courses, projects, and research for HSE students (allowing for the enrichment of students' educational trajectories with a wider scope of related competencies); students' independent self-control and self-training by means of intelligent systems and assistants; inter-campus courses (students from different campuses can attend to the same courses using digital technologies); courses open to everyone (digital technologies allow for inviting any student to study with a "live" teacher); additional educational modules for "microDegree" certifications for narrow competencies in demand on the market. The "real life" orientation of education is based on their involvement in real design and research tasks initiated by external customers and partners, and the creation of project teams of students in different areas of training. Student-centred planning allows the student to select courses and projects based on their individual goals (three trajectories are offered: general, applied, and academic, differing by the ratio of courses and research/project work).

Educational innovations have become the main priority within the "first mission" of HSE. Their key principles are students' decision-making experience, quick and flexible focus on relevant competences for graduates, and organisational innovation opportunities. Students' decision-making experience arises from the ability to set an individual trajectory for each student, including 50% of variable programme elements, the so-called minors (additional specialisations in an alternative direction of training), extended academic mobility (courses at other universities, including online platforms), and individual selection of projects and studies that make up one fifth of the entire training programme. This experience is also supported by quite strict principles of responsible study (cumulative assessment system encouraging regular learning activities; four sessions a year; a zero-tolerance policy regarding cheating and plagiarism, etc.). A quick and flexible focus on relevant competences for graduates includes the obligatory "Data Culture" module (digital literacy, programming, and data analysis) preparing all students (from humanitarians to physicists) to apply big data analysis methods in their profession, as well as an independent assessment of English language proficiency and teaching professional disciplines in English (prepares students to interact with foreign partners on an equal footing) and compulsory disciplines in economics and law for all (allowing graduates to get involved in such profession more rapidly). Organisational innovation is an important component of the new education strategy while enabling joint programmes with other universities (including foreign partners), combining online and offline learning technologies, allowing fully online programmes and fully English-language programmes.

HSE disseminates educational innovations through the so-called Institutional Network Partnerships with Regional Universities. In 2016–2020 the number of HSE partners increased from three to 40, the headcount of external students enrolled in HSE online courses rose from 100 to 7900, and the number of such online courses was multiplied tenfold (from six to 63). The first double-degree programme with domestic partners was introduced by HSE in 2018, and in 2020 it realised these programmes with five large Russian universities. In 2020–2030 the share of academic disciplines with online courses in collaboration with external organisations is planned to double.

The partnership with other universities is oriented toward increasing the positive impact from HSE on the whole education system. In addition to aforementioned online courses for partner universities, HSE provides internships for teachers, researchers, administrators, and realises a unique Russian Postdoctoral Programme. Initiatives for the integration of education and science with partner HEIs include joint research projects, "mirror laboratories", and joint publication programmes. For 2020–2030 it is planned to multiply headcount of Russian academic and teaching staff who had an internship at HSE (from 1900 to 4400), as well as the number of publicly available HSE online courses and equivalent digital resources (from 200 to 2000).

Additional professional education (APE) is one of priority impacts targeted by HSE. During the 2020s it is planned to increase respective revenues from 1.2 to 6 billion RUR. APE itself will be positioned not just as the sale of education programmes, but as the development of "adult" careers and skills. It will be based on an educational platform (marketplace for facilitation and development through formal and informal learning) and enable the development of APE microdegrees and microdegree "constructors", as well as the creation of additional professional education of a mass, niche, and educational nature at all faculties. Currently HSE is in the process of finalising the establishment of the Higher School of Business (HSB) as a complex APE unit. It will be a leading centre for the training of managers for various areas of the Russian economy and advanced research in the field of management, as well as a key provider of management personnel and technologies for the top companies functioning in the national market. The HSB is expected to dominate in the export of Russian management education and act as a methodological centre collaborating with regional universities, including the National Resource Center for Learning Cases. By 2025, the HSB will receive the main international accreditations EFMD and AACSB, and by 2030 it targets to be included in the TOP-50 of the world ranking of business schools by The Financial Times. Among other things, a modern business school campus is required to successfully accomplish this ambitious task.

Along with the APE, it is planned to create special programmes for the development of general education. The HSE will continue to develop a network of secondary schools realising advanced education programmes. Another direction of activity is support to schools educating children in difficult social conditions. Within the general education initiatives, the HSE implements new standards for education, teaching materials, and teaching methods, provides training for teachers and school administrators, and carries out the monitoring of general education on a regular basis. The overall number of schools supported by HSE in 2020–2030 will increase from 280 to 1500.

Integration with basic science is being realised by the new model of close cooperation with the Russian Academy of Sciences (RAS). It includes the creation of faculties and basic departments in cooperation with the RAS research institutes to promote joint education programmes and research activities according to the network principle of the involvement of associated scientists. Currently four HSE faculties are involved into the initiative, namely ones of Physics (cooperation with 6 RAS institutes), Chemistry (4), Biology and Biotechnology (1), Geography and Geoinformation Technologies (1).

The last, but certainly not the least, remarkable HSE achievement within its "first mission" is the implementation of a new project-based education activity model. By 2024, all HSE students will be involved in "real life" R&D and other practice-oriented projects within existing research departments and project teams. Three forms of project organisation are developed: research and educational groups (undergraduate and graduate students, young teachers and/or research assistants under the guidance of an experienced mentor), research and educational laboratories (horizontal cooperation of undergraduate and graduate students and teachers in the implementation of theoretical and applied R&D projects), and student research sections. All the three forms preserve the educational nature of project activities. The initiative allows for boosting the motivation of strong, project-oriented students and preventing the "burnout" of students from performing exclusively educational tasks.

The aforementioned innovations are based on digital tools and platforms improving the quality of learning, ensuring individualisation, and rejecting unnecessary routines. In 2020, 19% of HSE curricula were created and coordinated in digital or mixed form; by 2030 this share is to be raised to 75%. All HSE students will be submitted to digital individual career services and will have digital portfolios. The university already has many years of experience using the digital Learning Management System (LMS), and now develops an advanced generation of flexible and scalable "SmartLMS". The new system will include artificial intelligence (AI) to generate and grade assignments for online courses, augmented and virtual reality tools, simulators, individual career and digital portfolio services, and self-assessment utilities. In the next sections it will be shown that all missions and dimensions of the university are developing to great extent by means of deep digitalisation.

8.4 University Research and Innovation: Governance and Leadership

University science still occupies modest positions in the Russian NIS, but performs as the most promising and rapidly developing sector of R&D (Gokhberg et al. 2011; Gokhberg and Kuznetsova 2016). Leadership in R&D is a crucial target of HSE development, since it maintains the second position among Russian HEIs in terms of the scale of research activity (intramural R&D expenditure). The university is the second in Russia by number of the Russian Science Foundation grants in social sciences and humanities, and stays between third and fourth positions in mathematics and computer sciences. During the late 2010s, HSE researchers made a big leap forward in performance in terms of share of revenues from R&D realised for businesses and other non-government entities (from 28% to 47%), the number of grants from research foundations (from 76 to 308), off-budget R&D revenues of faculties (increased by 5.2 times), the number of applied research projects (from 189 to 492) and contracts (from 118 to 223), and so on. HSE is a participant in many federal, state, and regional target programmes of the Russian Federation, as well as national and federal projects (52 in total). Strategic partnerships have been formed with major Russian companies and large state corporations, as well as global companies like Samsung, Huawei, and others.

Complex research ("complex" refers to multidisciplinary, cross-field, interdepartmental, etc.) in educational departments is an important factor for the integration of education and science, especially in socio-economic development fields. It is planned to further increase the share of complex research projects in the 2020s from 20% to 40% in the total expenditure on basic and blue-sky research at HSE. Over the past few years, HSE has been acting as the expert and analytical centre for the Government of the Russian Federation. It holds the position of the largest centre in Russia in the field of S&T and socio-economic foresight and forecasting as well as the development of regional-, industry-, and corporate-level strategies. Conducting regular monitoring studies in the main areas of economic and social development (economic situation and behaviour of households, social well-being, digital economy, business climate, development of education, healthcare, science and innovation, knowledge-intensive services, civil society, etc.) and participation in expert groups of major international organisations (OECD, Eurostat, UNESCO, UNIDO, International Telecommunication Union, etc.) make HSE one of the key actors of complex research in the Russian higher education sector of R&D.

In this respect the HSE develops complex interdisciplinary scientific technological programmes responding to big challenges. They include basic and applied research, as well as experimental development projects, and provide variability of research and technology outputs together with the more intensive use of intellectual property. Particular focus is set upon the fields of natural science, technological and cognitive research. The HSE develops respective clusters of high-tech equipment and high-speed big data processing. The university's own advanced facility base, along with the use of the equipment of partner RAS institutes and public centres for collective use is an important factor for high-quality and cutting-edge research.

To set up a bridge between science, project education, and the "third mission", HSE launched the so-called Big Projects. The latter act as elements of a "project-based university" model including "educational sandbox" (an environment for the integration of educational programmes) for large-scale socially-oriented research projects uniting students of different courses and educational programmes. This initiative is aimed towards the new positioning of the HSE and Russian universities on the global academic arena. Its main goal is to enable the constant "assembly" of interdisciplinary research teams at the institutional level within the framework of integrative platforms. As outputs, the "Big Projects" will generate large-scale empirical databases to disseminate and apply as a core for further analytical research. The first "Big Project" is planned to start in 2021 on the basis of the Faculty for Humanities. It will combine four large directions: formal and informal institutional practices in the late USSR, applied ethics, modern Russian language in professional and ethno-cultural interaction, and practices and tools of interaction between literature and society.

The world-level research centre (WLRC) "Human Capital Multidisciplinary Research Centre" was created at HSE in 2020 in the framework of the National Project "Science" (revised in 2021 as NP "Science and Universities"). According to a prescribed open contest-based procedure, the centre was established by a consortium of four leading organisations in human potential research: the National Research University Higher School of Economics (HSE), the Russian Academy of National Economy and Public Administration under the President of the Russian Federation (RANEPA), the Moscow State Institute of International Relations of the Ministry of Foreign Affairs of the Russian Federation (MGIMO), and the Miklouho-Maclay Institute of Ethnology and Anthropology of the Russian Academy of Sciences. This is a typical case of a "centre of excellence" holding a leading position in the field of social sciences and humanities, ahead of many of the world's leading universities by number of publications in international journals (indexed in the Web of Science).

The WLRC programme covers a range of globally-discussed human potential research areas, including its social and humanitarian dimensions; demographic and social factors of active ageing; employment, social activity and basic skills and competencies; impacts from technological transformation and digitalisation; neurocognitive mechanisms of social behaviour; sustainable development and its factors, etc. The outcomes planned for 2021–2025 should appear visible nationwide and globally, while including 118 international publications (WoS- and Scopus-indexed) and 38 new educational courses to be developed and put in practice. More than 2600 researchers will be involved in these activities.

The development of basic research is regarded as a priority function of HSE's "second mission". The HSE has created and promoted globally competitive teams of experienced Russian and foreign scientists and teachers, including Nobel and Fields laureates. They form a strong academic network inside the university, including more than 30 successful R&D centres, 48 international labs, and 45 research and education labs. Annually these units realise more than a hundred basic research projects funded on competitive base. HSE basic research outputs measured by publication activity grew significantly by 2021 (1118 Scopus-indexed publications compared to 128 in 2013). About a half of publications are in the top 10% cited Scopus-indexed journals.

R&D promotion tools at HSE are constantly evolving and improving. Four "pillars" should be highlighted in this respect:

- infrastructure,
- forms of promotion,
- incentives, and
- promotion tools.

Infrastructure provides access for HSE teams and researchers to knowledge and equipment, namely to a large-scale cumulative empirical database, supercomputer, high-tech equipment clusters, in-house instrument base, library repositories and platforms. Forms of promotion are mainly complex S&T programmes, research collaborations, and initiative projects. Incentives include long-term academic bonuses and grants, support to young researchers, and individual research programmes with a three-year horizon. Promotion units assist in publication and include academic writing courses, working paper thematic series, and a number of scientific journals managed by editorial boards involving internationally renowned scholars.

Digital R&D infrastructure enables new opportunities for university science. Nowadays HSE is the only Russian university maintaining "megascience" digital infrastructure facilities in social sciences (under EU-Russia programme "CREMLIN plus"). Among them is the Unified Archive of Economic and Sociological Data (UAESD), a unique archival collection providing free and open access to the outputs from empirical research in social sciences (member of the International Association for Information Services and Technologies in the Social Sciences, partner of the Council of European Data Archives for the Social Sciences). Another unique project in this direction is iFORA, a big data analysis platform (Gokhberg 2020), built on the basis of a powerful supercomputer and data cluster at HSE, and implementing the latest advances in AI. It was recognised by the OECD (2017) as an example of cutting-edge initiatives. Other advanced large-scale resources of this kind include non-invasive brain stimulation facility, infrastructure for longitudinal Russian monitoring of the economic situation and health of the population, and so on.

8.5 The Third Mission and Innovation

The 2020s is the period of rethinking the role of universities in Russia (Gokhberg et al. 2017). HSE started integrating the traditional missions—educational and research—with an active position in the field of social, cultural, technological, and economic development of regions, cities, communities, and industries. HSE became the first Russian university to officially plan and implement its third mission. In 2020 the respective official report was published (HSE 2020). According to this paper, a dozen strategic domains are included in the third mission:

- Social mission
- Service learning
- Environmental projects
- Partnership with NGOs and social communication
- Knowledge transfer and continuing education
- University partnership
- Contribution to the development of the education system
- Development of an entrepreneurial culture
- Key HSE monitoring projects
- Technology transfer
- Development of innovation infrastructure
- Think tank for the regions

The social mission of HSE is being realised within a number of programmes aimed at assistance to vulnerable groups of enrollees, students, and staff, as well as at the promotion of wide public discussion on actual social problems. These initiatives include the “Social Lift” programme (supporting applicants from families with low incomes, with a low level of education of parents, deceased officers, or those originating from rural areas); student social support programme (25%-, 50%-, and 70%-discounts for well-performing paid students and students from low-income families); the Elderly Generation Support Centre (assistance to retirees within the university community); “University open to the city” (the development of the social activity of Muscovites); other initiatives to build a dialogue between city authorities, the expert community, and active citizens on key issues on the Moscow agenda.

Service learning includes regular expeditions (a group of 12–15 students guided by experienced teachers) to small towns and regional centres of Russia to solve practical and research tasks. Students realise field research projects resulting not only in reports and scientific publications, but also in practical recommendations and services useful for the local administration and community. During the first three years of the programme, more than 1500 students took part in 184 expeditions to 68 Russian regions. Another example of service learning is “Project fair” (a project marketplace at the university). Applied project training here is provided through the wide participation of managers and specialists from university research units and external leading organisations in the educational process. Also of great importance is the involvement of students, graduate students, and university staff in significant projects of socially oriented non-profit organisations, successful business structures, and start-ups.

These and many other above-listed directions are described in the above-mentioned official report in detail. The main idea of such activities is that the HSE within its third mission is responsible to the country and the regions where it is present, and should contribute to their social development on systematic basis. Considerable efforts are being made to contribute significantly to the development of the national education system. In addition to higher education network activities, it is worth mentioning the Olympiads ("I am a professional" and others) the HSE organises annually for the talented enrollees and successful future master's students to continue their studies at a leading university (one of partner HEIs) in the country and start a career at a leading partner company. More than 12,000 applicants get to the final competition annually, and their career opportunities are supported by 28 partner universities and over 300 partner companies. Contributions to the school education system are also made by the university. HSE maintains a nationwide network of "HSE lyceums". These are partner schools (350 in total in 55 Russian regions) advancing their education programmes in collaboration with the university and training their methodologists and teachers (more than 1100) in special HSE courses.

Beyond the education system, HSE acts as a "think tank" and contributes to development of the national regions by elaborating strategies and roadmaps; analytics and consolidation of advanced management solutions; the development of project proposals and support for their launch. In this context, in the late 2010s HSE realised over 300 regional socio-economic development projects.

The Higher School of Economics, besides organisational innovation in education and science, contributes to the innovation process directly as well. In 2006 in Moscow HSE students and professors launched their own Business Incubator, and it has quickly become a catalyst for student entrepreneurial activities far beyond the walls of HSE. The Incubator concurrently hosts up to fifteen startup teams. Startups get a fully equipped office space, administrative and consulting support, enjoy free participation at HSE and industry events, and take full advantage of the networking opportunities provided by the Incubator's team. At the end of 2010s, the HSE Business Incubator took first place in UBI Global ranking of the best university accelerators. It promoted more than 800 start-ups which accumulated more than 1.6 billion RUR in investments. More than 3000 young innovative entrepreneurs attended the "Start-up School" training programme.

The previous sections emphasise the role of digitalisation in the advancement of education and research activities at HSE. The same is true for the third mission. For instance, a complex digital environment was created to involve students and staff in socially significant and socially oriented projects. Among other elements it includes the Centre for the Implementation of the Third Mission of the University (the analytical and methodological office of the Higher School of Economics) and a platform for the exchange of experience in the format of free digital internships on the implementation of the third mission (organised for employees of Russian universities).

8.6 Discussion and Conclusion

The brief profile of the Higher School of Economics reflects certain elements of an "entrepreneurial university" and their role in the knowledge triangle environment. The key factors in the development of such universities are autonomy and openness, which, in turn, are based on the effective implementation of the three missions and their management. The knowledge triangle functions in this context are of a two-level nature. The external level includes links with education, science, and business actors within the NIS, while the internal one deals with the integration of the same activities inside a HEI.

The external KT links of HSE are well reflected by a set of performance indicators (mentioned in previous sections, the number and size of various contracts and grants, the number and significance of partners in particular domains, expenditures and revenue in large joint projects, etc.), the range of partner programmes, and positions in national and global thematic lists and rankings. An important detail is that HSE's impact is being manifested with a proactive position: the university declares itself at the national level as a think-tank, as an excellence model for dissemination, as a source of best models and practices, as a provider of valuable networks, products, and services for other HEIs and NIS actors in general. On the other hand, more and more KT links are being established by the HSE not only in terms of education or research activities, but within its third mission. In addition to innovation initiatives contributing to the business enterprise sector, HSE develops and promotes better educational standards (including school education), supports research applicable for the public policy evidence base and meeting the national (and global) social development challenges, enables social lifts, and so forth.

The internal knowledge triangle of a university seems to be a somewhat more basic and less visible subject field. External KT activities are unlikely to remain successful while education, research, and innovation are not combined effectively inside a HEI. HSE's case shows that the simultaneous expansion and merging of the three KT segments require radical organisational innovation (cross-departmental diversified project system, advanced quality management tools, more flexible organisational structure, etc.), as well as more sophisticated resource management. In this respect it is worth discussing digitalisation, human resource management, and financial policies in more detail.

Digitalisation enables cross-cutting organisational innovations in all areas of university activity. In 2019–2020 HSE faced crucial challenges requiring further transition towards a "digital university": the rapid development of ICTs, their expansion in services and everyday life, changing demand for skills and competences of graduates, new opportunities to optimise operations and gain competitive advantages, radical recent changes in lifestyle and professional activities due to COVID-2019. Simultaneously a number of challenges appeared to be met, including a shortage in additional resources, the immaturity of the legal base, a lack of widely accepted common standards, etc. Financial constraints appeared the most significant. In 2019–2020 HSE invested more than 1.5 billion RUR in analytics and the development of digitalisation process (31%), the development of particular digital solutions (26%), and building the necessary digital infrastructure (43%).

A two-year plan developed and realised in the end of 2010s by HSE could be a typical digitalisation “roadmap” useful for many large universities. It includes a number of complex tasks as follows:

- A digital university model has been developed: sub-models (information, process, role, system, etc.), product approach, policies, methods, and methodologies.
- Information security has been regulated in terms of IP security and protection of confidential information.
- An educational marketplace has been developed and put into commercial operation, as has the main components of an open educational platform of the new generation (SmartLMS), an up-to-date accounting educational system SmartReg (accounting for the students, assessment of educational activities) has been launched. In the context of anti-COVID-19 measures, distant admission (full cycle) of students to the university was provided.
- Changing approaches to infrastructure management: the introduction of cloud storage and data processing technologies has started.
- Implemented university management technologies based on big data analysis: the early version of tools and services for preparing analytical reporting, dashboards, forecasts, etc.
- Technological integration solutions have been implemented: authentication services, electronic signatures, access to a single communication bus, master data management services, etc., to ensure the digital transformation of business processes.
- The provision of administrative and management activities with up-to-date solutions and services (SmartBOSS platform): services for personnel, financial, legal, administrative, and other services.

The new system connects different categories of the university population including students, teachers, researchers, supporting and administrative staff, and partners in a smart and complex way, considering their activities, assets, outputs, links, and access/security levels and relays this information to various interdependent services of the university, related with educational, research, project, workplace, partnership, and infrastructure services. Some additional advances to the system will be made during the next decade (regarding possible changes and developments in the environment), but the general framework should remain as it was developed in 2019–2020. The main evolution will be related to improving usability and replicability in order to disseminate this experience and facilitate the digitalisation of other Russian universities. Such digitalisation “packages” will be developed in at least three versions regarding different types of customer universities (in terms of scales and financial resources).

HSE’s case has to some extent limited applicability since its scales, activities, and plans rely upon a relatively large resource base in terms of financial and human inputs. As for the latter, HSE tries to concentrate upon a significant (in some teams—

the main) part of the most productive Russian scientists, as well as a large group of foreign scientists. The best HSE teachers have unique competencies. Most of these employees, who are globally competitive, could have found work abroad, but obtain better incentives at HSE. To attract productive specialists, the university has developed and is implementing a system of incentives for scientific creativity, including high salaries, premiums for publications in leading journals, sabbatical, and academic autonomy.

A number of human resource management innovations were put in practice by HSE including multidirectional (multi-track) career assistance, encouraging academic growth (oriented toward higher level research and innovative educational programmes), teaching advancement (achievements in the development and implementation of educational programmes and tools), and applied performance (successful projects with business, public agencies, etc.). The transition of employees to a sustainable path of employment is encouraged by higher and more prolonged bonuses and preferences. Competitive remunerations are aimed at raising the performance of employees towards the global standards. Professional growth is being realised through personalised continuing training plans and adaptive social assistance schemes.

A relatively strong financial basis is required to support the transition towards an "entrepreneurial", "digital", "innovative" university. For instance, the budget for the complete "digital transformation" of HSE in 2021–2030 accounts for 9.9 billion RUR. In 2010–2020 the annual revenue of the university grew by fourfold, from 6.6 to 26.2 billion RUR with an equal proportion between the state budget subsidies and the university's own education and research activities. By 2030 it is planned to double the revenue with commercial income's share exceeding 60%. The Russian Federation as a founder of HSE provides subsidies as well as competitive programme funding including institutional grants. Being a crucial factor for the sustainable and less risky development of a university, state support should not substitute its entrepreneurial activity.

The results described in this chapter are visible in the global university rankings where HSE has continuously climbed over the decade. However, entrepreneurial universities in the context of their internal and external KT frameworks are characterised by an organisational ethos which is not limited to the university leadership and the preparation and announcement of visionary statements. Instead it is in the mind of university members who are supporting the implementation of respective measures. HSE was capable of establishing an internal entrepreneurial culture which is driven by leadership and university members at all levels. This development has been achieved by coordinated action initiated by the HSE leadership and communicated to HSE staff in transparent ways.

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9 Open Innovation Platforms Fostering the Co-creation and Value Creation in a Knowledge Triangle: The Case of Tampere, Finland

Mika Raunio, Nadja Nordling, Mika Kautonen, and Petri Räsänen

9.1 Open Innovation Platforms as Policy Tools

Under the broad label of Knowledge Triangle (KT), the case study of Tampere, Finland, introduces how co-operation or collaboration is organized within the framework characterized by open innovation platform approach. The main hypothesis is that an evolution from science parks and cluster/sectoral-based policies, with science-based and semi-closed development projects led by a few big companies, is leading towards more agile and user-driven processes of innovation, in which ecosystems and open innovation and platform models are key elements. Open innovation platforms (OIP) provide a new generation of co-creation spaces facilitating the interaction of research, education and innovation, fostered by

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advanced digitalized platform management tools. The emphasis is on orchestration of innovation activities by higher education institutions (HEIs) with external service providers applying a platform approach.

The value proposition of the OIP approach is to engage a much broader knowledge base for innovation activities as a part of the user-oriented open innovation services. The OIP approach moves beyond living laboratory or experiment environment concepts and stresses the service and management mode in digitalized platform economy context (Brynjolfsson and McAfee 2017). Approach enables network effects enhanced by an Internet-based service model. It integrates knowledge bases—including users—for mutual value creation and capturing on the platforms. Innovation services themselves frequently reflect well-organized co-creation and open innovation practices, but we focus more on organization of these services; how orchestration of co-creation and open innovation is organized between the HEIs and service providers. Traditional innovation fostering services at university–industry interface have focused on networking and matchmaking at the early phase of innovation process, whereas recent innovation services align with ecosystem approach and aim to provide more concrete outputs from the process, and thus focus on later phases closer to market. Innovation services with recognizable outputs and monetized value are often closer to private business services than public or semi-public support actions for innovation (Katzy et al. 2013).

KT and OIPs are often integrated or overlapping practices and the authors wish to contribute to the discussion on how to foster developments of KT both from the scholarly as well as from a policy-making perspective. In the case of Tampere, innovation support actions have evolved towards globally operating and Internet-based platform business modes. This development serves here as a case in point.

The data has been gathered as part of the Six Cities Strategy of Finland (ERDF, 2015–2018) to reflect OIP approach with smart city developments by applying a participatory research approach (PAR). The data consists of several interviews, seminars and workshops with policymakers, developers and other stakeholders conducted in 2015 and 2016 (see table 9.2).[1] Relevant documents were also reviewed (e.g. assessment reports and evaluation reports).

The chapter first defines the concept of an open innovation platform, as used in this study, from the regional economic development perspective with an emphasis on the KT context. Then, empirical data and methods are described followed by KT context in Finland and Tampere to frame the cases. OIPs are analyzed in the KT context from the orchestration perspective. Finally, discussion and short conclusion with tentative policy recommendations and some future research challenges are provided.

[1] The project team members, in addition to authors, were: senior advisor Jukka P. Saarinen (TaSTI, UTA) and project manager Taina Ketola, regional analyst Anniina Heinikangas and regional analyst Henrika Ruokonen (Council of Tampere Region). The project is The Six Cities, Open innovation platforms (ERDF and cities).

9.2 Theory, Approach and Method

9.2.1 KT and OIP Approaches to Frame Innovation

The Knowledge Triangle (KT) approach emphasizes the linkages between education, research and innovation. The KT places HEIs at the core of innovation ecosystems, and their performance is interpreted as crucial in scaling up national and even European innovation performance. However, there is still a lack of illustrative examples of what KT is in practice and at the university level (Markkula 2013). To distinguish the KT—that is rather a policy concept than academic approach—from more established university–industry–government models, like the triple helix (e.g. Etzkowitz 1993), we chose to focus on orchestration of two phenomena that the KT approach stresses. These are also crucial elements in the most recent HEI-related innovation activities in Finland.

Firstly, the open innovation and open co-creation activities represent the logic that is increasingly applied in both external relations and internal interactions of HEIs when university–industry–society interactions are organized. This suggests that the collaboration culture of the HEIs abolish silo structures or at least make them more porous. A more human-centred model, adding the fourth P ("people") to the PPP (public–private partnership) models, should be applied. New types of environments for interaction fostering an open innovation culture, communality and a collaborative way of working in the process of development have been labelled as innovation platforms in this context (Markkula 2013; Raunio, Kautonen, and Saarinen 2013; Kautonen et al. 2016). Secondly, many definitions agree that innovation platforms facilitate open innovation and co-creation processes between people, education, research and innovation in a well-organized manner, but on pre-commercial phase that works as argument for the (partial) public support (Lehenkari et al. 2009; Lehenkari et al. 2015), yet, this does not really distinguish the concept from many other parallel concepts like living labs (e.g. Tukiainen et al. 2015). In this paper, we hope to accomplish this task by defining the three categories of open innovation platforms based on their roles as orchestrators of the service provision who deploy the platform-based business model: two-sided or multisided platform that has now become relevant and timely in service orchestration along with "platform economy" (Gawer 2009; Brynjolfsson and McAfee 2017).

The KT framework does not define the *innovation platform* in detail, or much at all. To enable a meaningful discussion, we provide theory- and practice-based working definitions of open innovation platforms. In the KT context, OIPs may be seen as a collaboration model that HEIs may deploy while interacting with the surrounding society and economy to fulfil their "third mission".

The innovation platform discussion is fuzzy and dispersed in the literature and even more so in policy and real life. Thus, the study at hand is linked not only to one but to a few academic discussions and literature streams including regional studies, innovation policy, business management, economics that are consulted during the exercise. Open innovation as such has been discussed extensively during the last two decades (Chesbrough 2003; von Hippel 2005), and fairly solid and commonly shared ideas and concepts exist for both academic and practical discussions. Among the noteworthy concepts are the "lean-start-up" approach and its emphasis on shorter and more agile innovation processes (Ries 2011). Instead, the concept of a platform is much more ambiguous.

In the knowledge-based regional economic development literature, the concept of an innovation platform refers to a policy design fostering related variety (e.g. Asheim et al. 2011). The theory on related variety suggests that combining different knowledge bases (synthetic, symbolic and analytical) fosters innovation activities between different sectors and technology bases. This emphasis on "horizontal knowledge flows" and enabling the integration of different knowledge bases distinguishes the platform approach from the cluster approach in knowledge-based regional development (Cooke and De Laurentis 2010a; Cooke and De Laurentis 2010b; Raunio and Kautonen 2014). This rather ambiguous and abstract definition draws, however, only a fine line between the innovation platform and the cluster approaches. We would argue that a role of openness in the OIP approach also distinguishes the policy design from the cluster approach (Raunio et al. 2013; Kautonen et al. 2016). Importantly, the cluster and OIP approaches introduced here are not mutually exclusive; instead, they may be overlapping and complementary, and the actors in clusters, for example may extend their activities by setting up open innovation platforms. Breaking up of clusters and globalization of value-chains and "unbundling" have made business ecosystems global and development and innovation processes in this context offers "bundles" that advanced and knowledge-intensive regions are eager to focus on due to their high-value creation potential for the local economies.

In the management literature it is possible to find interpretations, which distinguish the concept of platforms from other modes of organization. In most cases, a platform is used to define how to organize production- and innovation-related interactions with external partners (Gawer 2009; Thomas et al. 2014). In various contexts, platform defines the modes of co-operation that usually open the process for new actors and consider new forms of value creation. These include technological product platforms (e.g. iPhone), value chain platforms (e.g. car industry) and industrial platforms (technologies). More recently a platform has been used to describe the Internet-based business models deployed on digital platforms (Facebook and Uber) on which value creation is highly dependent on the ability to attract users and/or developers to use the platform (network effects) (Choudary 2013; Haigu 2014). The capability to attract users/developers who create value for the platform is a shared concern in all platform approaches to various degrees.

Thus, despite the regional economic development-related discussion remains on a fairly abstract level of related variety of knowledge bases (Asheim et al. 2011), it provides the profound observation that innovation platforms have to integrate different knowledge bases, actors and technologies. The management literature, again, offers interpretations of how to organize this rendezvous in digital and physical environments in more detail and how to make it profitable activity (Brynjolfsson and McAfee 2017). A platform is then organizational model to coordinate open innovation processes and to explain their success and failure factors.

Importantly, platform owners do not produce all the key products, innovations or services—or at all—on the platform but rather facilitate the process whereby users of the platform provide most value for other users of the platform, or develop complements. Latter may be developers providing new applications for iPhone users and previous maybe Uber drivers offering a taxi service to Uber clients, who may be drivers themselves. The fact that users are creating value for each other makes it possible to foster network effects; that is, every new user on the platform provides more value for the other users (Gawer and Cusumano 2002, 2008; Sawhney 1998).

This provides many opportunities for knowledge-based development and KT policy measures that frequently refer to intermediaries that aim to bring together knowledge producers and users in order to foster innovation. There are several private services working as digitalized platforms providing open innovation services (Innocentive, NineSigma) that may be considered as a new generation of innovation intermediaries (Howells 2006) and whose practices link clients with innovation challenges and knowledge holders with potential solutions. They are frequently referred to be more suitable for the private sector to organize than traditional semi-public development agencies. Qualities of these platforms include well-defined innovation processes that may be monetized and of which ROI is visible for the service users (Katzy et al. 2013; Hallerstede 2013). It should be noticed that innovation intermediaries (Howells 2006) have deployed a multisided platform (MSP) or a two-sided platform model, by providing, for example science park environments and cluster programs with actors (e.g. research institutions) that attract other actors (e.g. companies) to join the platform. This resembles a shopping mall business model, where good quality shops attract customers, that again attract more shops to set up their branches to the mall, fostering the network effect based on mutual benefits and complimentary services (e.g. cafeterias and parking space) that makes it even more feasible for both groups of actors (retailers and shoppers) to use the platform that the shopping mall offers for their interaction as a multisided or at least two-sided platform (see Boudreau and Haigu 2009). Science park environments have, in principle, benefit from network effects and complement that make platforms attractive to their users (e.g. industry–university collaboration), but recently intermediary activities themselves have applied digitalized solutions that aim to increase the efficiency of the network effect substantially.

Finally, it should be noticed that open innovation (business model) fits well to the concept of a platform as used in the management literature, because platforms, in most cases, organize co-operation processes with external partners in terms of mutually beneficial value creation, in OIPs for innovation purposes. The platform as a mode of organizing interaction and learning—and ambiguous platform economy (Gawer and Cusumano 2002; Choudary 2013)—may be seen analogous to the discussion on networks and network society in the 1990s as an attempt to understand the new logics to appropriate way to interact in economy. Technological progress with parallel institutional and behavioural changes enable the co-evolution that seeks new systemic forms to organize the economy and its actors. Currently, “platform” has acquired a conceptual position that is applied to explain and describe the emerging mode of interaction in both social and economic fields. In general, the platform approach reflects the demands of the new socio-technological paradigm, in which megatrends in the digitalization of technology (e.g. Internet-based business) and globalization of the markets (e.g. business ecosystems) also transform the behaviour in the economy (e.g. a sharing economy) and then foster the emergence of new modes to organize co-operation in innovation (and production) activities.

In sum, the capability to combine different knowledge bases (synthetic, symbolic and analytical), and forms of knowledge in general (science- and experience-based knowledge, codified and tacit knowledge) as well as social capital (or trust) are frequently seen as a key to foster innovation processes. Both digital and physical platforms may enhance this knowledge "cross-pollination", for example in integrating different industries and scientific disciplines, or user groups to co-creation processes (e.g. in living laboratories to utilize experience-based knowledge). Various innovation centres, platforms, laboratories or science parks are largely discussed in regional innovation system and economic development literature and broadly used as examples on how to implement policy (Cooke and De Laurentis 2010b; Harmaakorpi et al. 2011; Boschma 2005). Also, the capability to speed up the innovation process from knowledge to markets in an agile and user-oriented innovation process that shapes the solutions towards practical and marketable products and services. Organizing and engaging users and other external actors, often start-ups, to be part of the innovation process (e.g. in living laboratories and proto projects) are typical tools to implement this goal. Chesbrough (2003), Ries (2011), and are among the key authors discussing these dynamics. Discussion relates also to business and innovation ecosystems and how they facilitate their opening innovation activities. Examples include user communities, online communities, living laboratories and other methods to integrate users or other externals parties to innovation processes, frequently close to the market. It is appropriate to distinguish business ecosystems from innovation ecosystems, according to their expected outputs. In business ecosystems aim to organize value creation and value appropriation in a systemic setting, while "the main output of innovation ecosystems is the increase in information flow and collaboration and therefore the creation of new business-relevant knowledge, ideas and technologies that lead to new products, successful companies, and economic growth" (Huhtamäki 2016: 11). Our aim is to introduce how to orchestrate the innovation activities of these different ecosystems in KT context; the relationships and interaction as service provision and benefits of fostering cross-pollination and opening innovation processes on platforms. The Internet powered and digitalized multisided platform model seeking network effect in innovation service provision for scaling and lowering the marginal costs suggest the emergence of KT fostering services in accordance with the latest developments of "platform economy type of orchestration" (Sundararajan 2016; Brynjolfsson and McAfee 2017).

9.2.2 The Key Question, Data and Method

The key question of the chapter is; What are the characteristic qualities of OIP orchestration in KT context?

We utilize the participatory action research (PAR) approach to answer this question, because it aims to provide knowledge and solutions to practical problems that hinder the achievement of given goals or everyday practices. Researchers are part of the process and aim to foster reflectivity, learning and communication in the target community and among the stakeholders to solve the problems and to foster development (Susman 1983). The essence of the approach is that the researcher, during the exercise, aims to improve a situation or create a positive benefit for people involved. PAR can also be a way of involving more people and new groups into the research in order to reach the set objectives (DeLyser and Sui 2013).

The first and second authors have been engaged in the Six City Strategy as project manager and project specialist in developing management and analysis tools for the OIPs the fourth author has been working in the regional council as an innovation and future manager and he has also been involved in incubating some of the regional OIPs and, the third author has a long experience on regional development and research in the Tampere region.

These roles in project have enabled us to collect the data during the process. The data has been collected as part of frequent practical joint activities with the OIP representatives including interviews, observation, workshops, seminars and a facilitated discussion forum. Policymakers, developers and other stakeholders have been engaged in various activities. These have either been recorded (and transcribed) or notes have been taken. In addition, documentary data analysis, consisting of reports, evaluations, strategy documents, project plans and research diaries have been consulted. The data has been analyzed using an inductive data analysis method (see Appendix).

The Six Cities Strategy of Finland (2014–2020), Open and Smart Services, is implemented by the six largest cities in Finland: Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu. It is a strategy for sustainable urban development, and aims to increase the number of service innovations and to promote competitive business and employment. It is part of the implementation of Finland's structural fund programme for sustainable growth and jobs in 2014–2020.

The strategy aims to strengthen Finland's competitiveness by using the country's six largest cities as innovation development and experimentation environments in the spirit of open innovation. The strategy is based on open "operating models that let the entire city community participate in development work". The functional city community is seen as an entity consisting of citizens, companies, research and development operators and authorities. The open operating model is based on the creation and testing of innovations while also increasing productivity (including the development of innovative procurement practices). (www.sixcities.fi).

Innovation platforms are seen as environments that enable development of new products, services, business and markets throughout their lifespan from idea to testing and from testing to ready-made products. Innovation platforms engage the whole city community to participate in the development processes. The approach is user-driven and encourages short and agile experiments in innovation activities. It may also support cities to develop their innovative procurement practices by their open nature in stakeholder engagement to provide better services and enable business development around the new services (Six Cities Strategy Office 2016). The specific context for the study is one of the three-year spearhead project's: The *open innovation platforms, according which OIPs* are used to create and test new services and products in real-world conditions (two others were the *open data* and the *open participation and services*). Spearhead projects provide create the models for co-operation to enable the city to work as a community. Additional pilot and trial projects support, test and develop further the contents of the spearhead projects.

Our three cases here were explored as a part of the strategy in order to better understand what open innovation platform approach means in practice, here in the context of KT and HEIs. Three specific examples of the OIP development in Tampere, Demola, Mediapolis and Campus Arena, focus on the practices and explain how HEIs and other key actors have worked to realize these ambitions and how they orchestrate differently oriented platforms.

9.3 National and Regional Context of KT-Related Policies and Strategies

9.3.1 National System of HEIs and Innovation Policy

According to some studies, university–industry collaboration is more intensive in Finland than in most of the European countries. However, while the share of the companies co-operating with HEIs was 33%, only 4.9% of firms have announced that the university link mattered. Still, both figures are significantly higher than the average among the EU countries (Evaluation of Finnish NIS 2009; Pelkonen and Nieminen 2015). In short, the impact on firms' real innovative outcomes can be considered as rather moderate and typically more indirect, and then maybe difficult to recognize, than direct and linear.

The R&D expenditure in proportion to the GDP has been among the highest in the world in Finland from early 2000 onwards. The proportion of R&D expenditure of the GDP in Finland peaked to 3.9% in 2009 but then decreased to 3.1% in 2015 (Statistics Finland 2016). The major reason for the decline is lower product development investments in the private sector, whereas the higher education sector and the public sector have reduced their investments only slightly from the top years (Statistics Finland, Research.fi).

The incentives to co-operate with industry or to conduct innovation-related activities are to a great extent lacking in the basic funding mechanisms of the Finnish HEIs, but they are included in the practices of the HEI's main public external funding source. Tekes, the National Agency for Technology and Innovation (named Business Finland from the beginning of 2018), demands and fosters co-operation between the private sector and the universities in its funding programmes. Furthermore, the European Social Fund (ESF) and Regional Development Fund (ERDF) projects encourage co-operation and clearly defined development goals. Tekes's funding concerns, especially the universities and latter universities of applied sciences (UASs, i.e. polytechnics). The direct funding from companies is fairly modest in the case of both types of HEIs and concentrated on the few universities of technology or medical schools among the universities. Direct funding from companies has also decreased during recent years (*Source: vipunen.fi*).

In the **science universities**, the share of external funding (1215 million euros in 2015) was around *55% of the total research funding* (59% major share from the Academy of Finland and Tekes). In the **universities of applied sciences**, the research and development (R&D) funding was 167 m euros in 2013 in total (major funding from ministries and the EU's development funds). Domestic companies provided less than 10% for external funding and foreign companies provided only a small fraction for science universities and virtually nothing to UASs (*Source: vipunen.fi*).

In sum, the profiles of universities and UASs differ from each other very clearly in terms of the amount and sources of external R&D funding. Further, co-operation with business life is strongly biased to a few universities in terms of corporate funding (e.g. in 2014 the University of Tampere alone gathered 57% of the total national funding from *foreign companies* in Finland, mainly due to its vaccination-related research, Aalto University (technology oriented) and Tampere University of Technology together collected about 45% of the total national funding from *domestic* companies).

Place-based innovation policies provide support for the development of KT activities. The wide geographical distribution of universities and UASs in Finland was significant policy action in the 1960s and enabled the introduction of several place-based or regionally oriented innovation policy programmes later on. Several innovation policy programmes and strategies from the 1990s onwards emphasized the collaboration of HEIs with their regional and local economies and societies (inc. Centre of Expertise I, II and III 1994–2013, Open Innovation Environments 2008–2012, Innovative Cities 2014–2017 and Six Cities Strategy 2015–2020).

The most recent national programmes link innovation strategies closely to local urban and economic development. *Innovative Cities* (INKA) is embedded in the regional and urban development frame and is overlapping with the *Six Cities* programme. INKA (Tekes funded) aims to foster the *innovation activities of firms* and develop "internationally attractive innovation clusters in Finland", while the Six Cities (ERDF funded) focuses on *building competences of cities and local public actors* to foster (open) innovation. Since the latter provides context also for this study, we define it a bit more in detail later on.

9.3.2 Tampere Region as an Innovation Environment

Tampere region is centrally located in Southwestern Finland and, together with the capital city region of Helsinki, forms nowadays the most dynamic regional economic zone in the country in terms of, for example population growth or investments. The administrative Tampere region has approximately half a million inhabitants of which about half live in the city of Tampere.

Table 9.1 Profiles of the higher education institutions in Tampere

HEIs in TAMPERE	University of Tampere (UTA)	Tampere University of Technology (TUT)	Tampere University of Applied Sciences (TUAS)
Students, 2014	14,952	8390	10,290
Teaching and research personnel, 2014	1068	1118	421.4
Foreign students, 2013	535	797	293
Degrees/graduates, 2014	2571	1598	1856
HEI spin-offs, 2014	.	3	2
Basic budget funding, M€, 2014	116.3	82.0	65.3

During the 1960s, the University of Tampere (UTA) and soon after followed by a small unit that would become the Tampere University of Technology. In 1990s, the Tampere University of Applied Science was established (as polytechnic first).

The University of Tampere (UTA), with its 16,000 students, focuses on society and health. Its leading fields of research include, for example information, information technology and knowledge; cities, the environment and the regions; journalism and media; changes of society; and the individual and the health of the population.

Tampere University of Technology (TUT), with its 10,400 students, has a reputation as an industrial university due to its long-lasting close collaboration with industrial companies. The leading fields of research are especially signal processing, optics and photonics, intelligent machines, bio-modelling and the built environment.

Tampere University of Applied Sciences (TUAS), provides a versatile supply of practically oriented graduates in, for example computer science, media and graphics, digital gaming and many other fields.

In addition, the large R&D facilities of the Technical Research Centre of Finland VTT (with more than 300 experts) provide the companies with an R&D partner, especially in those three areas of competence that are at the core of strong local clusters.

The integration of research, innovation and education may be found in the strategies of all three institutions in Tampere. However, the "third mission" and especially links to industry and business are much more explicitly formulated in the strategies of the Tampere University of Technology (TUT) and the Tampere University of Applied Sciences (TUAS) than the University of Tampere (UTA), which is more oriented towards social sciences and medicine. Importantly, the three HEIs have started a merger process that will be completed at the beginning of 2019 (Table 9.1).

In the current decade, every fifth inhabitant of Tampere is a student in a higher education institution and every third inhabitant over 15 years of age has a degree from a higher education institution. Out of almost 10,000 R&D workers in 2010, more than half were employed by the private sector. The most recent structural changes have changed the situation due to lay-offs from big high-tech companies. Changes have been significant, and it is likely that they are not yet fully reflected in the numbers provided above although it seems that employment of knowledge workers has not fallen due to growth of many new companies and growing entrepreneurship.

It seems that the recession in 1990s sped up the development towards more knowledge-intensive mode of the economy. In Tampere city region, for many years R&D expenditure has represented approximately 15% of the national total (more than 900 million euros annually). This is more than 2000 euros per inhabitant from 2006 until recently; thus, Tampere has represented the national top level in R&D intensity. Of the gross regional product, R&D has accounted for about 7%.

There are three key clusters and industrial agglomerations based on competences developed over time, and it is not likely that fundamentally new knowledge bases will emerge in the region.

The ICT cluster employed more than 6000 engineers until 2015, but recent turbulence in the ICT industry has made the situation less clear. A key long-term strength of the cluster is its wide-ranging spectrum of industries, application domains and product competences. Key areas include telecommunication networks and Internet and cloud services. The recent structural changes have taken place, especially in the field of mobile handsets.

Intelligent machines represent the traditionally strong technology cluster in Tampere and its immediate vicinity, with more than 1000 companies that account for the added turnover of more than 7000 million euros (2011) and employ more than 34,000 people. The R&D investments account for more than 750 million euros annually, which refers to the serious attempt of the leading companies in sustaining their innovativeness. In fact, ten world market leaders operate in Tampere. Many have invested in the local innovation environment (e.g. the world's largest production automation and testing site for container terminals as Cargotec Group invested approximately 35 million euros in its new technology centre in 2012).

Within the life sciences cluster, the city has a combination of multidisciplinary, technological, biomedical and medical expertise in the education, research, healthcare and business sectors. In recent years, the health, wellness and biotechnology sector in the city has been the fastest growing in Finland and received the largest number of private investments in business development.

In addition, the (digital) media have been a strategic field that Tampere has been emphasizing in its development programmes, mainly due to the potential that the location of the national broadcasting company has provided for the region rather than the actual significant size of the cluster as such. Of course, it has many ways integrated into the strong ICT cluster. ICT and digitalization clearly influence strongly on all the clusters of the region.

A knowledge-based development policy in the Tampere during the past decades includes the construction of a basic innovation infrastructure, such as universities and their mechanisms for technology transfer, science parks, programmes of centres of expertise and clustering, and so forth.

According to Smart Europe Assessment (Tampere Project 2013): “There is a unique co-creative and collaborative atmosphere between universities and businesses” and large, locally initiated public–private partnership-based innovation programmes have generated cumulative competences and confidence to conduct large-scale innovation policy operations with high impacts (see, e.g. the Final evaluation of the National Centre of Expertise Program).

The latter part of the 1990s saw the emergence of a supply-driven cluster-based innovation policy that bore fruit first as an enabler of rapid growth in the ICT cluster and then, on both sides of the millennium, as large innovation programmes (e.g. eTampere, BioNext and Creative Tampere). From 2005, a more demand-driven approach was applied. This is, for example to exploit the potential hidden in the large public sector (innovative procurement), in highly educated population (democratization of innovation) and in more active IPR management (open innovation) of companies and higher education institutions, (e.g. Open Tampere), including OIPs as tools with the potential to implement the goals of these strategies under the open innovation and the “smart city” frameworks. This is visible, for example in territorial strategies and regional funding decisions of the Regional Council.

9.4 Cases: Knowledge Triangle and Orchestrating Interaction through OIPs

Both city of Tampere and Tampere region (Regional council) have fostered the innovation platform-based on policy from 2008. The first application of the innovation platform approach was New Factory and its four “engine rooms” from 2008. The following substantial investments were Mediapolis (2013) and Campus Arena (2015), of which both included physical environments as a key element, while “the original platform laboratory of New Factory” focused more on the provision of service processes. For example, in the implementation plan of the wider city strategy—that is also aligned with other key policy strategies (“to make Tampere the best place in Finland to business”)—the policy measure is defined as “developing and scaling of innovation platforms and environments to new lines of business in order to create new business, growth companies and jobs” (City of Tampere 2013).

However, an “innovation platform” as a policy measure is still evolving. For example, subregional development agency Business Tampere introduces various open innovation platforms on its website (including all three cases discussed here) where the common nominator is the possibility for companies to somehow join innovation and development projects on these platforms. More precisely, various forms of collaboration (e.g. living laboratories and demo-projects) to foster opening innovation processes and well-organized facilitation that enables provision of numerous innovation projects are defining qualities (e.g. Lehenkari et al. 2015). However, our interest in this paper is to understand the orchestration of OIPs in the

KT context. Orchestrator in this chapter refers to actor(s) who provide value by organizing relationships and interactions on platforms for the members of the ecosystem, and beyond. It should be noticed that the multisided platform model applies to both, physical (tangible) and digitalized (intangible) platforms that aim to facilitate open innovation practices. By digitalizing and scaling services, it might be possible to run them more efficiently (e.g. without project funding from EU) and due to specific service processes possibly create a consistent and comprehensive set of innovation services.

Cases provide examples of HEIs orchestrating both physical and digitalized platforms. Three cases accommodate the diversity in types of higher education institutions as well as different partnering key orchestrators of the platforms:

- Platform management company New Factory International ltd. (NFI) orchestrates student–company innovation projects in partnerships with 58 universities in 13 countries (Demola Network). Company provides innovation services then globally with support of digitalized platform tools, including all three HEIs in the Tampere region.
- Finnish university property ltd. (SYK) works in partnership with Finnish universities (16 locations in Finland) and in our case of Campus Arena in close operation with Tampere University of Technology, orchestrating university and industry interface by gathering and curating various innovation services and practices as well as companies to the new building in campus.
- The Finnish Broadcasting Company (YLE) as a "keystone company" in premises owned by Technopolis ltd. (renting out premises for business in 4 locations in Finland and more in 5 other countries) with the Tampere University of Applied Sciences.

Three simplified models represent close partnership of HEIs with companies that focus on providing tangible (physical premises) and/or intangible (services, software, processes) assets that aim to foster KT activities with various extent.

9.4.1 Demola: Digitalized Global OIP for Local Innovation Ecosystem

Demola network is "lean corporate innovation engine" and "global co-creation platform to connect universities and business" according to its website. Network is facilitated by New Factory International ltd. a platform management company that works with more than 50 university partners in 18 sites spread to 13 countries and it has more than 650 customers. Concept of Demola was established and developed at Tampere by the local development agency as a part of the New Factory innovation centre in 2008. In 2011 a private company, New Factory International (NFI), was established by the key persons of Demola to run and develop the growing international network of Demola sites. In 2018 also Demola in Tampere was acquired by the NFI and the whole network was under the private "platform management company". To a large part, the spreading of the service may be seen as a result of applying the business model of a multisided platform with well-defined concept and supportive Internet interface and software. Service brings together university students and companies as "on-line-to-off-line" type of a service that use digital platform to link the users but actual service process takes place in physical space, and provides benefits for both sides of the platform (Bjyrnolfosson and McAfee 2017).

At first, Demola was part of the New Factory that itself represented a new type of "innovation platform laboratory", as or innovation centre in Tampere. It consisted of four "engine rooms": Demola (generate prototypes and demonstrations from ideas typically coming from private firms, developed in projects by multidisciplinary student teams), Protomo (similar service for self-employed and experts often in a phase of career transition), Suuntaamo (open test laboratory for new products and processes) and a service for social innovations. The aim was to be "customer focused, down-to-earth, agile, cost-efficient and effective" and then clearly foster the development of new type of practical innovation services compared to traditional cluster-based R&D projects.

Till date, a typical collaboration scenario in Demola includes a multidisciplinary student team gathering (cross-fertilization of knowledge) students from the universities and polytechnics, and a project contract signed by the stakeholders (the firm and the team), including issues related to IPRs and the timetable. Demonstration of the concept or prototype is carried out by the student team, followed by the project evaluation and the finalization of license agreements.

The benefits of Demola are not limited to a single firm, since the student team also has a chance to utilize the immaterial assets created by setting up a start-up company in a case in which a firm does not acquire a license for the IPRs. Students may also be recognized for their talent, leading to employment. All the IPRs generated during the project belong to the student team. At the end of the project, the partner firm can acquire a license for the results and reward the students for their work according to the performance criteria agreed earlier. The method is effective, due to the well-defined IPR framework (which avoids the contractual costs of collaboration), the focus on the concepts pre-selected by firms and the diverse set of skills and ideas of the students working on it.

Importantly, in case of Tampere, the projects are conducted by students from the three different HEIs, with wide disciplinary backgrounds. Student are also provided by credit points of the participating HEIs, with varying practices.

However, in terms of orchestration the most distinct quality is that structure makes the service scalable and with digitalized customer interface and management process enables the management of the open innovation projects globally. New Factory International employs around ten people (with less than one million euros turnover) and there is clearly one core service process that it efficiently repeats on the platform in co-operation with HEIs.

Demola facilitates a fairly complex student project, while usually on-line-to-off-line platforms provide simple and single service practices (e.g. Uber's taxi drive). As a (transaction) platform (Evans and Gawer 2016) it connects mainly two groups of users—university students and local firms (or other organizations) open innovation projects. While global networks provides data to be analyzed in order to develop organizational innovation management capabilities and this is done, as further investment to intangible innovation infrastructure, it may be claimed that not full potential of global network is yet utilized from customer, companies and HEIs, point of view. It seems that innovation projects are taking place mostly at local level around the each individual Demola location, rather than among the global network. Therefore, global networks and digitalization do not solve the problem of distance in innovation as such, and international innovation projects do not emerge simply due to global network of one of the orchestrators and platform owner, without active role of HEIs themselves as orchestrators. Demola as co-orchestrator of OIPs may be labelled as "Global innovation platform service".

9.4.2 Campus Arena: Physical and Digital OIPs to Renew Local Innovation Ecosystem

The Campus Arena is a building within the TUT campus owned by the University Properties of Finland Ltd. (SYK). Even though it accommodates some of the basic services of the university (e.g. the library), its profile is strongly built on the new kind of university–industry collaboration activities. It is marketed as a "meeting place for science, research and technology". Compared with the Demola or Mediapolis, the Campus Arena is more clearly service KT activities of one institution (TUT), as it is located in the central place on the campus and is a new landmark of the TUT (opened in September 2015). Consequently, during the course of the study at hand, many of its KT-related practices were still evolving.

The premises are owned by the SYK, a fairly new actor in the real-estate business, established in 2009 to maintain virtually all the premises hosting the Finnish HEIs (excluding Aalto University and the University of Helsinki), and it has been actively searching for new and innovative solutions (e.g. learning campus, co-creation) to maintain the value of the premises.

Campus Arena was developed by the SYK and the TUT by engaging companies, students and university personnel to search for feasible collaboration models as well as spatial solutions. Partly this was due to need to renew the business co-operation models, as the long-term partner Nokia closed its major research and development facilities next to TUT campus. In the selection of tenant companies the TUT holds a veto right to ensure that they fit to the research and educational goals of the university. The biggest single client of the Campus Arena is also the TUT.

The physical office spaces were planned to support collaboration (co-working spaces, big rooms, etc.) and services were planned to foster opportunities of actors to move "across the borders in their value creation process". This may be seen as an attempt to move from networking and interaction towards more "organized collisions", to support the innovation activities or co-creation between the actors. Specifically for the Campus Arena with an emphasis on co-creation and co-working opportunities was developed the Campus Club by the SYK, whereby premises are not rented to the companies but they may buy a membership of the club for three years. The club offers flexible space for long-term face-to-face collaboration compared to, for example many "cluster-based" projects, in which teams may work apart from each other and the most interactive link between the companies is the project steering group. However, service emphasis spatial solutions and self-organizing of members.

Campus arena hosts companies offering innovation supporting services, the building itself includes, e.g. sensors that enable its use for various analyses and TUT may organize workshops (e.g. with students and companies) or use of laboratories in campus area. Importantly, companies like DIMECC (Digital, Internet, Materials and Engineering Co-Creation) owned by several HEIs, knowledge-intensive companies and other stakeholders or SMACC (Smart Machines and Manufacturing Competence Centre) owned by the University of Technology and Technical Research Centre of Finland (VTT) ltd provide various services and support activities to companies to organize innovation activities with the university or with other companies. DIMECC, for example labels itself as a "leading breakthrough-oriented co-creation ecosystem that speeds up time to market" whose innovation platform offers both digital and process services. These include digitalized innovation services like "Demobuuster" service that is for sale for the companies who seeks "to speed up the commercialization of their software demos". Process as such is not very different from Demola process. SMACC offers one-desk service to manufacturing companies to research and innovation services. In sum, DIMECC and SMACC are entities owned by the business and research communities that aim to foster the innovativeness in their respective fields, to benefit the community and ecosystem at large.

Thus, as a Campus Arena offers a physical platform for various independent service providers and their real-life innovation services to foster the university–industry interaction. Tenants of the arena are aligned with the objectives of the research and education of TUT. The model resembles "innovation service shopping mall" mode where complementing services makes it more attractive for the users (e.g. companies, university researchers, and students) to deploy. As open innovation platform orchestration model, Campus Arena aligned with strong research orientation and strategy of TUT, with many specialized innovation supporting services may be labelled as "*innovation ecosystem hub*".

9.4.3 Mediapolis: Physical OIP for Local Business Ecosystem

Mediapolis gathers together over 700 employees and 600 students in Tampere in a renewed campus built around the old studio complex of the national television Channel 2 and national broadcasting company (YLE) outside the established university campuses. The Mediapolis aims to develop an internationally recognized centre of excellence and business in the field of media, especially by fostering collisions between ICT and creative industries. The motivation for local stakeholders is based on the attempt to strengthen the media business in the Tampere region, as it is increasingly concentrating on the capital city region, instead. In fact, one of the key triggers was the organizational restructuring of the national broadcasting company (YLE) and plans to move activities from the Tampere studio complex to the capital city. YLE is the largest content provider in Finland.

The idea of Mediapolis was initiated in 2011 when YLE was seeking more co-operation with its partners to support the vitality of the creative business in the region. In 2012, the YLE sold the studio complex to Technopolis, of which the core business is the management of business premises in several locations in six countries. The YLE and the University of applied sciences of Tampere (TAMK) made 20-year contract with Technopolis. Other firms move in 2013, students of arts and media (TAMK) and media assistant students from vocational training school (Tredu) in 2014. In 2016, there were more than 30 media, ICT and expert service companies on the campus. For students, the campus offers the opportunity to benefit from the audio-visual devices and studios of both companies and educational institutions, as well as co-operation opportunities with the companies (e.g. studio premises, design services and wardrobes), and assignments offer students opportunities to link with business.

Vocational training, civic engagement and links to the urban development suggest that experience-based learning and innovation play an important role. Mediapolis with studio facilities offers technological development platform for various innovative projects. For example, companies and educational institutions have co-produced the e.g. a trans-media storytelling project that cross-fertilizes different media and research fields (inc. Universities, vocational training school, Microsoft, Apex Games) with a contract according to which each actor maintain their IPR on everything they provided for the project. Clearly various knowledge bases from symbolic to analytical were integrated (e.g. virtual reality, acting, theatre and gaming). Mediapolis is also linked to urban development in the neighbourhood of Tesoma close by and solving of social problems that have agglomerated there.

The ultimate goal for Mediapolis was to increase the flow of innovations from the campus to the industry but also provide benefits for other platform users. Due to nature of the business, where key-stone company buying and orchestrating major productions, the external innovation platform services could focus rather on new technological solutions with (e.g. AR, AI or VR). The key actors of Mediapolis agreed that there is a need for a co-creation platform (co-operative among the small companies and another co-operative among the big players), but it should be noticed that in the media business, many small companies engage in co-productions, frequently led by major company in the field. Thus, in other words model where "strategically minded keystone companies shape and coordinate the ecosystem, largely by the dissemination of platforms that form a foundation for ecosystem innovation and operations" (Inanti and Levien 2004), may be recognized here. YLE is a key buyer and organizer of productions involving several companies, but it has not been eager to set up a platform to further enhance the innovativeness of the ecosystem. Instead, public sector actors have been funding the emergence of these platform type of activities on Mediapolis. For example, private media focused accelerator service was bought to offer services and VC fund for the creative industries was established (IPR VC fund for creative industries). In Mediapolis, the service development is based on regional development funds and projects rather than more established innovation services, although IPR VC fund has a private base.

Mediapolis may be seen as platform with technological environments, YLE as a "key stone" company (along with couple of others bigger companies), smaller companies and start-ups as members of ecosystem, and practically oriented HEI that brings these actors to the vicinity of each other and thus fairly passively foster their interaction and innovation activities. Due to given set up and lack of strong commitment of research institutions, Mediapolis may be considered as "business ecosystem hub" in terms of orchestrating it as open innovation platform.

9.5 Discussion and Conclusions: Towards Inclusive Innovation Policy Design

To reflect the knowledge creation and capture in OIPs, it was obvious that knowledge bases (Asheim et al. 2011) were combined and proximities (Boschma 2005) sought among them. The question is how to organize these processes efficiently among the "ecosystems" that platforms are serving. Digitalized (intangible) and physical (tangible) innovation platforms foster the interactions among the actors of the ecosystem. There are, however, differences how sufficient proximities (physical, cognitive, social or institutional) are sought and how in detail innovation processes are organized among the actors on the platforms.

The societal impact of OIPs is related to spill overs and serendipity that they foster. Many of the impacts are intangible and relate to learning or ecosystem developments. These are very difficult to measure and visualize, and when KT is expanded to solve social further problems and urban development challenges, even further revision of the measurement and indicators that are used to orchestrate the OIPs and related KT strategies, are required. Thus, OIPs offer potential tools to leverage the societal impact of KT activities. However, in orchestration and regional innovation policy at least the three questions emerge: (1) How does the ownership of the intangible and tangible assets on the platform impact on the orchestration and its focus? (2) How to create network effect by utilizing the platform model? (3) How to foster inclusive qualities in OIPs, especially when approach is transferred to urban development and more active citizen engagement?

Firstly, it should be further explored how the roles of the companies partnering with HEIs as key orchestrators and owners of the platforms impact on the development of innovation processes and services on the platforms. How to combine physical and digitalized platforms appropriate way to maximize the benefits for the users and ecosystem development. In our examples two of the partnering orchestrators, Technopolis and SYK both holds physical premises with more than one billion euros in value, and have related annual turnover between 100 and 150 million euros. Their business revenues are strongly linked to a tangible asset. In case of NFI, it mostly relies on intangible assets (e.g. concepts, software and training) for its clients (with less than 1 m turnover). In Mediapolis, platform is built around one key-stone company, in Campus arena mostly around TUT renewing its

KT interface with local business in a way that supports its research and education goals. NFI serves the HEIs and companies with one specific innovation service concept globally. It may be considered important, what are core incentives for co-orchestrators and platform owners who invest tangible or intangible assets in KT context; why is the platform created, what are expected outcomes and how the platform owners define the returns that they seek from these activities at the first place?

As we know, intangible and tangible investments have many different qualities, including the fact that value of intangible asset is much more depending on its successful performance than tangible assets. Further, distinctive features to provide serious competitive advantages are often much more likely to be organizational (intangible) than physical (tangible), and include elements like management, processes, software, trust and so on (Westlake and Haskel 2017). Further, in case of sufficiently digitalized platforms "perfect, instant and free" provision of service makes them more scalable than physical investments, but in "on-line-to-off-line platforms" physical world creates constrains that may seriously limit the scalability of the online services (Brynjolfsson and McAfee 2017). These are crucial questions in orchestration of OIPs that combine tangible and intangible platform models to foster KT strategies; do actors seek returns from intangible or tangible investments, do they consider private returns or social returns more crucial, and so on.

Secondly, key competences include capability to create network effects. Incentives and carefully built feedback loops, rewards and value capture processes including IPR management practices are crucial. For example, lack of funding or career related incentives in HEIs may hinder the participation of academics, or poorly done IPR the participation of companies. Therefore, benefits that different actors provide to each other and incentives for actors to work together should be carefully considered, not only at the operational level, but also more strategic level. Also, case of Global platform management company points out that crossing the geographical distances in knowledge deployment—innovation processes—does not occur simply by linking universities and companies to the same network, but further activities would be required to enhance the innovative interactions globally.

For the platform management the revenue logics, facilitation and curation, value creation and capture among the members of multisided platform, capability to create a network effect are crucial competences, among the others (Haigu 2014; Gawer 2009). These should be sufficiently developed to benefit all the users and owners of the platform in both, physical and digital environments.

Development of management capabilities both on strategic and on operational level include also the conceptual understanding of the tangible and intangible OIP approaches, tools to measure the outcomes (including intangible spillovers and investments in learning), recognizable service profiles and comprehensive and compatible service offerings for the target groups in regionally relevant innovation ecosystems. The HEIs in partnership with co-orchestrators have to consider these capabilities and various complementary services and assets to build the appropriate entity to foster societal impact while benefitting research and education.

Thus, the paper was able to provide only partial answer to the question introduced; Global platform management services and physical innovation hubs have different characteristics in orchestration of HEIs KT strategies. While there are some common ground, the role of intangible and tangible assets and returns should be well recognized when developing the OIP processes. What is the most appropriate combination of orchestrators in each case, requires tailor-made solutions, as usual in provision of local or regional innovation policy.

Finally, in the context of Six Cities strategy further challenges in network effect provision are likely to emerge as the even wider civic engagement (e.g. citizens and unemployed) is sought after. Public procurement and open data as a new source for innovative business offer various opportunities to use OIPs for sure, but the questions above should be considered. The value creation with users should not be based only on volunteers or ostensible rewards for the “lab rats”, but real benefits for the “external parties” are important. It is also important to monitor, that activities and their outcomes are societally responsible in the long run.

OIP approach may be seen as an inclusive innovation policy for the developed economies, which suggests that the inclusive processes engaging more people in innovation activities may also offer more benefits to a wider group of people. This may take place through their roles as innovators or as the users of the end products or services or both. Thus, the policy design is parallel to those that are suggested for many developing countries (OECD 2014, 2015), promoting the idea that not only innovations as such are important, but also the inclusive process and well-designed value capturing protocols.

The assumption is that people, for example receive returns from the use of their knowledge and may create networks or learn how to engage with and benefit from the surrounding innovation ecosystem. Benefits are acquired not only from the innovative outcomes but also from participating in the process (e.g. when solving the societal grand challenges).

Therefore, OIPs should be framed in the wider policy characterized by the inclusive innovation approach. This is not the only question of justice, but also most likely also crucial part of sustainable economic structure of societies, according to recent studies (Mazzucato 2016). Therefore, developing new modes of deploying knowledge of society—including HEIs—the responsible qualities in both processes and outcomes should be secured in terms of equity and sustainable economic growth.

The inclusive approach is parallel to the user-driven or open innovation approaches but has a different point of departure. In open and user-driven approaches and in creativity discussions more generally, the innovation process is believed to benefit from the wider engagement of users, various stakeholders or professionals as providers of useful knowledge and insights into the process.

The platform approach, with users providing value to each other, the facilitation of network effects and combinations of digital solutions and physical innovation hubs, should be considered carefully as a significant part of the solution to contemporary challenges in both KT policy and regional knowledge-based development policies more generally.

Appendix

Table 9.2 Summary data gathered from January 2015 to December 2017

Sources	Quantity	People engaged
Interviews with OIP representatives (the three cases)	14	14
Workshops and seminars engaging people from the three OIPs in questions and linking them to a wider discussion on OIPs (operational and strategic level regionally and nationally)	12	c/a 400 (20–40 people in each)
Strategic and operational level engagement **meetings** discussing OIP development (regional and national level), varying events from engaging a few people to festival events)	c/a 100	c/a 500 (altogether these events have gathered approx. 2000)
Discussion forum on OIP development in Tampere region (development of views) from spring 2016 to spring 2017	Platforms and strategy level representatives from the Tampere region and nationally	Forty in Tampere region, 80 nationally (13 platforms from Tampere, 25 nationally)
Innovation project (facilitated by an OIP in question)	2	The authors have been involved in two innovation projects (Lintukoto & Demola case project)

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Knowledge Triangle Configurations at Three Swedish Universities

10

Eugenia Perez Vico, Sylvia Schwaag Serger, Emily Wise, and Mats Benner

10.1 Introduction

Universities are currently facing mounting policy expectations to assume a broader societal responsibility. As part of these expectations, policy institutions such as the European Commission and the OECD (EC 2005; OECD 2016a) have stressed the need to strengthen the two- and three-way linkages between research, education and innovation,[1] which they refer to as the Knowledge Triangle (KT).

The chapter is based upon a previously published paper by the authors with substantial further developments. Vico, Eugenia Perez, Sylvia Schwaag Serger, Emily Wise, and Mats Benner. "Knowledge triangle configurations at three Swedish universities." Форсайт 11, no. 2 (eng) (2017).

[1] The third corner in the KT has been referred to as the third mission or innovation. Although largely overlapping, these concepts are not synonymous. In this chapter we frame the third corner of the knowledge triangle as innovation, since it is the most commonly used term in the KT concept. In the

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Although the value of linking research, education and innovation is well known, strengthening links has often proved challenging (Maassen and Stensaker 2011; Sjoer et al. 2016), revealing tensions between different tasks and institutional levels (Pinheiro et al. 2014). These tensions are to some extent inevitable, as the logics and reward systems of universities' tasks differ: education is place-bound and localised in its practices and reward systems, research is primarily valued according to its contributions to international communication, whereas innovation takes many different forms, from the tangible to the tacit. Hence, the task of aligning the tasks and creating meaningful and rewarding linkages between them is fraught with tensions. Moreover, these tensions can be assumed to play out differently in different types of universities. Universities are conditioned by factors such as their history, societal connectivity, operational focus and size (Clark 1998; Stensaker and Benner 2013). This means their strategies and procedures for creating KT links can be expected to vary: teaching-intensive universities start out from their educational mission and align research and collaboration to that ("vocational drift"); research-intensive universities can be expected to use education and research as prolongations of their research strengths ("research drift"), whereas universities with strong societal connections will mobilise their research and educational tasks to meet specific needs and demands of their societal environment ("societal drift") (Martin and Etzkowitz 2000). These developmental paths can then be related to and compared with the ideals behind the KT conceptions, namely that the three missions and tasks develop in parallel and without a hegemonic centre (cf. Etzkowitz and Leydesdorff 2000).

Given the significant policy interest in the KT, we see a need for a comprehensible understanding of real-world manifestations of the concept. Without such an understanding, resources may be misspent, and a misguided pressure on academics and universities may emerge. Although significant policy attention has been directed towards the KT, the scholarly interest has been lukewarm: only two studies explore the three-way linkages of the KT in universities and both focus solely on the individual level (Holmén and Ljungberg 2016; Sjoer et al. 2016). The question of how institutions organise for supporting KT principles, therefore, remains unexplored.

Against the above, we set out to study how the principles of a KT are orchestrated at universities, guided by an exploratory research question: how are the principles of a KT manifested in the organisation and strategy of different types of universities? Given this ambition, Swedish universities are of particular interest as an object of study. All Swedish universities are expected to cover the three corners of the KT within the same organisation and serve as "research institutes of society" that undertake a broad range of activities from basic research and education to contracted research and training. In addition, all educational programmes are included in the academic system, and all universities are included in the same unified university system with a similar remit. Furthermore, due to recent reforms, Swedish

context of this chapter, we define innovation as the exploitation of university-based knowledge outside the academic realm.

universities hold a large degree of organisational independence from the state: their reward system, organisational matrixes and structure of positions can be decided without governmental approval. This creates an opportunity to study a diversity of institutions within a unified system with similar expectations and opportunities to incorporate the principles of the KT.

10.2 Analytical Framework and Method

In line with Markkula (2013) and Goosens and Sjoer (2012), we regard the notion of a KT to be a conceptual and normative framework for understanding the creation and dissemination of knowledge as a multifactorial and systemic process that integrates education, research and innovation in a synergic way. The KT may be manifested in a rhetorical or political way, or through the build-up of new structures and processes on micro- (individual or research groups), meso- (faculty, departmental or organisational) or macro- (national or international policy) level. The KT builds on the assumption that linkages are fruitful and thus should be strengthened; our starting point is instead that such linkages will be temporary and conditional in the multipurpose setting that contemporary universities form (cf. Maassen and Stensaker 2011).

10.2.1 Literature Review

To our knowledge, only two scientific studies explore the three-way linkages of the KT on an institutional level: Holmén and Ljungberg (2016) find reinforcing spillovers between tasks, with research being the task that contributes most, and Sjoer et al. (2016) show that individual perceptions on the nature of a task is the main barrier for creating linkages. However, there are other relevant contributions covering two-way links that help us set a framework for capturing KT manifestations.

Firstly, the link between research and education (the Humboldtian tradition) has received significant scholarly attention. Studies offer evidence of mutually nurturing links between research and teaching (Robertson and Bond 2001; Holmén and Ljungberg 2016), and task integration (Colbeck 1998). Concurrently, others show that the Humboldtian ideal is hard to live by. Geschwind and Broström (2015) provide evidence of a division of labour on staff level between the tasks, and Marsh and Hattie (2002) show that there is no significant relation between research productivity and teaching quality. Debated causes of the divide include the concentration of research and the factual cost-effectiveness of the division of labour on individual or institution level (Clark 1997; Maassen and Stensaker 2011; Pinheiro et al. 2014).

Secondly, the link between research and innovation has been explored through studies of research collaboration (Sonnenwald 2007; Bozeman and Boardman 2014), university–industry interaction (Mansfield 1998; Scott et al. 2001; Perkmann and Walsh 2007; Perkmann et al. 2013), modes of knowledge production (Gibbons et al. 1994), triple helix (Etzkowitz and Leydesdorff 2000), the entrepreneurial university (Clark 1998), the third mission of universities (Laredo 2007; Pinheiro et al. 2015) and universities in innovation systems (Fagerberg and Verspagen 2009; Jacobsson and Perez Vico 2010). Many such studies describe fruitful complementarity (Gulbrandsen and Smeby 2005; D'este and Perkmann 2011; Wigren-Kristoferson et al. 2011; Fogelberg and Lundqvist 2013), and underline the embeddedness of innovation in research (Etzkowitz and Leydesdorff 2000; Pinheiro et al. 2015). However, other studies raise concerns that short-term commercialisation comes at the expense of long-term research and undermines the efficiency of the division of labour between public and private science (Larsen 2011), and even deteriorates academic virtues (Slaughter et al. 2002). Although empirical evidence predominantly shows a positive relationship between commercialisation and research performance, there are notable exceptions: Perkmann et al. (2011) find no uniform relationship between industry involvement and faculty quality, and Buenstorf (2006) identify an occasional negative correlation between entrepreneurship and scientific performance as well as weak evidence of benefits from entrepreneurship on scientific undertakings. Indeed, the direction of causality in the link between research and innovation is unclear (Larsen 2011).

Thirdly, and as to the education-innovation nexus, Holmén and Ljungberg (2015) studied how experiences from innovation feed into education, and vice versa, albeit to a lesser extent. Other studies indicate that conflicting logics hamper this particular form of interplay: Maassen and Stensaker (2011) argue that the standardisation of academic programmes within Europe stands in contrast to ambitions of renewal and creativity associated with innovation, with decoupling as a possible consequence.

This review reveals that linkages include both task combination and mutually reinforcing spill-overs. However, it also reveals tensions, trade-offs and a misalignment between formal and informal institutions in the pursuit of KT combinations. In exploring the nature of KT manifestations, the concept of institutions as formulated by North (1991) and Scott (2014) therefore appears useful as it helps us identify and structure observations. Institutions are the humanly created rules that condition interaction and thus the evolution of organisations. Institutions may be regulative (Scott 2014), or as North (1991) puts it, formal, and include laws, regulations or constitutions. They may also be of an informal character and include normative and cognitive dimensions, such as attitudes, beliefs, sanctions and codes of conduct.

Against the above, we explore KT manifestations as formal and informal institutions at universities on micro- (individual or research groups) and meso- (faculty, departmental or organisational) levels, and contrast this to macro (national or international policy) level conditions. Formal institutions encompass manifestations such as policy priorities, documented strategies, work routines, evaluation schemes and other tangible incentive frameworks. Informal institutions in this context include cognitive interpretations of and attitudes towards the KT held by individuals representing different levels, as well as their culture and norms.

10.2.2 Method

We conduct our analysis through a two-step mixed-method approach. Firstly, we search for insight into the conditions of the current Swedish policy landscape of relevance to the KT using scholarly articles and policy reports from public and private research funders, public agencies, non-profit organisations and interest groups. Secondly, we conduct case studies on three universities selected for their representativeness of the Swedish university population in terms of size and type (i.e. comprehensive, specialised or regional). The selected universities are Lund University, Chalmers University and Malmö University. Lund University is one of Sweden's large, comprehensive universities with long-standing traditions and experience in all three areas of the KT, but a clear budgetary focus on research. Chalmers represents a specialised university with ambitious management traditions and extensive industrial collaboration; research-oriented as Lund University but with a stronger emphasis on innovation. Malmö University is one of Sweden's newer regional universities, where the articulation with the local community (including the city and industry) has been central to the formulation of research and educational programmes; it is also a heavily teaching-oriented university with roughly two-thirds of its turnover in education.

The case studies mainly build on 17 interviews conducted between November 2015 and November 2016: 5 at Lund University, 7 at Chalmers University and 5 at Malmö University (M1 interviewed twice). Interviewees made up a representative sample of individuals with regard to research group, department, faculty and university management level (including Professor, Dean, Pro Vice-Chancellor and Vice-Chancellor levels), as well as to the universities' three tasks (see Appendix for details on interviewee positions). The interviews are labelled in numbered order with the initial letter indicating the affiliation (e.g. L1 for the first interviewee at Lund University, C2 for the second interviewee at Chalmers and M3 for the third interviewee at Malmö University). In addition to the interviews, university policy documents and previous studies of relevance have been reviewed, and a relevant workshop was attended at Chalmers. This allowed us to triangulate findings.

10.3 Knowledge Triangle Configurations at Three Swedish Universities

In this section, we first provide a brief overview of significant elements in the Swedish system and then analyse how the KT principles manifest themselves at the three selected universities.

10.3.1 The Contextual Policy Setting

Ever since the KT concept was introduced during the Swedish EU presidency in 2009, Sweden has been at the forefront of related policy development (Benner and

Sörlin 2015). The Swedish innovation agency Vinnova was commissioned by the government to operationalise the concept. Consequently, and in line with Vinnova's focus on innovation, the work with the concept has been narrowed down to the strengthening of the third mission. Thus, despite the overarching ambitions, Sweden lacks policies and instruments explicitly targeting the KT as a whole. However, there are several different policy strands that influence and relate to KT principles.

Firstly, as in many other countries, Sweden has seen an increased focus on research excellence and concentration as a motive for significantly increasing R&D expenditure dedicated to universities (Bienenstock et al. 2014). Funding instruments targeting excellent or strategic research environments and areas have been abundant, and in 2009 the Swedish government introduced a partially performance-based, excellence-focused research funding scheme for block funding (OECD 2016b). Consequently, an already strong prioritisation of research has been reinforced (Pinheiro et al. 2014). As advanced research and education are combined in one organisation, scientists can "liberate" themselves from teaching and transfer the task onto individuals with lower research ambitions or less success in gaining research funding (Carlsson et al. 2014; OECD 2016b).

Secondly, in line with international trends, the Swedish education system has undergone a dramatic increase in the volume of students and staff. Between 1985 and 2014, the number of full-time students in Sweden tripled (Eriksson and Heyman 2014). Even though public funding for teaching has grown, universities' funding for R&D has increased significantly more (Swedish Higher Education Authority 2015).

Thirdly, policy has encouraged a more systematic way of handling societal interaction at universities which indeed have started to embrace more systematic views, albeit evidence of causal links is lacking (Benner and Sörlin 2015). Indeed, the historically close societal interaction of Swedish universities has been unsystematic, revolving around certain individuals, groups or communities. During the 1970s and 1980s, policymakers applied an institutional approach to societal interaction (Benner and Sörlin 2015), setting up publicly funded programmes for university–industry interaction and "intermediaries" (e.g. offices and technology parks), which has created a strong focus on the business sector in general and technology-based firms in particular.

Fourthly, a scattered research funding landscape together with dispersed management and funding of the policy areas of research, education and innovation creates significant challenges from a KT perspective. Sweden's research funding system is characterised by a large number of funding organisations that mainly target selected research groups or individuals who obtain considerable resources and leverage (Jacob 2015). Changes in strategy occur through specific R&D programmes that thus yield effects that are limited to specific research groups or academic disciplines (Benner 2013). In addition, Sweden has, since the late 1990s, deregulated its academic career system: individual universities control the content of positions, including relative shares of research and education, as well as funding sources., It is quite common to have permanent positions on the basis of external funding alone, with little or no education tied to them (Government of Sweden 2016).

Table 10.1 Key figures for the universities for the year 2014 (Swedish Higher Education Authority 2015). This includes funding from research funding organisations that require the participation of non-academic actors, such as from VINNOVA or the Knowledge Foundation. This data was provided directly by VINNOVA and includes an elaboration by VINNOVA on data from Statistics Sweden

	Lund University	Chalmers University	Malmö University
Year founded	1666	1829	1998
Vision	"To be a world-class university that works to understand, explain and improve our world and the human condition"	"Chalmers for a sustainable future"	"A world where diversity, knowledge and creativity is transformed into action for sustainable development"
Full-time students (undergraduate and graduate students)	27,702	8926	12,340
Of which graduate students	7146	3137	1438
Full-time faculty	2997	1173	753
Professors	708	201	77
Total revenue	7.5 million SEK (app. 815 KEUR)	3.4 million SEK (app. 370 KEUR)	1.3 million SEK (app. 141 KEUR)
Research revenue as a share of total revenue	67.6%	71.5%	20.8%
Share of block funding (research and education)	56.2%	48.4%	75.7%
Share of public funding requiring collaborative research with actors outside academia (2013)	9.7%	22.5%	14.8%

Consequently, much of the steering power lies in the hands of research funding agencies and research groups.

Fifthly, in line with international arguments that increased autonomy strengthens research performance and societal connectivity (Aghion et al. 2008), Swedish universities have seen their autonomy increase. Consequently, the expectations of task integration fall on universities themselves.

10.3.2 The Three Cases as Exemplars of the Swedish University Population

The Swedish university population includes three types of universities: comprehensive, specialised and regional universities. The three cases are selected as exemplars of these categories. An overview of key statistics is provided in Table 10.1, illustrating the differences in the character of the three.

Lund University is one of Sweden's large comprehensive universities with a long tradition of embeddedness in and interaction with its local contexts. Although the university carters to a large number of students, it is strongly research-oriented as 2/3 of the revenues come from research (see Table 10.1). Chalmers represents a specialised technical university with extensive and long-standing "natural" ties to related industries.[2] It has ambitious management traditions and is even more research-oriented than Lund but with a stronger emphasis on innovation, as revealed by the relatively large share of collaborative public research funding (see Table 10.1). Malmö University is one of Sweden's newer regional[3] universities, where the articulation with the local community (including the city and industry), particularly with regard to the demands of the local labour markets and the public sector's demand for skills in education and healthcare, has been central to the formulation of research and educational programmes. In contrast to Lund and Chalmers, Malmö is heavily teaching-oriented with roughly two-thirds of its turnover in education (see Table 10.1).

In the following cases, the manifestations (in terms of informal and formal institutions) and observed challenges in realising the KT are explored.

10.3.3 Lund University

Founded in 1666, Lund University (LU) is one of the oldest universities in Northern Europe and is ranked among the top 100 in the world.[4] LU is comprised of eight faculties[5] located on campuses in Lund, Helsingborg and Malmö. LU is also home to a number of institutes, specialised research and innovation environments, and platforms for societal interaction. Two major facilities for materials research are currently under construction in Lund: the MAX IV Laboratory (a synchrotron radiation laboratory) and ESS (a European facility that will be home to the world's most powerful neutron source). These will be of decisive importance for materials and life sciences and for industrial development.

[2] Other specialised universities in Sweden include agricultural and medical universities.

[3] The term "regional" may be seen as a misnomer, as these universities recruit students and faculty as broadly—sometimes even more so—than comprehensive and specialised universities. The term "regional" indicates that they were founded as part of the regional mobilisation of resources after the industrial crises of the 1970s and 1990s.

[4] LU ranked 70th in QS ranking 2015/2016 and 90th in Times Higher Education World University ranking 2015/2016.

[5] Engineering (LTH), Social Sciences, Humanities and Theology, Economics and Management, Medicine, (Natural) Science, Law, Fine and Performing Arts.

10.3.3.1 Informal Institutions

At LU, the attitudes towards and perceived value of pursuing each task of the KT vary—resulting in fragmentation or unbalanced linkages between the tasks.

Central management at LU expresses the importance of the interplay between research, education and innovation—highlighting the university's vision "to be a world-class university that works to understand, explain and improve our world and the human condition" (Lund University 2012). At the same time, central management recognises that the faculties have no common interpretation or way of operationalising the KT.

> On an ideological level, the importance of the interplay is well understood and embedded in our strategy and employees' understanding. However, there is a long way to go before we realise our aim of having 'complete' learning environments—with a well-functioning and balanced integration between research, education and innovation—across our faculties. (L1)

On an individual (or group) level, there is a general perception that research, education and innovation should be mutually reinforcing activities, as more "integration" can enhance the quality of each aspect. Yet the approach for linking the various elements differs broadly across LU's faculties and departments. For some faculties or disciplines with more direct and practical application to societal issues (e.g. engineering or social sciences), there is a more natural integration and responsiveness to societal needs. This has led to differing levels of competence and experience across the faculties in engaging with "outside" actors in the local/regional system and understanding and addressing their needs.

> Certain institutions are doing well to integrate research and education. These are often the same environments with well-defined strategies for interacting with society. In other cases, the three missions are developed in isolation of one another. (L2)

Many interviewees highlighted the importance of the culture and attitudes towards the different dimensions of the KT. The general perception is that efforts to integrate research, education and innovation are not recognised or rewarded.

> People don't get paid or recognised in any way for the third mission. Third mission activities are not seen as enhancing research and educational tasks, but rather taking time away from 'core' tasks such as securing research financing. (L2)

> LU is a rather traditional university—where a focus on research excellence has top priority. It is not easy to change a culture or an orientation towards scientific excellence. It's a long-term process, but also necessary to undertake to ensure that LU is well-positioned in the future. (L5)

10.3.3.2 Formal Institutions

The central management at LU is comprised of a Vice-Chancellor, a Deputy Vice-Chancellor (responsible for education and international relations), a Pro-Vice-Chancellor for Research, a Pro-Vice-Chancellor for External Engagement and a University Director. Each of the eight faculties has similar management structures, with a Dean and Vice-Deans with separate responsibilities for education and research (and, in some faculties, for innovation and/or international relations). Management of financial resources and personnel is highly decentralised.

The Strategic Plan for LU 2012–2016 sets out the overall goal of “highest quality education, research, innovation and interaction with society” and outlines four strategies for achieving this goal (cross-boundary collaboration; internationalisation; quality enhancement; and leader, teacher, and employee excellence). These strategic ambitions are reflected in a number of recruited positions or support functions within the University’s central administration, which were initiated or further developed under the leadership of the previous Vice-Chancellor.

> It is important to work proactively with developing collaborative relationships. The central administration can play an important role as a ‘development motor’. [LU management] developed a number of structures, including LU Open[6] and the Research and Innovation *Council* of Skåne, recruited personnel, and initiated activities to strengthen the interplay between research, education and innovation. (L3)

The current Vice-Chancellor and leadership team[7] are in the process of formulating a new strategic plan for LU and undertaking a number of changes to central support functions—including a shift of responsibility for initiating and leading cross-boundary collaborative activities from the centre (through LU Open) to the faculties to ensure stronger embeddedness with core operations, that is research and education (Lund University 2015).

> All faculties should have their own platforms for developing relations with external actors, proactively initiating and following-up on collaborative projects. It’s understandable that the central level may be involved in initiating some platforms, such as cross-disciplinary ones, but these should be integrated and developed within the faculties and departments. (L4)

> There are examples of ‘integrated knowledge triangles’ within departments, but cross-disciplinary programs or platforms are rare. The central administration has limited resources to support cross-disciplinary efforts, and those activities that have been initiated are not always viewed in a positive light. It seems to work better if one faculty has the lead—with the responsibility of involving other faculties. This ensures structures are stable and are perceived as ‘core’. (L2)

The forthcoming strategy will play an important role in signalling LU’s priorities for a stronger interplay between research, education and innovation (guiding the respective strategies at the faculty level). There is also a need for more concrete guidance on how the University will work operationally with the KT.

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[6]LU Open was initiated in 2011 as *a development unit (under the central administration’s section for research, collaboration and innovation) specialized in matching external stakeholders with researchers and students, and designing and executing projects with the objective of solving complex challenges.*

[7]As of January 2015.

> The University leadership needs to provide a strategic direction, support structures and incentives, as well as visibility of good examples. [Integration of research, education and innovation] won't happen by itself. (L1)

> There seems to be a need for simplifying and clarifying the central support functions—clearly communicating a service offering to the recipient faculties and departments. (L4)

In addition, the central administration and faculty management see a need for changing the financing system to enable a better integration between research, education and innovation. Needed changes include flexible use of existing budgetary allocations and financial support (or other incentives) for societal and cross-disciplinary collaboration.

> It is difficult to finance the development of new educational programs or research areas, as the financing system does not allow for flexible use of budgetary allocations in research and education. A strengthened integration between research, education and innovation needs to be not only interesting, but also financially viable. (L2)

> There should be better incentives and financing for working with the third mission. It is important to have accessible financial support or seed money to start new things and weave in the third mission as part of educational and research activities. (L4)

> Collaboration across disciplines and with external actors [on education and research] can be strengthened through financing—or by making collaboration a requirement for accessing [certain] research financing. (L5)

10.3.3.3 Observed Challenges in Realising Knowledge Triangle Links

There are two main tensions that challenge the implementation of the KT at LU: the tension between the tasks, and the tension between the role of central administration in relation to the faculties.

There are different ways of interpreting and implementing the KT across the faculties of LU. In general, most effort is focused on securing financing for and producing high quality research. Education is also a core priority, but may be viewed as a "second place" priority behind research. Innovation and societal interaction is conducted on a very ad hoc basis (driven by individual values and passion, mostly in free time). The result is a fragmentation between the various tasks and a lack of clarity about the benefits of strengthened integration.

LU also experiences a tension between having centralised or decentralised support functions and platforms for collaboration. Thus, LU seems to be navigating between different integrative models. One is the centralised model (including formal institutions such as LU Open, that actually initiated activities). The other is the current distributed model that anchors notions of integration among its faculties (which have very different structures, financing models, and attitudes towards both the importance and the operationalisation of the KT). This results in diverging views on how resources should be used and which activities provide the most value, and barriers to establishing cross-disciplinary collaboration for LU as a whole.

10.3.4 Chalmers University of Technology

Chalmers University of Technology (CUT) is a research-focused technical university situated in Gothenburg, Sweden's second-largest city. Gothenburg has a rich industrial history and high R&D intensity (Fogelberg and Lundqvist 2013). CUT's industrial connectivity is reflected in its position as the fifth university worldwide (2015) with the highest share of industrial co-publications according to the Leiden Ranking. CUT was founded as a vocational school in 1829 through a donation by an industrialist but soon became state-owned. In 1994 the university transformed into a private foundation with greater autonomy than other Swedish universities (Jacob et al. 2003). Education (chiefly engineering) and research are conducted within 18 departments.

10.3.4.1 Informal Institutions

At CUT, there are diverse cognitive understandings of what a KT includes. Consequently, attitudes towards its usefulness vary, as illustrated by two vice presidents:

> Through [. . .] a fruitful KT, we can create arenas for change [. . .] We have to train our organisation to enable this. (Holmberg 2015)

> We do not work with the knowledge triangle [at CUT] because we do not think the concept fits with our integrated picture of the utilisation of research and education. The KT polarises the three tasks by placing them in corners. (C6)

One first point of divergence in understandings regards whether the KT implicates something new. According to some interviewees it does not:

> I feel that I truly work with the KT, but I seldom use the expression, maybe because it's self-evident. (C1)

Others emphasise that the concept brings much-needed attention to the third mission (C2, C3).

A second point regards whether the realisation of the KT implies additional activities (C4), or redesign of existing tasks:

> The relation between education and innovation should not be about activities that 'season' education [. . .] but about revising entire educational programmes on the basis of universities' wider societal role. (C5)

A third point concerns diverse third mission perceptions. While some equate the third mission with innovation and focus on its link to research (C4, C7), others emphasise wider societal responsibilities including sustainability (C5, Holmberg 2015).

This diversity in understandings adheres to the various cultures and values of individuals that both reflect CUT's industrial and entrepreneurial spirit and traditional academic norms. Researchers with strong traditions of doing basic research in industrial contexts embrace the integration of academic and applied cultures (Fogelberg and Lundqvist 2013). Others mainly identify with academic norms and perceive integration as problematic (Jacob et al. 2003; Fogelberg and Lundqvist 2013):

> Some researchers need to go upstairs in the ivory tower [. . .] and only come out every now and then to say things that amaze everybody [. . .] if we only direct our research toward the needs and issues of specific actors [. . .] what about the future societal needs? (C7)

The link between research and education is often combined in the same persons. However, division of labour appears partly due to the higher status of research that materialises through attitudes and norms (C3, C5). The link between education and innovation is often driven by the commitment of teachers who use their networks to introduce practical elements (C3). The interest and motivation of students are also significant (C5).

10.3.4.2 Formal Institutions

CUT applies a process-oriented management model, where vice presidents lead education, research and utilisation, respectively. Education has its own organisation that procures courses from the departments that employ researchers and teachers.

On top of these layers runs the eight Areas of Advance (AoA)[8]—an organisational structure introduced in 2010 with the vision to "match [CUT'] scientific excellence to global challenges" and the mission "to create a unique integration of the KT" in thematic areas (CUT 2011). The AoA vice president holds the formal KT responsibility. The AoA were a response to a government initiative to strengthen strategic research areas that provided AoA with significant funding. A national evaluation of the initiative praised the AoA and recommended increased funds (Swedish Research Council 2015). Lately, rhetorical KT references in relation to the AoA have faded (C6) and the AoA have developed into platforms for third mission activities and cross-cutting research targeting scientific excellence (C1, CUT 2016).

The AoA is a unique initiative but a somewhat natural trajectory for an ambitious university with strong management and industrial traditions. During the last decades, CUT has strived to transform into an entrepreneurial university and established innovative structures such as a venture capital firm, a seed financing company and an entrepreneurship school (Jacob et al. 2003; Fogelberg and Lundqvist 2013). This has successfully integrated innovative research, entrepreneurial education and action-based training (Jacob et al. 2003). However, these structures emerged as ad hoc experiments without clear guidelines under diverse legal structures and were steered by strong individuals. This created opacity and fragmentation (Jacob et al. 2003) that increased with additional, often government-induced, third mission initiatives. One example is the innovation office, a service function installed in

[8]The areas are Energy, Materials Science, Nanoscience and Nanotechnology, Production, Transport, Life Science, Information and Communication Technology and Built Environment.

2010 targeting research utilisation. Despite revisions during the latest decade, the sense of opacity somewhat remains. Thus, the current vice president of utilisation has a strong focus on integration and coordination (C6).

Despite CUT's AoA and innovation support structure, management schemes seldom target KT integration. Recently (2016) CUT introduced a faculty fund allocation system and guidelines for staff appointments that account for the three tasks. However, task integration is not in focus and some researchers and deans argue that staff appointments will become less flexible and that emphasis is on traditional academic excellence at the expense of societal engagement (C2, C3). Relevant management schemes targeting the third mission also appear in individual departments. Examples are appointments of vice-deans of utilisation, long-term strategies and key performance indicators as well as employee support and encouragement through salary negotiations and rules of procedure (Hillemyr et al. 2015, C2).

10.3.4.3 Observed Challenges in Realising Knowledge Triangle Links

Although CUT's AoA and innovation efforts have been advantageous, significant tensions related to the KT remain. Firstly, the division of roles between the departments, the infrastructure for innovation and the AoA is unclear. The AoA have the KT responsibility, but the departments hold the human resources and are responsible for core tasks. AoA-induced KT connections appear to be rare (C1, C7). Rather, induced connections mainly include intra-departmental research (C3, C1). As a researcher puts it:

> We had developed our connections [before the AoA]. We had the application, international relations, government relations, etc. [. . .] For us [AoA] has been more of a hassle and created ambiguity [. . .] it's getting so much more complex, and you do not know what to expect from whom anymore. (C7)

Secondly, tensions stem from a perceived distance between management and researchers. Some faculty perceive that management steering is over-ambitious and inaccurate:

> I perceive the steering to be over-ambitious [. . .] management is trying to steer things that they have little influence over, and limited information about. (C7)

> The steering is somewhat inconsistent [. . .]one moment we should focus on innovation, the next we should be excellent [. . .] but we know our business, it is through [the faculty] that the knowledge triangle is realised. (C3)

Thirdly, although research-innovation tensions at CUT have been perceived as minor (Fogelberg and Lundqvist 2013), there is still a distance between support structures and needs (C6). While some faculty utilise the support to act entrepreneurially, others perceive that the structures signal a too narrow view on utilisation (C7). Also, a tension adheres to the focus on excellence:

> I notice an augmented pressure to strive for academic excellence, but there are significant trade-offs [. . .] I am concerned because this increased pressure may potentially hinder societal engagement [. . .] and the development of new research venues. (C3)

There are however also concerns about the ability of academia to conduct unbiased and curiosity-driven research in the light of third mission ambitions (C7).

Fourthly, significant tensions concern education:

> The education task has at times been taken hostage by innovation and research players [. . .] that have influenced the content of education dominantly based on perspectives from research and innovation that aren't necessarily in line with those of education [. . .] Strengthening the connection between education and the third mission is not about matching students to the direct needs of beneficiaries or introducing individual elements where students are utilised to reach [innovation goals]. Instead, [strengthening the connection] should be about producing students who can formulate problems that address societal challenges and critically observe society to push social development in the right direction. (C5)

The organisation for education and the AoAs have both worked with integrating societal engagement in education, but rather uncoordinated and unsuccessful (C1, C5, C2). However, interviewees are sceptical towards a stronger integration of education into the AoA due to the risk of increased complexity.

Finally, tensions have emerged between faculty or department initiatives, external initiatives, and university-wide strategic schemes—mainly due to overlapping missions, resources and mandates. For example, the innovation office was created as a government-induced add-on organisation. Although their activities have been significant for third mission developments, they have not yet been successfully integrated (C1, C6).

10.3.5 Malmö University

Malmö University (MU) was founded in 1998 as a state-accredited university college, granting it powers to award first- and second-cycle degrees and with a restricted remit for awarding third-cycle qualifications. MU is the ninth largest higher educational institution in Sweden with five different faculties, providing over 100 programmes of study and 350 courses to well over 20,000 students and almost 200 graduate students. In 2016, it was announced that MU would become an accredited "university" in 2018, which—inter alia—means that it will be empowered to award third-cycle degrees without restrictions, as well as receiving increasing state appropriations for research.

10.3.5.1 Informal Institutions

Interviews contained few direct references to the KT itself, but societal interaction was a recurrent theme in the self-understanding of MU. One interviewee (M1) described MU as "quick and flexible", keen to engage with social challenges such as migration and inequality. Societal engagement thus emerged as a core value for Malmö, including “social innovation” in a very broad sense: “it’s about processes, not things—meetings, feelings, experiences” (M1). This attitude helps to cement and embed KT principles within the university, and students and faculty are inspired by interactive attitudes and possibilities. Hence, the articulation between education, research and innovation is viewed as an integral and attitudinal part of all activities of the university. The approach is more cultural than formalised:

> I don’t think in a triangle way—I try to look at the strategy and the vision that we have—dynamic system thinking is more useful here. A triangle model is perhaps not so helpful. (M2)

In line with the broad understanding of the university’s role, its representatives articulate an eclectic perspective on innovation. One of the interviewees (M3) emphasised a belief that there should be a variety of forms of innovation rather than merely commercial applications. Involving external parties in the early stages of research processes is seen as having an impact on what “knowledge” is for MU and is a valued form of interaction.

Achieving this is not seen primarily as a matter of drawing on experiences developed elsewhere; important knowledge on societal collaboration resides within the university itself, and there is a need to generalise these experiences beyond the specificities of these individual undertakings (M1). One way in which Malmö could better structure their KT activities is by generalising the experiences made inside the university (M2). More research could be done, for example, to evaluate collaborative projects in a way that forms a subject for research in itself. Another way to enhance the structuration of K3 is to move from spontaneous interactions with societal stakeholders to a more focussed and conscientious model, where the rich and dense societal networks of MU can be translated into research strongholds:

> People are very committed to solving societal challenges at MU, it is in their mindset. People already have the drive, although they need to develop awareness about relating work to research in a more focused way. Research at MAH needs to be boosted via these collaborative projects. (M2)

Regarding the topics for societal engagement, one interviewee stressed that social sustainability could form a particularly good platform, relating strongly to the KT as well as to many different societal issues, while still putting the university at the centre (M4). This approach has also been used in forming alliances within different calls based on principles of “grand challenges”, for instance within the European Union Horizon 2020 programme (M1).

As a very recently established university college, MU has been more heavily focused on teaching, particularly professional education, and practical, socially contextualised benefits. MU’s identity is shaped by comparisons with the older universities of Sweden, which tend to be research focussed and with a broader educational profile; in contrast, MU is focussed on professional training and expectations emerging from a societal context.

> We are more heavily focussed on education, particularly professional education. As a very recently established university, we put emphasis on these more practical, socially contextualised benefits. (M4)

This shows also in its recruitment patterns. As an example, one-third of MU doctoral candidates are employed outside of academia, most often working on their doctorate part-time. This brings in a lot of outside influence, giving the university a clear "imprint" outside in the world beyond its doors and providing opportunities for gaining commissioned research (M3).

10.3.5.2 Formal Institutions

MU leadership brings different backgrounds that combine many years of public organisational experience, private sector management and experience in running long-term collaboration with societal actors (M1, M2, M4). The MU leadership sees the combination of these sectors as a major driver of quality in education and research. As an illustration, societal challenges form the core mission for the entire university, rather than an add-on (M2, M4). Even though models like the KT are seen as somewhat too rigid and unimaginative to function as organisational blueprints, they serve as mementos and ideals stressing the virtues of aligning the three missions. There are also tangible organisational signs of the significance of societal connectivity, for instance as the university functions as a national hub for social innovation. This is an important profile for the university and is seen as a way to attract potential external funding and collaborators (M2, M4).

There is much innovative work being done by staff and students that senior management would like to harness, in particular by evaluating their collaborations in more detail and therefore providing an opportunity for further research projects (M2, M4). As societal interaction is such a strength at Malmö, "there is a huge communication task ahead" (M4) with raising the profile of these kinds of collaborative activities with civic society, explaining what they do and how they are beneficial. One example is MU's active engagement in crime prevention research, a key issue for the long-term viability of Malmö as a city (M1).

MU continues to integrate KT corners predominantly through its overall value-based approach to innovation and inclusivity within its internal systems for recruitment and promotion. Its own merit system for employment takes into account experience with innovation and collaborative processes (M2). The university has a model for the distribution of faculty research funding based on an average from the last 3 years' external funding that does not discriminate between different sources (e.g. EU, regional or corporate). This becomes an incentive for making contacts with outside partners. Another example is trainee teachers working in the local community who are being used as "change agents" by creating "innovation hubs" for education, and who subsequently become links that create research opportunities (M4).

Senior management would also like to create a common space where faculty, staff and students can "get out of their daily life and work" and where external partners can more easily gain access. MU has also developed value-based leadership at the

Anna Lindh Academy[9] with a special focus on large public and private organisations (M2, M4).

A core aim at MU is to extend research into society and bring society into research. The principles of embedding knowledge flow between actors are "not really top-down" and are "built-in" to the core activities of education and research (M3). Often MU works with the NGO sector and these kinds of cooperations are embedded, becoming the "regular way of thinking and acting" (M3). Collaborative efforts are a serious added dimension to teaching and research, and experience with collaborative activities is now seen as an important consideration in the recruitment process.

10.3.5.3 Observed Challenges in Realising Knowledge Triangle Links

The many societal interaction activities taking place at MU are being used to strengthen the university's research base which is currently scattered: Some areas are well-endowed and resourceful whereas others are nascent or non-discernible. This is dependent on proactive measures from other levels, including national policy: Senior management feels that better facilities for interaction and innovation projects are needed and that more than just economic goals should guide the steering mechanism of research funding at the national level (M2, M4). This may, however, be partially alleviated by the elevation to university status in 2018. Hence, MU straddles between positions: wanting to expand its research basis (which would necessitate an adherence to the current model of funding competition) but also securing a protected and growing space for interactive activities, which would cater to a broader constituency of interests. According to MU leadership, social innovation—MU's niche in the Swedish university system—has different needs from other forms of innovation, and specific tools, goals, financing and structures are required to serve this purpose (M2, M3, M4). There are structural problems in Sweden as regards funding for higher education, particularly in terms of facilitating societal interaction (see Sect. 10.3.1). In the view of MU leadership, all sides must come together to solve societal problems, but currently, there are not enough incentives as funding is lacking. Also, the feeling is that state funding is still benefitting traditional universities for structural and political reasons (M2). In addition, at MU 80% of the revenue is dedicated to education and 20% to research, so there is a great imbalance and limited resources to build a doctoral education and broad-based research environments. Thus, MU leadership sees an integration of the funding of education and research as necessary to better align the different tasks of higher education institutions.

[9] "Anna Lindh Academy has been formed with the aim to contribute to a new generation of value-driven leader who promotes human rights and democracy both in Sweden and internationally" (http://annalindhacademy.se/om-anna-lindh-academy).

10.4 Discussion on Findings

The previous section revealed KT manifestations at three universities. CUT is purposefully orchestrating the KT through a matrix organisation. Tensions have risen as the new organisation complicates resource flows and governance, both vertically between organisational levels, as well as horizontally between the three tasks. LU has a weak steering centre and considerable variation between its different constituent parts. The organisation of KT activities reflects this variation, where a recently adopted top-down approach co-exists rather uneasily with bottom-up activities, and where some faculties have profound and elaborated models whereas others have only minimal experience. MU has predominantly been oriented around education. As a result of limited research funding, they have been pushed to find innovative ways of seeking external funding, primarily through interaction with the local community. However, tensions exist between current structures for research funding in Sweden and the principles of KT integration that MU aims to realise.

Combined, the cases leave us with four key observations on KT manifestations at universities. Firstly, there are contradicting views within the universities related to the third mission and the KT. This observation is in line with those of Sjoer et al. (2016) who identify a great diversity in perceptions that concerned actors have of their tasks, and that not all actors adhere to KT virtues. While this may be expected at a broad and decentralised university such as LU, or a young and evolving university as MU, the observation of contradicting views at a management-driven university as CUT is less expected. When contrasting the experiences, funding patterns and mandates of interviewees with their views, we find indications of how the fragmented Swedish higher education and research system contribute to this diversity. The separated funding streams (for the three tasks, and for research in particular) each channel divergent views on the third mission and task integration, which strongly influence concerned actors at the universities. A clear consequence observed in all three cases is that innovation is conducted on an ad hoc basis, either enabled by different funding actors or driven by individual initiatives. The result is a fragmentation between the various tasks and a lack of clarity about the benefits of strengthened integration.

Secondly, it is clear that education has fallen into second place and the focus on research excellence and attaining research financing has overshadowed the incentives of an integrated KT. These findings are in line with Geschwind and Broström (2015) who found signs of a growing division of labour between teaching and research at Swedish universities. However, the task separation and research dominance are less clear at MU. Dominated by educational activities and adhering to a civic context, MU does not oblige to traditional academic expectations in the same way as CUT and LU.

Thirdly, the ongoing macro-level process of professionalisation and integration of the third mission has been challenged by the drive for research excellence. At LU, challenges have varied with the diverse prevailing conditions within different faculties and groups, while at CUT the conflicts in goals between research and the third mission appear clearly. MU has provided good examples of KT principles in practice by using societal interaction to maximise investment in research but still suffered from the misalignment to existing research funding structures. For instance, MU exemplifies how creative approaches to KT integration through societal engagement can be underfunded due to a preoccupation by funding bodies with industry collaboration over civic engagement, or when a societal impact is disregarded altogether.

Finally, the universities have used their increased autonomy in different ways with diverse consequences for orchestrating KT principles. Following its proactive management tradition of responding to external expectations, CUT has continued on the road of creating structures and defining processes by mediating visions of KT integration through the new organisational-wide AoA. However, vertical tensions have emerged due to unclear mandate distribution between overlapping structures, and since incentives for researchers to strengthen KT principles at the individual level are not in line with political ambitions on institutional and national levels. LU has mainly redistributed the increased autonomy to the faculties by increasing their mandate. This has led to a more dispersed orchestration where KT initiatives must emerge bottom-up to gain legitimacy. The result is a federation of faculties that are not uniformly directed. Consequently, the decentralised (and autonomous) faculties further exacerbate the aforementioned task separation due to excellence. MU is more agile given its youth and modest size but is however limited by its rather small resources. The result is promising visions combined with the potential of being an evolving university species, but a lack of strength for execution.

10.5 Conclusions and Implications

This chapter deals with how universities blend their tasks. We set out to study how KT principles are manifested in the organisation and strategy of different types of universities. The exploratory approach has provided us with rich descriptions from three universities. We observe a great diversity in the way in which the principles of KT (conjoining education, research and innovation) are orchestrated at the universities, both in terms of informal institutions such as interpretations and attitudes and in formal institutions such as articulated strategies and incentive schemes. On the macro-level, the KT remains a policy priority and living concept, yet task integration is increasingly expected to be arranged by universities themselves. Our study reveals limited ambitions from university managements to forge new combinations of remits. This in turn mirrors the structure of policymaking in Sweden, where the areas of research, education and innovation have been compartmentalised in terms of funding and governance. As this structure trickles down to the individual and group level, we observe that the articulation of tasks is weak. What we do find is that some individuals take on the task of aligning the three missions despite the obstacles, and thus serve as role models and KT exemplars. We also observe tensions as the responsibilities of operationalising the KT fall on individuals who sometimes lack the mandate and resources to create enabling conditions and tackle divergent expectations. With these findings, we make a significant empirical contribution to the understudied phenomenon of the KT. To sum up, our major empirical observation is that there is a misalignment between the political goal of K3 and the actual policy mechanisms of the three areas. Despite the ambition to reduce the political steering of universities, the resource flows (and concomitant evaluation and assessment criteria) foster a compartmentalised strategy.

These observations offer implications for policymakers and universities. A key group of actions concern supporting the knowledge development needed to fill the aforementioned gaps. If future research indicates that we are in fact to create well-balanced and nourishing links between research, education and innovation within a single university, we need to create a credible, sustainable but also reasonably malleable (allowing for variation) operational model of the KT, to serve as a flexible starting point for the articulation of the different tasks. Our results suggest that this would require extensive and profound changes in the Swedish academic system. The increased resources and autonomy that the sector has experienced so far has not proven to be sufficient to foster better linkages; indeed, it could be argued that they were better aligned when state steering was more pronounced. Initiatives for change can not only emerge through external funders' initiatives and programmes but must also stem from universities themselves. This would require an academic leadership that, together with the collegiate, can formulate and implement the ambitious goals and strategies required to realise a fruitful KT.

These findings also raise questions for further research. Firstly, a significant but methodologically necessary delimitation is that we see the KT linkages as given in the setting that contemporary universities form and take them for granted in our point of departure. Consequently, what remains is the question of the factual cost-effectiveness of division of labour vis-à-vis the benefits from complementarities stemming from the integration. Secondly, it is unclear whether the university is the most suitable level on which the KT should be enacted.

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Appendix: List of Interviewees and their Position

Interviewees from Lund University:

L1: Pro-Vice-Chancellor (for external engagement)
L2: Pro-Vice-Chancellor (for research and research infrastructure)
L3: Previous Vice-Chancellor
L4: Professor (and Principal Campus Helsingborg)
L5: Professor

Interviewees from Chalmers University:

C1: Leader of an Area of Advance
C2: Former Dean
C3: Professor A
C4: Vice-principal A
C5: Vice-principal B
C6: Vice-principal C
C3: Professor B

Interviewees from Malmö University:

M1: Dean and incoming Deputy Vice-Chancellor
M2: Vice-Chancellor
M3: Research coordinator
M4: Pro-Vice-Chancellor

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Knowledge Triangle in the Health Sector: The Case of Three Health Faculties in Norway

11

Siri Brorstad Borlaug and Siri Aanstad

11.1 Introduction

As in policy, the focus of the academic literature on the interaction between higher education institutions (HEIs) and the surrounding society has primarily been on the relationship between research and innovation and the role HEI research may play in economic development and growth. Lately, the role of education and the quest for HEIs to provide education relevant for society has entered the political agenda (Meld. St. 16 2017), and given nurture to a re-introduction[1] of the 'Knowledge Triangle' concept, which assumes there are potential synergies between education, research and innovation.

Furthermore, and reflecting the focus on the contribution of HEIs to economic growth, most studies have investigated HEIs' interaction with the industrial sector (see Perkmann et al. 2013). Little attention has—to our knowledge—been paid to how HEIs interact with and contribute to innovation in public sector services. This is rather peculiar, considering that innovation in the public sector has received increased policy attention over the recent period, and is seen as essential for improving the efficiency and quality of public services and for addressing some of

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[1] Used in the Lisbon-strategy (2000), and under Sweden's EU Presidency period in 2009.

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the major societal challenges we are facing, linked, e.g. to an ageing population and maintaining the welfare state.

This chapter looks at the health sector, where HEIs interact with private industry as well as public healthcare services. It builds upon a study from Norway carried out in 2015 in the context of an OECD project, which mapped and analysed knowledge triangle policies and practices on the national and institutional levels. The study shows that the interplay between education, research and innovation is a key concern in national policies for the development of the health sector, and that knowledge triangle interaction with both the private and public sector is a central aspect of current practices at the health faculties at three Norwegian HEIs. The interlinkages between the health faculties and public healthcare services are especially interesting, as they provide other patterns of interaction compared to the patterns identified in the existing literature, and because education plays a central role.

We start by providing a short overview of central findings in the literature on HEIs' interaction with society, followed by a presentation of the Norwegian policy context and the findings from case studies of the health faculties at three different types of Norwegian HEIs. We end the chapter by discussing and concluding on some of the main observed patterns of interaction between the health faculties and the private and public actors within the healthcare sector.

11.2 Interaction between Higher Education Institutions and Society

Many studies have investigated the relationship between research and innovation and the channels of interactions between HEIs and private firms. One strand of the literature takes its outset in 'entrepreneurial activities' building on, amongst others, insights from studies of the entrepreneurial university (Clark 1998; Etzkowitz et al. 2000). Entrepreneurial activities involve, on the one hand, entrepreneurship education programmes and entrepreneurial research activities like patenting, licensing and start-ups, and on the other hand, systemic and institutional initiatives for supporting and enhancing these types of activities by the use of, e.g. technology transfer offices and science parks (Siegel et al. 2003; Clarysse et al. 2005; Perkmann et al. 2013). This is a typical example of the knowledge triangle where student projects and commercialisation of research lead to the introduction of new products, processes, services and businesses.

However, another strand of the literature has underlined that commercialisation of research accounts for a relatively small part of knowledge transfer from universities to the surrounding society (Cohen et al. 2002; Schartinger et al. 2002; Bekkers and Bodas Freitas 2008). In fact, one study from Norway reports that no more than approximately 6% of the scientific staff engage in these types of activities (Thune et al. 2014). Other and more important channels for interaction are collaborative and contract research (Meyer-Krahmer and Schmoch 1998; Perkmann and Walsh 2007; D'Este and Patel 2007), mobility (university faculty working in industry/public sector and vice versa) (Gübeli and Doloreux 2005; Bekkers and Bodas-Freitas

2008), informal networks and conferences (Meyer-Krahmer and Schmoch 1998; D'Este and Patel 2007), and paid and unpaid consultancy (Amara et al. 2013). These formal and informal channels enhance the potential for interlinkages between research and innovation as the HEI researchers get access to central knowledge needs in the private sector and the private sector gets access to research in HEIs, and may as such contribute both directly and indirectly to innovation.

As these studies show, we have relatively good insights into the interlinkages between HEIs and the private sector when it comes to research and innovation, but our knowledge about channels of interaction with regard to education is more limited. There are some relevant studies, however. Bekkers and Bodas-Freitas (2008) have underlined hiring of graduate students and student trainee programmes as important knowledge transfer channels, and Tømte et al. (2015) have emphasised continuing education. The latter study found that employees in both the public and private sector update their knowledge bases and obtain access to relevant research through courses at HEIs, and that HEIs interact with employers to provide relevant courses. A survey of Norwegian academic staff shows that this is in fact one of the most important channels of interaction between HEIs and the public and private sectors (Thune et al. 2014). The same survey also shows that academic staff more often collaborate with the public sector than the private sector, but these channels of interaction are, to our knowledge, understudied. There are many reasons for this: one—as pointed out above—is the emphasis on HEIs' role in economic development and growth. Another is that HEIs themselves in many countries belong to the public realm and have traditionally played a key role in educating public sector staff. Therefore, interaction with the public sector may be seen as an embedded part of HEIs' mandate. A third and perhaps more significant reason is that studies of innovation in the public sector seem to have focused on internal administrative, often technology-driven processes, and not on cooperation with external actors (De Vries et al. 2016).

Against this background, it is especially interesting to investigate the channels of interaction between HEIs and public service providers, and how they collaborate on education, research and innovation. The literature on the knowledge triangle concept assumes that the interaction between education, research and innovation may be strengthened by so-called orchestration tools (Sjoer et al. 2016), which are platforms and processes that may be found both on the systemic and institutional level. In this chapter, we focus on such tools and the many channels of interaction between three different health faculties and external actors in both the public and private sectors. In the case studies, we will show that the patterns of interaction are varied and complex, and partly reflect institutional and disciplinary differences. Within research-intensive fields such as medicine and pharmacy, we find patterns of (i) the entrepreneurial university where staff and students are involved in entrepreneurship and commercialisation; (ii) institutionalised collaboration on education, research and innovation with public hospitals; and (iii) research-based innovation collaboration with private industry. Other health sciences with weaker traditions for research are characterised by different patterns, and notably collaborate with (i) both public hospitals and municipal healthcare providers on education and incremental service innovation, and (ii) with municipalities and private technology firms on the development and implementation of health and welfare technology.

11.3 The Norwegian System and Main Policies for Education, Research and Innovation within the Health Sector

In Norway, state-owned universities and university colleges have a main responsibility for education and research within the health sciences. Historically, there has been a division of labour between the different types of institutions: The universities have been responsible for the research-intensive scientific fields, such as medicine and odontology, and the university colleges for shorter professional programmes within nursing and other fields with a relatively weak tradition for research. This picture is changing, however, as recent mergers between universities and university colleges have resulted in the establishment of integrated health faculties covering a broad range of different health sciences.

Generally, the faculties of medicine and health carry out education and research in close cooperation with the public healthcare system. The specialist healthcare services—or public hospitals—in Norway are organised as health trusts administered by regional health authorities that are owned by the Ministry of Health and Care Services. The historic ties to the medical faculties at the universities have been very strong, and interaction between the public hospitals and the higher education sector is institutionalised in various ways. First, the hospitals have a legal responsibility to take an active part in the education of healthcare personnel, e.g. by offering practical training to students at HEIs, which is a function they receive earmarked government funding for. Research is also a legally defined task for the hospitals, and the regional health authorities receive dedicated research funding from the Ministry of Health and Care Services. The research funding is allocated to the hospitals in close cooperation with universities and university colleges. In accordance with government guidelines, the regional health authorities have cooperative bodies with HEIs in their respective regions that are responsible for the allocation of the research funding, as well as for discussing matters of mutual interest in the areas of education and research. Much of the research funding goes to projects involving both hospital and HEI staff, and collaboration between the professional and academic fields is moreover underpinned by a widespread use of dual affiliations. Collaboration between the university hospitals and medical faculties is particularly strong, with a high degree of integration in terms of staff, buildings and infrastructure.

The primary healthcare system covers a broad range of services offered by the municipalities, which also cooperate with HEIs and in particular the institutions offering shorter health education programmes. However, the municipalities do not have the same explicit responsibility for health-related education and research as the regional health authorities and do not receive earmarked government funding for these tasks. This means that the cooperation between HEIs and the municipal healthcare services is not institutionalised in the same way, and because it primarily involves health sciences and professions with limited research activity, it relates mainly to education.

11.3.1 Policies for Research and Innovation

Over the past decade, several government ministries in Norway have initiated so-called 21-strategies, which are national research and innovation strategies within priority areas for research-based development and value creation in the twenty-first century. There are currently nine such strategies, for priority areas ranging from oil and gas to health and care, that have been developed with the involvement of several ministries, research institutions, industry, and other societal stakeholders.

The Health&Care21 strategy stands out by emphasising the importance of an integrated approach to education, research and innovation, and referring explicitly to the knowledge triangle concept. Knowledge triangle interaction is seen as essential for the realisation of the three main goals set out in the strategy, which are to achieve better public health, breakthrough research, and industrial development and economic growth.

The strategy is concerned with facilitating innovation through increased interaction between education, research and the healthcare services, as well as between education, research and industry. It recommends that many of the mechanisms that are in place to ensure interaction between public hospitals and HEIs are introduced in the municipal healthcare services. This includes giving the municipalities a stronger legal responsibility and dedicated funding for contributing to education and research, and the establishment of regional cooperative bodies for municipalities, HEIs, and other research institutions.

Linkages between educational and research institutions and industry are described as underdeveloped, reflecting—among other things—the limited size of the Norwegian health industry and a lack of culture and incentives for cooperation. Thus, key recommendations include introducing incentives for HEIs and health trusts to engage in patenting, commercialisation and innovation cooperation with industry, as well as compulsory courses in entrepreneurship and innovation in health-related educational programmes.

Besides allocating research funding to the regional health authorities, the Ministry of Health and Care channels funding for health-related research and innovation through the Research Council of Norway (RCN). Unlike research funding agencies in many other countries, RCN covers all disciplines and research-performing sectors and provides support for industrial R&D and research-based innovation. The Research Council has developed a separate policy for innovation in the public sector, where a basic idea is that knowledge-triangle interaction should be strengthened through so-called practice-oriented R&D. Practice-oriented R&D takes place in close cooperation between institutions for research and education and public sector professions, with the aim to develop research-based solutions to practical problems as well as to strengthen knowledge-based education and professional practice. The Research Council's efforts in this area have so far been targeting two sectors, the educational sector—spanning from kindergartens to higher and continuing education, and more recently, the health, care and welfare sector.

11.4 Case Studies

The case studies were performed as a part of the OECD study on the knowledge triangle (OECD 2017), and are based on a predefined template. In order to assure variation and comparability we studied three different health faculties at three HEIs; the Faculty of Medicine at the Norwegian University of Science and Technology (NTNU), an integrated health faculty at UiT—the Arctic University of Norway, and The Faculty of Health at the University of South-Eastern Norway (USN). The case descriptions below[2] are based on document studies and interviews with the deans and a group interview with 2–4 members of the academic staff—all conducted in 2015.

11.4.1 NTNU Faculty of Medicine

The Faculty of Medicine (FM) at NTNU is a classical medical faculty offering a medical doctor programme as well as bachelor's, master's and Ph.D. programmes in several medical and health-related areas, including a master's programme in pharmacy. The faculty is organised in seven departments and hosts several research centres.[3] Main areas of research include translational research, medical technology and health surveys and biobanking.

As a medical faculty, FM is strongly embedded in the regional healthcare services, with particularly close ties to the regional health authority Helse Midt-Norge and its subordinate hospitals. The faculty is fully integrated with St. Olav's Hospital, and the two institutions make up the Integrated University Hospital in Trondheim. The national system for cooperation between the specialist healthcare services and medical faculties means that FM has close institutionalised ties to Helse Midt-Norge. The system is an important platform for interaction between education, research and innovation, and the integration of FM and St. Olav's Hospital in the Integrated University Hospital is explicitly based on the idea of the knowledge triangle. In practical terms, the two institutions function as one organisation—they are physically co-located and represented on each other's boards and have joint leadership meetings, cooperating bodies for education and research, and a high number of bridging positions.

The tight integration is also reflected in the funding sources of the faculty; basic government funding accounted for 34% of total R&D expenditure in 2013. Twenty-

[2] They are based on Borlaug et al. (2016) The knowledge triangle in policy and institutional practices—the case of Norway. NIFU report 2016:45.

[3] NTNU merged with three university colleges in 2016 and has now a different structure.

four per cent was Research Council funding and 30% funding from other public sources. The high share of funding from other public sources shows the importance of research funding from Helse Midt-Norge, which makes up around 50% of external funding at the faculty. Industry accounted for a small share of total R&D expenditure in 2013—less than 2%.[4]

Integrated education, research and innovation cooperation with the specialist healthcare services, and particularly St. Olav's Hospital, is an essential part of the faculty's activity. Other types of cooperation such as with the primary healthcare services are considered to be important, but underdeveloped because the majority of the educational programmes are directed towards specialist healthcare services. The faculty also has long traditions for close research and innovation collaboration with the technology departments at NTNU, e.g. within the area of ultrasound, where it has resulted in a spin-off company which is now part of GE Vingmed Ultrasound. Still, there is potential for stronger cross-disciplinary cooperation, according to our informants.

There has not been any systematic integration of innovation in the educational programmes at the faculty, but the newly established master's programme in pharmacy includes a mandatory course in innovation. The objective is to give the students an introduction to the drug development process "from idea to final product", and the course draws on the expertise of the university's technology transfer office. Another initiative is earmarked funding for Ph.D. positions in innovation projects. The faculty funded three Ph.D. positions in innovation projects in 2014/2015, and another two positions in 2016.

Industry collaboration is widespread and takes many different forms. FM has a cooperative agreement with GE Vingmed Ultrasound, and the company rents offices in the Integrated University Hospital, funds Ph.D. and postdoctoral positions, and is involved in education and research at the faculty through part-time positions. Moreover, the faculty has hosted two Centres for Research-based Innovation in recent years, both within medical imaging and with GE Vingmed Ultrasound as an industrial partner: Medical Imaging Laboratory, MI Lab (2007–2015), and the Centre for Innovative Ultrasound Solutions, CIUS, which was started up in 2015. CIUS is a collaboration with researchers from St. Olav's Hospital and technology departments at NTNU and around ten national and regional industrial partners. There are several master's students associated to the Centre, but our informants point out that IPR issues prevent direct student involvement in research cooperation with the industrial partners.

Whereas cooperation with the specialist healthcare services is institutionalised, cooperation with industry and commercialisation is for a large part dependent on individual interest and drive, according to our informants. For instance, one of our informants has established his own consultancy firm based on previous work experience in the medical industry. Another point they make is that education in many cases is the responsibility of the members of academic staff who are least

[4] National R&D statistics, NIFU.

active as researchers, while those who engage in research and innovation may not take part in education—primarily because of time constraints. This may have a bearing on the interest in research and innovation among students, and good role models for knowledge triangle practice are considered to be important.

The faculty is also engaged in commercialisation and makes active use of the university support system for innovation, including the internal funding for the development of research ideas with innovation potential and the technology transfer office. One example, where researchers at NTNU and St. Olav's Hospital have collaborated closely with the TTO, is the development of a method and surgical navigation device for the treatment of severe headache, called MultiGuide.

11.4.2 UiT—The Arctic University of Norway—The Faculty of Health Sciences

The Faculty of Health Sciences (FHS) covers the traditional academic areas of medicine, dentistry, pharmacy, and psychology, as well as the shorter professional programmes within nursing, physiotherapy, etc. that traditionally have been offered by the university colleges. FHS is strongly embedded in the public health sector in Northern Norway and has close ties to the primary and specialist healthcare services and the dental care services in the region. Interaction with the public hospitals governed by the regional health authority *Helse Nord* is especially strong, and there is a high degree of integration between the faculty and the University Hospital in Northern Norway (UNN), which is located on the university campus. *Helse Nord* is furthermore an important source of research funding for FHS. Local and regional industry plays a limited role as collaborative partner and funding source, and with the exception of funding from *Helse Nord*, national research funding seems to be more important than regional funding.

The close ties between FHS and the healthcare services in Northern Norway are reflected in the composition of the Faculty Board, where both UNN and a municipality in Troms County are represented. There are no industry representatives on the Board. The external representation is said to be important by bringing in stakeholder perspectives and giving broader societal legitimacy to strategic decisions.

The national system for interaction between HEIs and specialist healthcare services provides an important platform for education, research and innovation cooperation between FHS and the public hospitals in Northern Norway. The cooperative body with *Helse Nord* which allocates the research funding the regional health authority receives from the Ministry of Health and Care Services is said to play a major role in developing interlinkages between the faculty and the hospitals.

Cooperative bodies are in place at the level of individual hospitals too, and FHS has worked systematically to develop the institutional basis for interaction with UNN. The two institutions have joint leadership meetings and joint education and research committees, which function as important arenas for regular strategic dialogue and joint initiatives.

There is furthermore extensive use of dual affiliations, through which hospital staff work at FHS and academic staff at the faculty work in the hospitals. FHS currently employs more than 300 people with main positions in specialist healthcare services, who are said to contribute significantly to quality and relevance in the educational programmes. Dual affiliations have traditionally been most common within medicine, but FHS is working to increase the number across all health sciences/professions. The faculty has—as the pioneering faculty in Norway and in cooperation with UNN—established 30 dual affiliations for both hospital and university staff within areas other than medicine. It is an ambition to extend the initiative to the municipal primary healthcare services. However, the municipalities' lack of tradition, explicit mandate and earmarked funding for active involvement in education and research poses a challenge, both for the establishment of dual affiliations and for systematic interaction between education, research, and professional practice in the primary healthcare services more generally.

FHS has a strategic focus on innovation in education, and more specifically on developing new forms of education to meet the competence needs of the healthcare services. As an integrated health faculty, FHS places a strong emphasis on so-called "cross-professional learning" in the educational programmes and has introduced joint courses for all students with the objective to teach them how to interact and cooperate across healthcare professions. The faculty is also in the process of developing joint arenas for practical training through various pilot projects carried out in close collaboration with the healthcare services. The projects have been initiated by dedicated faculty staff as well as by actors in the healthcare services and embedded at the faculty level. This is seen as an example of innovation in education that has been directly motivated by the need for new types of competence in the healthcare sector following from a major national health reform, the Coordination Reform.

FHS is also engaged in commercialisation and innovation collaboration with industry, mainly in the areas of medical biology and pharmacy. It utilises the services of the local technology transfer office and has collaborative projects with industry which include a Centre for Research-based Innovation, MabCent—Marine bioactivities and drug discovery (2007–2015), and two Industrial Ph.D. projects at the Department of Pharmacy. Within the area of pharmacy, innovation is closely integrated with education at both bachelor's and master's levels, and the Department is actively developing master's projects with direct industrial relevance.

11.4.3 University of South-Eastern Norway—The Faculty of Health Sciences

The Faculty of Health Sciences (FHS) specialises in four areas of study—nursing, optometry, radiography and health technology, and health promotion. It has a strong educational profile and offers shorter study programmes qualifying students for healthcare professions within these areas, as well as programmes and courses for the specialisation and further education of professional practitioners. These are areas with relatively weak research traditions, but the research activity and competence has been increased over time, and the faculty offers a cross-disciplinary Ph.D. programme in person-centred healthcare (focused on the development of healthcare services based on practical needs).

FHS has close cooperation with the local and regional health sector, and primarily the municipal primary healthcare services, when it comes to education, both through practical training for students and continuing education for professional practitioners. Practical training is an important mechanism for systematic interaction and knowledge exchange between the faculty and the healthcare services and contributes to quality and relevance in education as well as continuous and incremental improvements in professional practice. Continued education too plays a central role in health service development, and FHS has an extensive portfolio of courses commissioned by actors in the industry and working life and tailored to their competence needs.

Innovation in education is a central area of activity that includes the development of innovative educational designs, as well as teaching students about innovation. The faculty has, for example, worked systematically to integrate the innovation concept and innovation thinking in all bachelor's-level programmes through a project with funding from the Government's "Entrepreneurship in Education" initiative.

The way our informants see it, knowledge triangle interaction is an inherent part of the activities of a health faculty offering professional education in close cooperation with the healthcare services. A key point in this context is that innovation is understood broadly, as something that includes incremental improvements in healthcare services based on the continuous exchange of knowledge between students, academic staff and healthcare professionals.

It is important to note that research at FHS is practice-oriented, illustrated by that the faculty has received project funding from the Research Council's programme for practice-oriented R&D in health and welfare services. The projects link research, education and professional practice, with the aim to strengthen the knowledge base and thereby improve the quality of the health profession education and healthcare services.

The main campus for the Faculty of Health is part of *Papirbredden Knowledge Park*, where the university college is co-located with knowledge-based companies, innovation support agencies, and the regional innovation company *Papirbredden Innovation* which was established with HBV as one of the initiating partners and owners. The company is a collaboration with municipalities, private industry, and a national agency, and engages in innovation projects, commercialisation, and business development within regional priority areas. *Papirbredden Innovation* has health and welfare technology as a priority area. The university college is also represented on the board of *Driv Incubator*, a SIVA incubator that specialises in health-related commercialisation and start-ups. In close cooperation with *Papirbredden Innovation*, the faculty initiated a process around 2007 to establish a cluster of local technology firms specialising in the development of health and welfare technology, primarily for the municipal primary healthcare services. The cluster, which has received funding from a public programme, is an important platform for enhancing systematic innovation collaboration between FHS, municipalities and private industry. Many projects in the cluster are aimed at developing, testing and implementing health and welfare technology. The role FHS plays in innovation projects is primarily that of facilitator of innovation processes in the healthcare services, e.g. through scientific consultancy, competence development, and formative research. Commercialisation of research results is not a central activity at the faculty.

In 2012, FHS opened a centre for testing and demonstration of the technology developed by the health innovation cluster. The centre brings together students and staff at the faculty, the technology firms, and municipalities and other users of health and welfare technology. FHS uses the centre actively for educational purposes, and the students are introduced to the new technologies through simulation training and lectures from the technology producers and from users in the municipal healthcare services.

11.5 Discussion and Conclusion

As the case studies show, there are differences between the three health faculties regarding the intensity of the collaboration and the channels of interactions with the public and private sectors. We see that the differences in academic profile have a bearing on the activities the faculties engage in. The faculties at NTNU and UiT that cover research-intensive medical sciences are involved in Centres for Research-based Innovation, as well as commercialisation and entrepreneurship activities. Here we see patterns of what we can call the entrepreneurial knowledge triangle (Clark 1998).

NTNU and UiT also have strong integrated education, research and innovation cooperation with the specialist healthcare services, and especially the university hospitals in their respective regions. These practices are intrinsically linked to the national system for interaction between the public hospitals and medical faculties, where the hospitals have a legal responsibility—and receive dedicated government funding—for engaging in education and research. There are strategic collaborative bodies in place, which discuss matters of mutual interest in the areas of research and education and the allocation of research funding. The system is also characterised by extensive use of dual affiliations, and close physical integration between the medical faculties and the university hospitals. These top-down, formal and institutionalised channels of interactions strengthen the opportunities for knowledge triangle practices between the specialist healthcare services and medical faculties.

The two faculties that offer shorter health professions education, UiT and USN, cooperate with both hospitals and primary healthcare services when it comes to practical training for students and continuing education for healthcare professionals. This contributes to competence-development based on the needs of the healthcare services and thereby improvements in professional practice. However, there is less systematic and integrated knowledge triangle interaction than between the medical faculties and the specialist healthcare services—for several reasons. First, the primary healthcare services do not have the same explicit mandate to contribute to the education of healthcare personnel and do not receive government funding for engaging in practical training of students. Second, the shorter health education programmes and the corresponding fields of professional practice have traditionally not been based on research to any significant extent. Thus, the collaboration concerns primarily the training of students and the development of courses for continuing education and to a lesser extent research collaboration.

The differences in the patterns of collaboration and degree of institutionalised ties health faculties have with the specialist and primary healthcare services and private firms, illustrate the importance of long-term agreements and funding for collaboration on education, research and innovation.

Collaboration between HEIs and the private sector is primarily based on bottom-up initiatives, and it might be that good examples and practices of collaboration between HEIs and the public sector could be transferred to private sector collaboration. This would, however, require new types of policies on both institutional and national levels. One way HEIs may strengthen their knowledge triangle interaction with industry can be through establishing strategic long-term partnerships on research and education with private firms. This may not just be one-to-one partnerships, but can involve multiple firms. At the national level, there are already cluster programmes that serve a similar function as they offer long-term funding for HEI-industry collaboration on education, research and innovation. These programmes may, however, be developed to include new instruments for collaboration such as dual affiliations and incentives for mobility.

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Part IV

Knowledge Triangle in Light of Science, Technology and Innovation Policy

Knowledge Triangle Governance in Science, Technology, and Innovation Policy 12

Leonid Gokhberg, Mikhail Gershman, Stanislav Zaichenko, and Dirk Meissner

12.1 Introduction

The Knowledge Triangle (KT) concept focuses on activities and interactions in the science, higher education, and innovation framework, providing advice for a more efficient policy mix within these domains (Unger and Polt 2017). A typical KT policy framework combines national or local authority functions remaining outside the KT that are, however, connected with science, innovation, industry, and education. Other actors among the state act as sources for initiatives or provide expertise, and these include large corporations, associations, public universities and research institutes, or academic communities.

Good practices of KT-related state policy focus upon the effective encouragement of and assistance for science industry academia cooperation to boost the national innovation system (NIS) and support sustainable future development. Science-industry relationships have, over the decades, tended to be the most articulated side of the triangle (OECD 2002, 2019). Among the recent success stories are Austria's experience with targeted programmes (COMET, CDG, BRIDGE, COIN, RSA; Ecker et al. 2019), successfully terminated SHOKs and INKA initiatives in Finland (Halme et al. 2019), various sector- and region-specific collaboration schemes in Norway (Borlaug et al. 2019), and many others.

Universities and other higher education institutions (HEIs) fulfil a special role in the entire KT by combining education (teaching and learning), R&D, and innovation/entrepreneurship functions simultaneously (Cervantes 2018). Such activities can be supported by respective tax incentives for companies, academia-industry R&D cooperation schemes, small business innovation research initiatives, industrial PhD programmes, innovation vouchers for SMEs collaborating with HEIs, and so on. The aforementioned policy tools are, to a great extent, being organised

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and financed at the local level. However, some national triangle policy models deserve attention as well, such as Dutch Ecosystem Networks (Stam et al. 2016). The benefits of such initiatives include strong incentives for universities and firms to develop and promote their missions, research and innovation towards social priorities; grounds for the more systemic and evidence-based design of STI reforms; and more visible trajectories for national and local STI ecosystems development (OECD 2017).

Typical policies related to the facilitation, transformation, and development of the KT vertices include the restructuring of public research organisations (PROs), project-based research funding, and excellence/competence initiatives involving R&D actors. The education side is often influenced by the conversion of HEIs towards entrepreneurial universities and new industrial initiatives (demand for new skills and research related to emerging technologies and cooperation schemes). On the innovation side, direct support can be considered for demand-pull (via innovative public-private partnerships or competitive funding schemes), and science-push (commercialisation of publicly funded research) approaches as well as indirect tools (like tax incentives).

However, KT policies always need to be considered in the national contexts, which leads to a noticeable variation in KT policies. For instance, in some countries, university-focused initiatives dominate due to the advanced role of these institutions in NIS. In other cases, more policy efforts are made to encourage R&D co-funding from the business enterprise sector. Countries like Japan or Israel avoid massive government interventions in terms of R&D expenditure financing, while in Norway or Chile, S&T systems are almost half-financed by the state. The status of HEIs (public or private) defines to a great extent the choice of KT support mechanisms (OECD 2017). In this respect, the Russian case is more specific, since the national government allocates more than two-thirds of gross R&D expenditure, almost replacing private investments and ensuring the dominant role of the state in all KT domains (Gokhberg and Kuznetsova 2016, 2021).

The next section of the chapter discusses the NIS background and evolution of the KT in the Russian context. It is followed by the overview of KT policy deployment, which, in turn, addresses the strategic framework and recent trends. The last section provides a summary and conclusion.

12.2 The Russian National Innovation System—Background

The NIS concept provides a theoretical and analytical framework of STI combining economic, institutional, and social dimensions of engaged actors, functions, norms, processes, assets, and outputs (Freeman 1988; Lundvall 1992, 2007; Nelson 1993). It allows for describing an ecosystem of science and innovation under a specific focus highlighting more significant features and structures. The Russian NIS framework seems to remain mainly a product of an incomplete and disproportional transition from the former Soviet command administrative system toward more democratic and market-focused institutes. While the first decade (the 1990s) after the collapse of the USSR was somewhat stagnant, the next one (post-millennium) saw significant expansive changes in STI policies and activity. This progress was induced by incipient economic growth (against the background of an outstripping industrial recovery after the default of 1998 and soaring oil prices) and optimistic expectations for a further transition toward a "new" economy and a highly competitive NIS (Gokhberg 2004). After the global crisis of 2008, however, positive trends began to fade. STI policies and the NIS structure continued to evolve toward greater complexity and maturity, but no further significant shifts in performance appeared (Gokhberg and Kuznetsova 2010, 2016). The main systemic long-term characteristics of S&T in Russia include the dominant role of the state (both as owner and as a funding source), the presence of obsolete institutional forms, and a protracted resource deficit. At the same time, the Russian NIS faces certain problems with industry innovation activity. These and other factors influence the Russian KT and related policies greatly and are to be discussed more in detail below.

As do some other former Soviet states, Russia has a somewhat disproportionate S&T system with a relatively large government R&D sector exceeding 38% of overall R&D-performing organisations (HSE 2017, 2020a, b). Privatisation since 1991 has resulted in about 22% (2018) of private R&D organisations only, and almost 64% are still entirely state-owned. One of the main reasons is the preponderance in Russia of specific forms of R&D organisations with limited commercial abilities. For instance, the uniform type of R&D organisation in the Soviet era was the so-called "research institute" (a stand-alone organisation, sometimes very large, directly subordinate to a head ministry or a state agency and separated from enterprises or HEIs). Today almost 40% of the Russian S&T system is comprised of research institutes, and most of them are still administratively separated from both the market and academia. For instance, HEIs represent only 23% of Russian R&D organisations. Another reason is the comparatively low industry demand for R&D and new technologies, given that the share of innovative industrial enterprises has not exceeded 10% since the mid-2000s.

In absolute figures, the S&T burden of the state appears even greater. Throughout the post-Soviet period, the number of organisations carrying out R&D fell moderately (from 4600 to 3900). However, R&D personnel nearly halved (from 1.7 million to 700,000 employees) following the respective drop in R&D expenditures. In this situation, performance was bound to suffer. Showing the level of gross R&D expenditure comparable with such economies as the UK or France, Russia's output with regard to research articles in indexed journals and patent application is nearly two times lower (HSE 2020b).

The industry itself is quite limited with regard to innovation opportunities. Against the background of high non-market risks, highly monopolised markets, short planning horizons, and hardly accessible investments, technological innovation activity has remained commercially rational of about 9% of the enterprise over the last few decades but is supported by the quite high quality of human capital and education, as, for example it is reflected in the Global Innovation Index (Cornell University et al. 2020). In the years since 2017, this share of firms suddenly jumped from 7% to 20–21% due to fundamental changes in the official statistics methodology, but the expenditures on technological innovation in real prices continued stagnating (HSE 2018, 2020a, c). More than 44% of expenditures by industrial firms is related to equipment purchases and half of this (24%) is connected with R&D. Innovative goods and services account for less than 7% of total production.

Russia, therefore, provides a very interesting example of a large and rich country with a disproportionate, scattered, and still transitional NIS. According to the recent Russian national innovation surveys, external factors hampering innovation are more significant for enterprises than internal ones (HSE 2020c). The first group is dominated by the high costs of innovation, high economic risks, and lack of financial support from the government. Only 21% of innovative enterprises succeed in obtaining support from the state, and 28% participate in R&D projects. Linkages between innovative enterprises, state authorities, and R&D organisations are quite unstable, while the R&D sector itself is fragmented by HEIs and separated research institutes. Considering the high risks, costs, and fragmentation of the NIS, R&D and innovation seem to be close to market failures. This is a fundamental challenge for Russian KT policies, and the responsibilities of the state appear more complex than in many other economies.

The Russian government no longer officially claims total control of the economic and social spheres as it did three decades ago and earlier. At the same time, it has to somehow substitute the underrepresented private business actors to maintain the NIS in the market-based economic environment. In order to do so, specific "quasi-state" structures were established realising such functions, among which are the state development institutions and large state corporations. The first category includes two large state-funded foundations (the Russian Foundation for Basic Research and the Russian Science Foundation) and a number of specialised development institutions targeting innovation in various sectors at different technology readiness levels (Foundation for Assistance to Small Innovative Enterprises in Science and Technology, Skolkovo Foundation, Industry Development Fund, Internet Initiatives Development Fund, Rusnano, VEB.RF, Russian Venture Company, Agency for Strategic Initiatives, and Russian Small and Medium Business Corporation). While allocating and reallocating public funding, these organisations maintain "oases" of initiatives, competition, and entrepreneurship within Russia's NIS. A large-scale reform of development institutes is planned in 2021 in order to optimise operations and eliminate the duplication of functions. For instance, VEB.RF will become more significant, taking control of Rusnano, the Industry Development Fund, the Foundation for Assistance to Small Innovative Enterprises, and others; two state science foundations will be merged, and some development institutes will be reorganised or dissolved.

The category of innovative state corporations is represented by five dozen large state companies implementing (by directive) their own medium-term innovation programmes. These actors account for about 60% of GDP and have their own initiatives related to large-scale innovation projects, innovation management development, and open innovation ecosystems. These corporations are somewhat protected from economic and non-market risks, as well as from risks connected with a lack of resources and competitive pressure, as they seem to be the main and most active innovators in the Russian NIS. At the same time, innovative state corporations act as mediators, enabling access to innovation projects for smaller firms, HEIs, and research organisations (Gershman et al. 2019).

Probably, the most significant change in the Russian NIS since 1991 is related to an expansion of its university sector (Gokhberg et al. 2011, 2017; Gokhberg and Kuznetsova 2016, 2021). In most countries, HEIs are where a large portion of R&D and research personnel are concentrated. The former Soviet S&T system regarded universities as primarily education institutions with little exception and conducted R&D in the industrial system (sector-specific applied R&D institutes) and the USSR Academy of Sciences (basic research). Forceful, condensed, and continuous public support during the recent decade allowed for increasing the higher education sector's share in R&D expenditures from 5% to 10% (HSE 2020b). As a result, the share of HEIs carrying out R&D changed from 40% to 74%, and the number of Russian universities represented in global rankings increased from nine to nearly 50. However, the Russian higher education sector of R&D is still relatively modest compared to many leading nations.

In line with the key actors mentioned above, some others play an important role as well. Among them is the Russian Academy of Sciences as a body coordinating government-funded basic research activities, various centres of excellence and STI infrastructure networks (technoparks, special economic zones, technology platforms, etc.). The state authority system in STI is also quite complex and multidimensional.

The goal of this chapter is to summarise the KT-related policies, and it does not focus much on the structural description of the Russian NIS. The next sections discuss the respective policy trends, addressing them to particular NIS elements.

12.3 Russian KT Policies as a Response to Systemic Challenges

The general context described above provides the necessary background for shaping the policy framework of the Knowledge Triangle in Russia.

The integration of education and science offers opportunities to increase the efficiency of R&D and the quality of human resources, as well as to boost science-industry relationships. As mentioned before, Russia has three distinctly separated S&T segments (universities, industrial science, and academia); none of them is able to handle all the integrated functions so far, and university science has historically played a modest role despite the visible increase in research performance over the last decade. In the late 1990s, it was decided to allow the creation of joint R&D centres between HEIs and research institutes in line with respective federal laws "On science and state S&T policy"[1] and with support of the targeted federal programme

[1] Federal law of the Russian Federation N 127-FZ of 23 August 1996 "On science and state S&T policy."

"State support of integration of higher education and fundamental science for 1997–2000."[2] Since 2009, public universities also were allowed to create spin-offs for technology transfer according to federal law N 217.[3]

These changes allowed for new institutional forms of integration but did not promote them properly. To launch this transformation of the R&D process, the scientific competitiveness of Russian universities had to be improved. The first shift took place in 2008 with the adoption of the "national research university" (NRU) status (this is granted to research-intensive universities on a competitive basis for a period up to 10 years).[4] In 2008–2010, a group of 29 universities (out of about one thousand in total) became NRUs and obtained government subsidies in accordance with their development strategies and annual performance assessments. Faced with high heterogeneity of performance indicators within the NRU group, the government applied much stricter selection criteria to 21 leading universities under the "Project 5–100"[5] in 2012 and provided them with increased and more flexible competitive institutional funding. Additional initiatives were realised to support innovative infrastructure at HEIs,[6] as well as to promote "mega science" facilities and world-level labs.[7] After 2020, policies promoting university research and the integration of science and education changed.

Russian enterprises, besides industrial policies, are also involved in KT integration. Since the early 2010s, a number of indirect incentives for industrial R&D (tax exemptions, increased amortisation fees, etc.) were developed and put into practice. In 2010, the so-called "Statement 218" was adopted.[8] This policy enables continuous competitive co-funding of innovation cooperation projects (full cycle including

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[2] Approved by the Statement of the Government of the Russian Federation N 1062 of 9 September 1996 'On the Federal targeted programme "State support of integration of higher education and fundamental science for 1997–2000."'

[3] Federal law of the Russian Federation N 217-FZ of 2 August 2009 "On amending legislative acts of the Russian Federation on creation of legal entities by state R&D organisations and HEIs for the purpose of practical application (implementation) of intellectual activity results."

[4] The pilot NRU initiative was launched by the Decree of the President of the Russian Federation N 1448 on 7 October 2008. The first competitive selection of NRUs was initiated by the Statement of the Government of the Russian Federation N 550 on 13 July 2009.

[5] The "Russian Excellence Academic Project" ("Project 5–100") was adopted by Decree of the President of Russian Federation N 599 of 7 May 2012 "On measures to implement state policy in the field of education and science." The formal target is the presence of at least five Russia's leading HEIs in the world's top 100 rankings by 2020.

[6] Statement of the Government of the Russian Federation N 219 of 9 April 2010 "On state support for development of innovative infrastructure in federal HEIs."

[7] Statement of the Government of the Russian Federation N 220 of 9 April 2010 "On measures to attract leading scientists to Russian HEIs, research institutions and state research centres of the Russian Federation."

[8] Adopted by the Statement of the Government of the Russian Federation N 218 of 9 April 2010 "On approval of the Rules for provision of subsidies for development of cooperation between Russian HEIs, state research institutions, and organisations of the real sector of the economy in order to implement complex projects to create high-tech industries."

R&D, technology implementation, production launch, and market entry) under the condition of the engagement of HEIs and R&D organisations as subcontractors. Most large and medium enterprises enter the “Statement 218” competition. The most significant part of manufacturing enterprises (and innovative ones as well) is comprised of large state corporations implementing their own innovative development plans. One should note that these plans (in fact, corporate innovation strategies arranging innovation projects for the medium term) were “recommended” by the Strategy for Innovative Development of the Russian Federation until 2020 (discussed in the next section of the chapter) and are a part of national KT policies.

Small innovative enterprises appeared in the focus of KT policies even earlier, in 2009, with adoption of the federal law N 217 mentioned above in this section. This act allows for the creation of small innovative enterprises by public R&D organisations and HEIs and, most importantly, offers opportunities to commercialise outcomes from publicly funded R&D by means of these spin-offs. However, it took about six years more to implement exemptions into the Tax Code and the Civil Code in order to eliminate the multiple taxations of technology ownership and transfer and to regulate the rights and responsibilities of all actors in such transactions.

Innovative SMEs are able to benefit from the activities of development institutions as well. The Foundation for Assistance to Small Innovative Enterprises has provided competitive grants to innovative start-ups, teams, and individuals since 1994. It supports a wide spectrum of programmes covering all stages from R&D to commercialisation. Since 2006, the Russian Venture Company has acted as a hub for venture investment flows and operated (since 2015) a large programme “National Technology Initiative” aimed at creating and fostering the entry of Russia into new globally competitive markets based on advanced technologies. Skolkovo Foundation provides innovative start-ups not only with grants but with research and innovation infrastructure as well.

R&D organisations in Russia are difficult to study as a single segment or a KT “corner” since they are excessively numerous (about four thousand) and heterogenous (private and public, industrial and academic, groups and stand-alone, large and small, belonging to different R&D sectors and S&T fields). In the KT context, industrial-vs-academic specialisation looks more relevant. Russian industrial R&D arises from the former Soviet “branch” system where all industrial sectors were controlled by respective ministries and agencies, and each of them was an “umbrella” for a number of highly specialised R&D organisations. After 1991, the state policies were aimed mainly at maintaining the largest and most promising representatives of this cohort. To distinguish the leaders, a number of status modes were introduced. State research centres (since 1994, there have been 43 units in total) and national research centres (since 2010; two units) are the best-known ones. No significant initiatives were introduced specifically for industrial science, but such institutions are allowed to apply some aforementioned policies, including participation in competitions under “Statement 218” and “megascience” projects, the creation of spin-offs according to the Federal law N 217, benefits from various tax incentives, among others.

The academic group of R&D organisations is represented by units, which previously belonged to the Russian Academy of Sciences (and even earlier, the former USSR Academy of Sciences). By 2013, this system amounted to 514 organisations, specialising mainly in basic research. These are accompanied by a number of smaller so-called state "branch academies" (academies for agricultural sciences, medical sciences, education, and arts) subordinated to particular ministries and containing in total 358 research institutes. In contrast to "branch academies," institutes of the Russian Academy of Sciences (RAS) had unclear administrative status (while operating as public organisations, they were not subordinated to any authority, but simply to the RAS). In 2013, a radical reform was launched. As a result, entities from "branch academies" of agricultural sciences and medical sciences were transferred to the RAS network, but the Russian Academy of Sciences was deprived of administrative and economic functions, keeping only scientific coordination responsibilities (in 2013–2018, these functions were realised by the Federal Agency for Scientific Organisations—FASO—subordinated directly to the government). Nowadays, FASO does not exist, and its institutes are subordinated to the Ministry of Science and Higher Education of the Russian Federation (since 2018). So, after the reform, the performance of academic science was controlled, while its network underwent certain transformations aimed at increasing research productivity (Gokhberg and Kuznetsova 2016, 2021).

The KT infrastructure includes various elements supporting the operation and interaction of its three segments. In Russia, technology platforms were expected to act as a communication tool within this context. This initiative was implemented in 2011[9] to establish science-industry communication hubs within particular high potential technology fields or platforms (35 platforms in total). This essentially deals with the cooperation framework and the regulation of platform strategies as well as joint R&D programmes, which are composed of active platform participants. Unfortunately, this framework is currently almost stagnant. Another case is technoparks. They have existed in Russia since 1990 (initially—on the basis of the leading universities) as bottom-up initiatives. However, in 2006 a special status of "Technopark in a high-technology field" was introduced under the State Programme for the "Creation of Technoparks in High-Technology Fields in the Russian Federation."[10] It provided capital expenditure subsidies (on a competitive basis) for the period in 2006–2011. Innovation clusters in Russia have been supported on a competitive basis by the government since 2012.[11] The respective official list includes 25 clusters realising their own innovation development programmes and obtaining such forms of support as institutional development subsidies from local

[9]The structure of technology platforms was approved by the Decisions of the Government Commission on High Technologies and Innovations of 1 April 2011, Protocol N 2, dated 5 July 2011, Protocol N 3, Decision of the Presidium of the Government Commission on High Technologies and Innovations of 21 February 2012, Protocol N 2.

[10]Launched by the Order of the Government of the Russian Federation N 328-r of 10 March 2006.

[11]The list of innovation territorial clusters was approved by the Order of the Prime Minister of the Russian Federation No. DM-P8-5060 of 28 August 2012.

budgets, priority assistance from development institutes, and large state corporations. In 2016, the Ministry for Economic Development selected the 11 top-performing clusters for more condensed assistance in governance and co-funding.[12] Other infrastructure measures include technology transfer centres, special economic zones, centres for the collective use of research equipment and unique scientific installations, engineering centres, business incubators, and accelerators. Many of these initiatives use instruments of alleviated taxation and low-interest bank loans.

The period until 2020 shows a great variety in KT-related policies in Russia. Some of them appeared to be quite successful, especially those targeting a limited number of large leading stakeholders. However, hampering factors often emerged as well, including a limited funding base, short durations, incoherence, among others. For instance, about a dozen leading HEIs forming the "core" of NRU and "5–100" cohorts were the main contributors to the "outputs" of these initiatives. The scale of NRU institutional funding did not provide sufficient opportunities for significant breakthroughs, but still ensured NRUs' sustainability. "Statement 218" demonstrated quite good performance as a source of assistance to particular innovative cooperation projects, but does not encourage long-term cooperation; moreover, it has a limited scope of participants. The federal law N 217 is a crucial step towards the commercialisation of publicly funded research, but it was not enough to launch spin-offs until the whole legal framework was adjusted. By that time, the economic crisis hampered such activities.

The Russian KT infrastructure is quite diverse. On the other hand, some initiatives remain incomplete, some others provide limited access or appear to not be in much demand. Thus, the technoparks programme participating units were created, but their load and performance appeared low; however, a limited number of full-fledged competitive technoparks (mostly university-based) developed independently as bottom-up initiatives. Many technology platforms appeared underutilised, but some of them proved to be useful. Special economic zones and innovation clusters concentrate high potential and resources inside but look more like S&T "reservations" than centres of rapid development. Hence, The Russian case differs from the traditional KT concept (Fig. 12.1).

This triangle looks "smaller" because all three segments are involved only partially. On the side of HEIs, three quarters are inside the triangle (the rest do not carry out R&D), but the main impact comes from NRUs and "5–100" members. The industrial side is represented by innovative enterprises, which constitute about one-tenth or one-fifth (depending on the calculation method) of the total firm population. Among them, the most significant players are large firms (first of all, state corporations with innovative development plans); a group of spin-offs and start-ups holds its position inside as well. Research organisations should entirely

[12] Order of the Ministry of Economic Development of Russia N 400 of 27 June 2016 'On the priority project of the Ministry of Economic Development of Russia "Development of innovative clusters—leaders of investment attractiveness of the world level."'

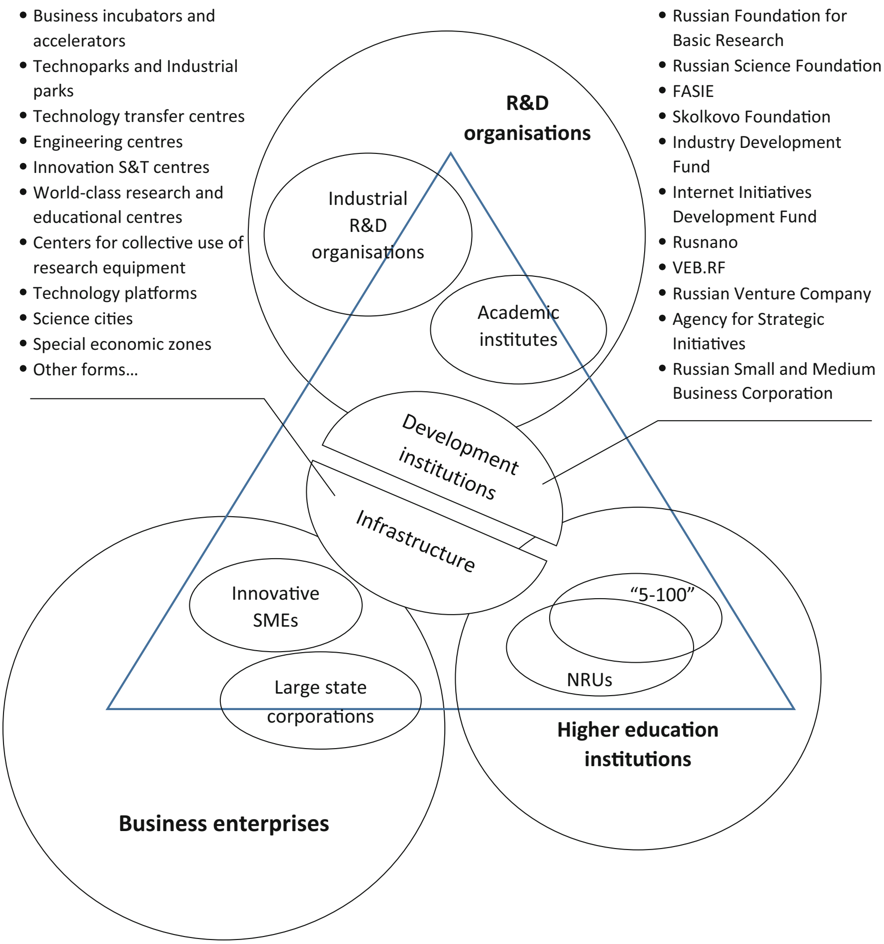

Fig. 12.1 Knowledge triangle in Russia

appear inside the triangle, but in fact, some of them do not have any contact with both education and innovation. The infrastructure elements, as mentioned above, are quite limited in scope and load, but the current state of the KT still ensures their operation and the interaction between the most active participants.

Regarding this background, coherence, completeness, horizon, and scale can be regarded as the main factors for KT policy effectiveness. In order to realise the future development of KT policies and intentions, it is important to consider their arrangement at the national strategic level. The next section discusses the ongoing KT initiatives in Russia in the context of main STI strategies.

12.4 Recent Development and Prospects

The first self-sufficient strategic document in the STI domain in Russia was the Innovative Development Strategy Until 2020,[13] adopted in 2011 (in the framework of the more general Concept of Long-Term Socio-Economic Development until 2020[14]). It was based on the long-term S&T Foresight and aimed at ambitious goals to be reached by 2020. It determined the KT landscape in the 2010s to a great extent. For enterprises, it was planned to raise innovation activity up to 50% (and value added by innovative enterprises to GDP up to 17–20%), the share of innovative products in the total industrial output up to 25–35%, Russia's share in the global high-tech exports up to 2%, and some other targets. The research sector was expected to increase the share of R&D expenditure in GDP up to 2.5–3% (and more than a half of R&D expenditure was to be financed by businesses), the share of Russian authors in global scientific publications up to 3%, and the number of international citations per publication of Russian authors up to 4б. At least four universities had to enter the top 200 in word rankings.

This strategy was a full-scale KT initiative not only by targets, but by the content as well. The latter included an excessive number of specific KT initiatives, including ones mentioned above, namely

- "5–100" project
- "Statement 218"
- Innovative development programmes by large state corporations.
- Technology platforms.
- Innovation clusters.
- Support for the activities of existing development institutes.
- Support to the national research centres, and others.

Not all the actions were implemented successfully (e.g. the Long-term Programme for Basic Research) or in balance (the uneven development of innovative clusters and technology platforms), and many of them could be wider in scope and longer in duration. Nevertheless, these elements generally performed well or at least satisfactorily. All the more surprising was the failure of the strategy in terms of achieving the targets, for example almost none of them were achieved by 2020 (however, the goal of Russia's share in WoS publications was achieved mostly due to the high performance of leading universities). The state realised its capacities in the establishment of a "basic" (or "core") KT, but failed to encourage businesses or academicians to join the efforts and expand the triangle to the whole NIS.

[13] Adopted by the Order of the Government of the Russian Federation N 2227-r of 8 December 2011 "On the Innovative Development Strategy Until 2020."

[14] Adopted by the Order of the Government of the Russian Federation N 1662-r of 17 December 2008 "On the Concept of Long-Term Socio-Economic Development until 2020."

Before the termination of this initiative, a new "Strategy for S&T Development until 2035" was adopted in 2016.[15] In fact, it is a framework of documents, including the strategy itself, an implementation plan for 2017–2019,[16] a set of rules of coordination and monitoring for the realisation of the strategy,[17] and some others. In contrast to its predecessor, this strategy has long-term horizon and allows for some further revisions as circumstances change, or new conditions emerge. The strategy document was designed as an officially declared vision of the grand challenges and corresponding S&T priorities. Against this background, the document formulated goals and objectives for S&T development. The implementation plan combines particular actions, mostly state programmes in line with the S&T priorities and a system of so-called complex S&T programmes/projects with full innovation cycles. The latter is quite a new kind of initiatives aimed at the elimination of "gaps" and "bottlenecks" in support of innovation at particular stages. It is also worth noting that this strategy is not strictly oriented toward the achievement of a set of target indicators (but there are still two control indicators included: 2% of GERD in GDP by 2035 and a 50% ratio of business to government R&D expenditures). Instead, it is provided with a complex evaluation procedure measuring the success of programmes and projects within the implementation plan.

Since 2019, the complex programmes and projects related to the priorities of the Strategy for S&T development until 2035 have been incorporated into the large-scale state programme "S&T Development of the Russian Federation in 2019–2030". Its function is the allocation of public funding within five "subprogrammes" related to areas such as intellectual capital development, global competitiveness of national higher education, and long-term basic research. The programme will be revised in 2021.

The strategies and programmes mentioned above look quite complex and even chaotic, but they still do not exhaust the whole range of such policies in Russia. A set of so-called "May Presidential decrees" were developed and implemented in 2012 in a kind of "parallel" to the Innovative Development Strategy until 2020 as a top-level strategic tool. A set of 11 decrees from the President to the Government were submitted in order to declare official targets in the domains of economic and social policy, healthcare, defence, science and education policy, and others. The KT policy tools arose from one of them, the Presidential Decree on Science and Education Policy.[18] This directive included 24 tasks supplied with respective benchmarks such as the implementation of "efficient contracts" for research and teaching staff, the growth of Russia's share in global scientific publications, the enhancement of R&D

[15] Approved by Decree of the President of the Russian Federation N 642 of 1 December 2016 "On the Strategy for S&T development of the Russian Federation."

[16] Statement of the Government of the Russian Federation N 1325-r of 24 June 2017 "On the Plan of Implementation of the Strategy for S&T Development of the Russian Federation for 2017–2019."

[17] Statement of the Government of the Russian Federation N 421 of 4 April 2018 "On approval of the Rules of coordination and monitoring of realization of the Strategy for S&T Development of the Russian Federation."

[18] Decree of the President of the Russian Federation N 599 of 7 May 2012.

expenditures, increased support for science foundations, and others. Ministries and local authorities were supported by respective state subsidies to implement the decrees.

A new version of presidential decrees was adopted in 2018.[19] This initiative looks more complex and large-scale since it declares more general high-level goals[20] and, most importantly, introduces so-called "national projects" (NPs) as a new form of state support packages. Each NP acts as a targeted programme arranging a set of actions and allocating respective public funding with a particular timeline. It also has its own set of target indicators related to the general targets/goals within the 2018 May Decree framework (also known as the "Unified Plan for the Achievement of National Goals up to 2024"). NPs in this respect differ from other programmes by their longer timelines, larger scales of funding, and the presence of more complicated target indicators connected more with expected effects than with immediate results.

At least one NP launched after 2018 has a quite strong relationship with the KT framework, namely NP "Science" revised in 2021 as NP "Science and Universities." The national project "Science" initially was divided into three so-called federal projects (FPs): "Development of Research and Production Cooperation," "Development of Advanced Infrastructure for R&D," and "Development of Human Resources in S&T". The first of them plays an important role for the KT framework in establishing and promoting new forms of science-industry cooperation, including 15 world-class research and education centres, 16 world-class research centres, including mathematical and genomic centres, and 14 centres of competence from the National Technology Initiative. These centres of excellence/competence will obtain large-scale public institutional and project co-funding in 2019–2024.

The FP "Development of Advanced Infrastructure for R&D" within the NP "Science" will upgrade at least 50% of research equipment at R&D organisations, develop "megascience" facilities and national research fleet facilities, as well as advanced innovation infrastructure elements. For these and other forms of competitive support, a wide-scale R&D performance assessment system will be created.

The third FP "Development of Human Resources in S&T" is aimed at the integration of education and science and the promotion of university R&D. It includes various project funding schemes involving grants for 900 research labs guided by young researchers, support for 7500 research projects within the national S&T priorities, 7000 research grants to PhD students, 1000 grants for domestic academic mobility, ten training and competence centres for research project managers, and 300 grants for the best research projects in the field of social and political sciences.

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[19] Decree of the President of the Russian Federation N 204 of 7 May 2018 "On national goals and strategic objectives for the development of the Russian Federation for the period until 2024."

[20] For the STI domain, these goals include (1) the acceleration of Russian technological development and the increase in the number of organisations implementing technological innovations, up to 50% of their total number and (2) ensuring the accelerated implementation of digital technologies in the economy and social sphere.

The new revision NP "Science and Universities" is still under development and is expected to be approved later. At the time of preparation of this chapter, four policy areas (FPs) have been developed under this NP. They include additional initiatives of research excellence (20 world-class research centres, 30 regional research and education centres, 35 centres for technology transfer), research competence (1000 PhD student grants, 30 nationwide academic mobility projects, 600 postdoc grants, IPR and commercialisation competence programme), the integration of education and science (academic excellence programmme for at least 100 universities, 30 world-class research and education centres), and research infrastructure (the modernisation of research equipment at the leading universities and research organisations, the design, construction, and reconstruction of campuses).

However, by 2020 it became clear that the general target framework of economic and social policies was hardly achievable because of the evolving COVID-19 pandemic and allied economic crisis. For instance, the most problematic KPI of a 50% innovation activity level was withdrawn in 2020 (almost the same way as happened with the preceding Innovation Development Strategy). For that reason, a new corrected document was approved in 2020.[21]

At first glance, the strategic framework described above looks quite complicated. This impression is to a great extent supported by the initiation of new policies before the termination of previous ones. However, by the end of 2020, two general frameworks were active: (1) the "Strategy for S&T Development until 2035" with related acts including the programme "S&T Development of the Russian Federation in 2019–2030" and (2) the "Presidential Decree" (2020 version) including NPs "Science" (draft "Science and Universities" has not been launched yet) together with related FPs. The strategy framework maintains gradual, sustainable development of three corners of the Russian KT in the context of long-term challenges and goals, while the Presidential Decree and related NPs support breakthroughs in cooperation within the KT, especially science-industry relationships, the integration of education and science, and infrastructure development.

This strategic base looks diversified and deeply structured. It is supported by up-to-date tools like foresight and technology forecasts, R&D performance evaluation standards, a multilevel and cross-sectional KPI system, and policy mix mechanisms. At the same time, it lacks sustainability due to the internal and external factors hampering this process and imbalances. The obsolete strategy was not ready to follow the macroeconomic changes, but the actual one should be more flexible and pragmatic. Bigger problems are related to the various versions of the NPs devoted to S&T and other areas of socio-economic policies. They are fixated on quantitative targets without an appropriate evidence base (and sometimes correspondence between the general priorities and the NP indicators is not completely clear); co-funding requirements are not always being met by partners; not all contractors are able to absorb the whole amount of funding; some tasks in STI require funding

[21] Decree of the President of the Russian Federation N 474 of 21 July 2020 "On the national development goals of the Russian Federation until 2030."

and planning horizons longer than five years, and so on. There is a strong focus on project mechanisms, while institutional measures are largely neglected.

To sum up, there has been certain progress in the Russian KT policies during the last few decades. Many KT elements and links were established, many actors improved their performance (especially in the university R&D sector). At the same time, the whole "triangle" is mostly built by the state with quite weak initiative demonstrated by businesses and academia, and it remains quite "undersized" regardless of the massive support from the state. There are certain systemic and strategic factors inside the Russian NIS that hamper KT development. The next section of the chapter discusses and summarises these considerations vis-à-vis the general KT idea.

12.5 Discussion and Conclusion

During the previous discussion, only STI characteristics and factors were taken into account. From this point of view, it is difficult to explain the distinct state-centricity and limited scope of the Russian KT. Even considering its structural path dependency and the transitional nature of institutes and policies, some more powerful external long-term factors seem to be present affecting science-industry-university cooperation to such an extent. According to the national statistics open data,[22] in 2019 fixed capital investment accounted for 17% (even lower than before the 2008 crisis), and human capital investment remained steady at 14%. Such low and stagnating levels indicate deep systemic problems in social and economic development. The mean value of annual economic growth in 2010–2020 was only 1.47%, while the industrial production index decreased from 107% to 97%. This chapter is not devoted to the general macroeconomic, political, and social contexts of the Russian case, but the respective crisis factors are likely to be much more forceful than any internal KT parameters. These factors set limits for the expansion of the knowledge triangle and hamper bottom-up initiatives. Considering such a context, the following summary can be formulated:

- The structure and composition of the Russian KT are diverse and include various forms and groups of actors. A complex network of development institutions as well a broad infrastructure framework should enable entire innovation cycles, efficient human resource reproduction, as well as knowledge and technology transfer. The corners of the triangle (HEIs, R&D organisations, and enterprises) are heterogenous as well. Such variety could be a sign of still ongoing transition (old forms and new ones co-exist simultaneously). At the same time, many forms were initiated officially under various policies but are not always actually functional (like state research centres or "high-tech technoparks"). Most probably, both arguments are valid.

[22] Federal State Statistics Service official web site (English version). URL: https://eng.gks.ru/ (last accessed 5 Feb. 2021).

- The inner proportions of the triangle are uneven. Populations of enterprises, R&D organisations, and HEIs are quite large, but just a small fraction of universities (about two dozen) are involved in the KT. On the one hand, output from university R&D (which started to develop only three decades ago) is steadily increasing. On the other, these outputs are being generated by a fixed cohort of leading universities, which hardly expanded over the last few decades.
- The balance of effort in the Russian KT is difficult to estimate for its three corners since it is strongly biased towards the state. Government funding, initiatives, and regulations remain the core and the main driving force of the triangle. The weakness of bottom-up initiatives and private investments imposes limits on the scope of the KT.
- Policy coherence is far from optimum. Only the vertical correspondence of actions (within the structure of strategies, programmes, projects, etc.) is established well enough. Horizontal coherence is weak given that different KT-related programmes and even strategies are being realised in parallel by different responsible bodies (ministries, agencies). The continuity of policies over time is the most problematic issue due to the radical incongruence between preceding and succeeding initiatives. Some strategies or programmes can terminate in advance (or appear too short to have desired effects) and be followed by completely different initiatives.
- Policy focus is complex and fragmented. General coverage support in line with national priorities is being realised at the level of strategies and state programmes, while new "breakthrough" policies arise from "Presidential Decrees" and ambitious NPs. Mid-term horizons of these initiatives look quite short compared to their missions. Policy learning capacity should be limited as well since their evidence base and policy evaluation tools are mostly formalistic and underdeveloped. It can also be noted that there is a shortage of policies aimed at the KT as such. The overwhelming majority of measures are narrowly focused on its elements.
- External factors and constraints seem to be much stronger than the internal composition and parameters of the Russian KT. In general, the role of the state is dominant due to unfavourable entrepreneurial climate and is related rather to preserving the KT actors and assets rather than with their expansion.
- The performance of the KT in Russia can be estimated as a simple function of public support. However, lessons from the NPs show that additional public funding allocated to achieve breakthrough outcomes in some cases cannot be absorbed efficiently by recipients.

The scope of the Russian KT is, therefore, limited under external constraints. A certain number of the same leading HEIs, research organisations, and enterprises take part in its processes and initiatives like "Statement 218" or the National Technology Initiative, or the new NP "Science and Universities." Being like a kind of a club, it lacks inclusion mechanisms since the competitive support policies of the state look more like a means to preserve the leaders rather than a way to promote the newcomers. Such a "preservation" strategy (whether deliberate or not) can be reasonable in the context of high external risks, limited resources of the state, and weak initiatives from other stakeholders. There exist, however, some policy directions, which have not been fully developed until now, but can contribute to further KT improvement: open science, open innovation, the expansion of international cooperation, liberalisation of small innovative business, and so on. On the other hand, STI and the KT could benefit if the development of education, science, economics, and society would be of higher priority for the state.

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The Role of Knowledge Triangle Policies in Development of Science-Industry Links in the New EU Member States: The Case of Czech Universities

13

Vladislav Čadil and Miroslav Kostić

13.1 Introduction

Science-industry links or more specifically collaboration of universities with private companies is considered as one of the key factors of innovation based competitiveness of companies and regional/national economies and a driving force of regional development (Etzkowitz and Leydesdorff 2000; Chatterton and Goddard 2000). In this sense, universities produce knowledge and highly qualified human resources for the private sector and cultivate socio-economic environment including innovation systems. Universities play a role of a key regional and, in the case of large universities in small national economies, national stakeholder. Therefore innovation policies strive to the effective involvement of universities in innovation systems and introduce tools for development of the university-industry collaboration.

There are several theoretical or policy concepts dealing with universities as key stakeholders in innovation systems such as the Triple Helix or the Knowledge Triangle. The latter has become one of the basic policy concepts for strengthening of competitiveness of the EU and building the European Research Area (Council of the EU 2009). It integrates three roles of universities—education, research and collaboration with the industry—and innovation processes in a systematic and multidimensional way as a result of mutual interactions of them (Jávorka and Giarracca 2012; Soriano and Mulatero 2010).

In addition to the EU innovation policies, the Knowledge Triangle concept has been directly or indirectly used for a conceptual setting of many regional and national innovation policies. It gains importance especially in lower innovation performance countries, in which universities can become a crucial source of knowledge for technological upgrading of traditional industries as well as development of new branches effectively exploiting local innovation potential. The case in point of a

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lower innovation performance country facing challenges of technological upgrading of traditional industries is the Czech Republic. Although there are, on the one hand, many universities and research organisations of a high quality and, and the other hand, a relatively developed manufacturing sector fully integrated into the EU market, science-industry links and involvement of universities in innovation processes remain key weaknesses of the whole national innovation system (Žížalová 2010; Klusáček et al. 2010; Arnold et al. 2011).

The issue of the insufficient intensity of science-industry links is often discussed at various levels and incorporated into national and regional policies and programmes in the field of research, development and innovation. This chapter analyses national and regional policies and programmes based on the Knowledge Triangle Concept, with the aim to find out their influence on development of science-industry links. In particular, the chapter seeks to detect how they change strategic behaviour of universities in terms of Knowledge Triangle activities.

Our analysis covers all public universities except academies of performing and fine arts. Special attention is paid to three universities representing three basic university types: the University of Chemistry and Technology in Prague for technical universities, the Palacký University Olomouc for general (traditional) universities and the Technical University Liberec for regional universities.

Our empirical analysis is based on a combination of desk research analysis and field survey. The desk research analysed national and regional strategic R&D and innovation policy documents and university strategic and conceptual documents, as well as internal regulations. The desk research identified topics for the field research grounded in structured interviews with representatives of selected universities.

The chapter is structured as follows: The first part describes recent developments in research, development and innovation policies and changes in the university sector after the year 1989. The second part analyses current research, development and innovation policies. Next, we explore programmes supporting the Knowledge Triangle activities in the Czech Republic. Subsequently we deal with strategies, policies and Knowledge Triangle activities of universities. The last chapter provides summary of main findings and discussion of the influence of the policies on current changes in university-industry collaboration.

13.2 Development of R&D&I Policies and Changes in Science-Industry Links after 1989

The role of universities within the Knowledge Triangle and the national economy has fundamentally changed since 1989 as a consequence of the post-communist transition from a centrally planned economic and societal system towards a market economy (Žížalová and Čadil 2013; Gál and Ptáček 2011). Nevertheless, the development of science-industry links and namely the initiative of universities in formation of collaborative activities still remain influenced by some features inherited from the communist system. During the previous communist regime the research system had been subordinated to bureaucratic, economic and Communist

Party's interests, which limited academic freedoms and internal democracy (Gaponenko 1995). The state possessed universities and the industry and directed the relations between them (Etzkowitz and Leydesdorff 2000). Public research had been divided between universities and public research organisations (Buenstorf 2009), of which national academies of sciences dealt with basic research whilst specialised research organisations controlled by relevant ministries focused on applied research and development (Blažek and Uhlíř 2007).

Similarly to other communist states in the Central-Eastern Europe, in the former Czechoslovakia the universities should play the role of teaching facilities; basic research would be carried out by the Academy of Sciences and applied research by specialised branch research state-owned organisations. Despite the effort to minimise research activities of universities, research did not disappear completely, but did not belong between priority areas of universities. Research was subjected to strict state and party control and subordinated to the needs of the centrally planned economy (OECD 2007). Also creation and further development of science-industry links were centrally planned—each university had to collaborate with industrial companies. This collaboration was known as an additional economic activity of universities and took different forms, ranging from routine testing to joint research.

The collapse of the communist regime in November 1989 brought renaissance of the importance of universities as centres of the highest education and scientific work. The Acts of 1990 and 1998 restored academic freedom and self-governance to universities, although they continued to be state-owned organisations and return research to the universities. The Academy of Sciences was reduced in terms of the number of its institutes and researchers. However, the attempt to transfer some key researchers to universities was an almost complete failure (OECD 2007). The branch research state-owned organisations were partly privatised and partly dissolved. Only a few organisations remained in state ownership (namely in the medical and environmental fields). Some privatised organisations were unable to withstand the competitive pressure and went out of business (Blažek and Uhlíř 2007).

New legal conditions also enabled establishment of new faculties and universities in regions outside traditional university centres. During the first wave in 1991 and 1992 five regional universities were established. While one was established almost from scratch (i.e. the Silesian University in Opava) others (Jan Evangelista Purkyně University in Ústí nad Labem, University of West Bohemia in Plzeň, University of South Bohemia in České Budějovice and University of Ostrava in Ostrava) could follow in the tradition of existing higher education establishments (Žížalová and Čadil 2013). Other three institutes of higher education were founded in 2000 and 2007. Establishment of regional universities, however, was not a specific initiative or tool of state-implemented regional policy. The National Government has neither launched a specific programme for the creation and funding of regional universities nor stimulated their establishment. Founding of universities rather reflects efforts of regional politicians to increase the prestige of their cities and regions and strengthen the quality of regional human capital (OECD 2007).

The growth of the university sector led to massive increase in the number of students and university graduates and strengthening of the R&D role of universities

Table 13.1 The growth of the university sector in Czech Republic since 1990

	1990	1995	2000	2005	2010	2014
Number of public universities	18	23	23	25	26	26
Number of students enrolled	112,980	148,235	198,961	265,372	339,353	308,428
Number of graduates	16,069	16,603	23,582	41,300	73,072	74,391

	2000 (%)	2005 (%)	2010 (%)	2014 (%)
R&D expenditures as % of GDP	1.21	1.41	1.34	2.00
Higher education R&D expenditures as % of GDP	0.17	0.23	0.27	0.51
Share of higher education R&D expenditures in total R&D expenditures	14.2	16.4	20.0	25.4
Share of business sector financing in higher education R&D expenditures	1.1	0.8	1.2	2.5

Source: Czech Statistical Office (2015)

(see Table 13.1). Growth in the number of students enrolling for university studies reached its peak in 2010 (339,353 students enrolled), while the number of graduates was highest in 2012 (76,853). The massive increase in the number of students and graduates was also supported by the funding mechanism for higher education institutions (Matějů et al. 2006). The main component of income for universities was constituted by subsidies on education, which were calculated on the basis of the number of students and financial demands of study fields in place. Regarding the scope of R&D activities, since 1990 the gap between universities and the governmental sector represented mainly by the Academy of Sciences had been disappearing. Regarding R&D expenditures university sector exceeded governmental sector in 2011 (CZK €.57bn, while governmental sector €0.46bn), in the case of the number of R&D employees universities outstripped the governmental sector in 2005 (10,776 in FTE, while the governmental sector 10,584).

During the nineties development of science-industry links underwent several major changes. Firstly, strengthening of research activities of universities and modernisation of research facilities created conditions for efficient collaboration, including long-term joint research. On the other hand, a duty of cooperation with the industry fell down, and at the same time the privatisation of industrial enterprises and their subsequent restructuring severed traditional ties with universities. Furthermore, no appropriate state programmes stimulated development of collaborative or contract research. This resulted in a crucial reduction of any collaborative activities and led to reorientation of universities towards basic research or applied research fully paid from public resources. Therefore the low share of business expenditure on university research funding (HERD) is not surprising. According to OECD data, in 2013 private firms financed approximately only 2% of total expenditure on R&D of Czech universities. This low share stands out especially in comparison with other countries, for instance 14.23% in Germany, 5.09% in Austria, 8.61% in Hungary, 3.16% in Poland and 2.59% in Slovakia. Nevertheless, as shown in Fig. 13.1, in the

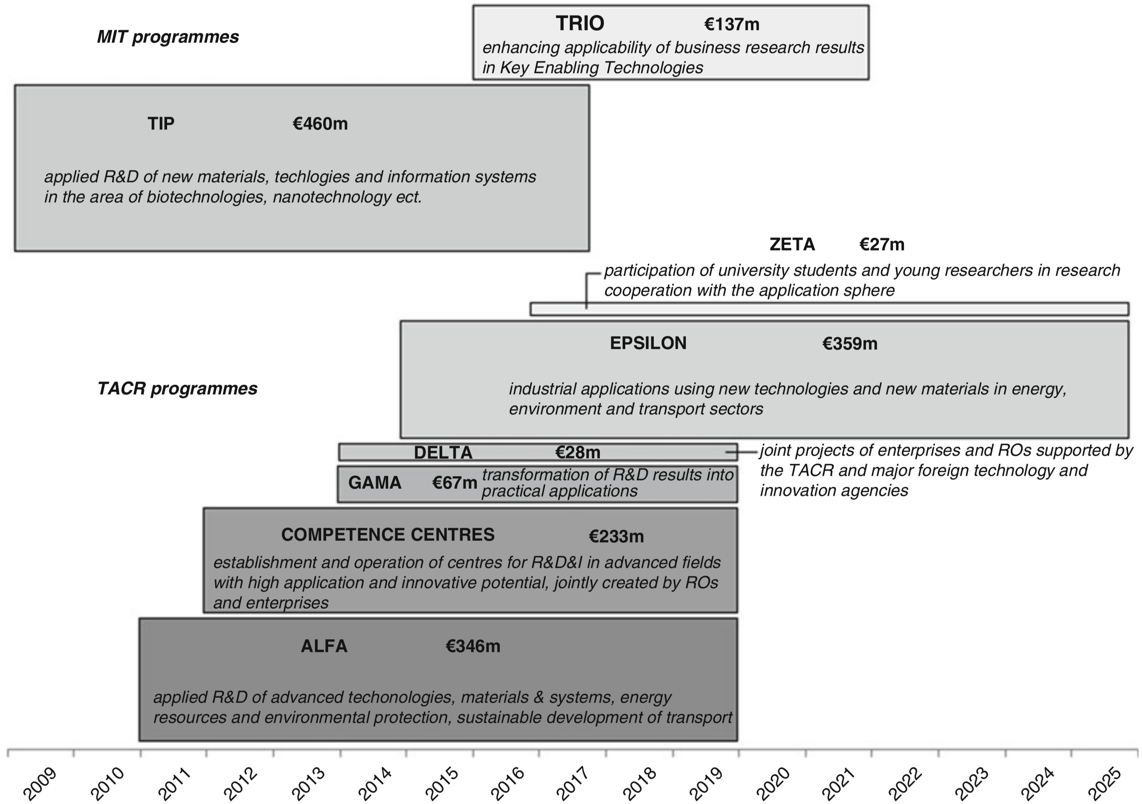

Fig. 13.1 Programmes of the Ministry of Industry and Trade (MIT) and the Technology Agency (TACR) supporting applied R&D and cooperation between research organisations and enterprises (*with volumes of financial support from the national budget*). (Source: Technology Agency of the Czech Republic, Ministry of Industry and Trade)

last two years, the volume and share of business sources rose significantly from 0.8% in 2012 to 2.5% in 2014, which means the massive increase from €5.85 m in 2012 to €19.22 m two years later (Czech Statistical Office 2015).

Which factors caused such massive increase of business expenditure on university research funding? In the following parts we argue that it has been caused by implementation of Knowledge Triangle policies at both hierarchical levels—the level of national policies and the level of individual universities.

13.3 Current Policies Supporting Knowledge Triangle Activities

The reforms of the higher education sector at the beginning of the post-communist transformation together with privatisation and restructuring of many traditional business partners resulted in a significant decrease of the scope and intensity of the university-industry collaboration. However, this decline had not been perceived by politicians and many businessmen as a severe problem and barrier for growth of knowledge based competitiveness of domestic companies. The first comprehensive policy to support research, development and innovation—the National Innovation Policy of the Czech Republic for 2005–2010—came about 10 years after the identification of the problem. Concerning development of science-industry links the policy set a goal to utilise the R&D results in innovation processes and enhance the cooperation of the public and private sector in R&D&I. One of the key outputs of the Policy was the Reform of the R&D System, which was approved by the Government in 2008. Its central motto was "Science turns money into knowledge, innovation turns knowledge into money". The Reform's aim was to ensure that public funds invested in applied research, development and innovation bring concrete economic or other benefits. The Reform's main activities in the field of university-industry collaboration were the establishment of the Technology Agency of the Czech Republic (TACR) and the extension of fiscal incentives for research carried out by companies.

The TACR was founded in 2009 as the main provider of applied research competitive funding. The agency elaborates and implements programmes to promote applied research and development, whose results should be used in innovation. Fiscal incentives for the private sector have been introduced in 2005 and allowed private companies to deduct costs of their in-house R&D from the tax base (donations could reach a maximum of 5% of the tax base). Later, based on the reform, the incentives have been extended to deduct R&D purchased from universities and other public research organisations.

The National Innovation Policy of the Czech Republic for 2005–2010 was replaced by the National Research, Development and Innovation Policy 2009–2015. Its measures, apart from other things, were focused on the reorientation of research organisations in order to achieve more results applicable in practice and to improve the efficiency of the knowledge transfer to businesses. According to the new policy measures, research organisations should elaborate own knowledge transfer strategies and research organisation employees should be encouraged to cooperate with enterprises and create knowledge usable in practice. Furthermore, the policy promoted development of technology platforms and establishment of a venture capital fund. In 2015, the new National Policy on Research, Development and Innovation for the years 2016–2020 was approved. It states that the public support of applied research should be adapted according to the needs of the economy and introduces a continuous process of identifying and evaluating the needs of companies. Besides, it introduces a new tool for an effective promotion of applied research—National Research and Innovation Strategy for Smart Specialisation of the Czech Republic (RIS 3).

The National Research and Innovation Strategy for Smart Specialisation of the Czech Republic (RIS 3), an "umbrella-document" for operational programmes in the current programming period of the EU as well as for newly introduced national programmes supporting R&D&I, stresses the importance of cooperation between research organisations and businesses and commercial applications of knowledge generated by research organisations. Corresponding measures defined within the strategy and performed through operational programmes and national R&D&I programmes should lead to the improvement of links between knowledge providers and users.

The need for better collaboration between universities (and other research organisations) and businesses is also accented in the Long-Term Plan of Educational and Scientific, Research, Development and Innovation, Artistic and Other Creative Activities of HEIs, which is a fundamental policy document for the higher education sector. The current document valid for 2016–2020 as well as the previous one regards university-industry cooperation as a prerequisite for the competitiveness strengthening of the Czech Republic. These documents also stress the need of interaction among all components of the knowledge triangle—research, education and innovation.

The aforementioned National Policies and Long-term Plans focus on development of science-industry links in the form of collaborative research (joint research activities or contract research) and knowledge transfer to the business sector. Other forms of collaboration and activities needed for effective knowledge transfer are not mentioned. However, establishing and intensifying university-industry links for gaining value added from knowledge transfer is a multifaceted issue depending on satisfactory personnel and infrastructural conditions, as well as the absorption capacities of the business sector (Hofer et al. 2011). Therefore, support to only one type of science-industry links (i.e. one form of knowledge transfer), while omitting development of other forms and the necessary conditions, do not have to lead to intensification and more effective cooperation between enterprises and universities. Surprisingly, with some exceptions, in the policies carried out there is no significant progress or shift in supported activities and ways how to strengthen science-industry links. In this sense all policies promote almost the same activities without an explicit progression in defined activities and tools, from simple to more comprehensive, based on in-depth evaluation. In fact, there has not been an impact evaluation of the policies. The only evaluation carried out was an assessment whether the measures were implemented. The policies' activities and their tools were defined on the basis of foreign best practices (Blažek and Uhlíř 2007) without any assessment of their relevancy to the national innovation system and their adoption to specific legal and institutional conditions and the historical experiences.

13.4 Funding of Knowledge Triangle Activities

Development of science-industry links within the Knowledge Triangle has been promoted by several national research programmes as well as operational programmes co-funded by the EU Structural Funds. National programmes focused on collaboration of universities and private firms are implemented by the Ministry of Education, Youth and Sport (MEYS), the Ministry of Industry and Trade (MIT) and the newly established TACR.

The MEYS programme Research Centres 1 M, aimed at concentration of research capacities into centres ensuring an effective knowledge transfer to applied sphere subjects, supported establishment of 25 research centres, which brought together research teams from universities, research organisations and private companies. Evaluation of the programme proved that the cooperation within the centres was strengthened and led to more complex research activities. Nevertheless, funding of centres' activities from the firms involved into the centres remained very low (Čadil 2010).

The MIT through its programmes has supported industrial research and development. The completed programmes TANDEM (2003–2010) and IMPULS (2003–2010) targeted on the technology transfer to applications in products, technologies and services by composing teams of people from science and industry. However, no evaluation showing importance, development or impact of supported science-industry links was carried out. In spite of that, the MIT has launched follow-up programmes TIP (2009–2017) and TRIO (2016–2021), which aim to promote R&D projects carried out in phases prior to the entering of new products into the market.

The most important programme tools financing science-industry cooperation from the national budget are programmes implemented by the TACR and by several governmental ministries. Since its establishment in 2009, the TACR united a substantial part of public support to applied R&D and innovation. The TACR implements several programmes aimed at strengthening collaboration of research organisations (incl. universities) with the application sphere (mainly businesses). As regards knowledge triangle activities, the most important are programmes ALFA (2011–2016), which has been replaced by the programme EPSILON (2015–2025), and Centres of Competence (2012–2019). The ALFA programme provides support to applied R&D mainly through joint projects of research organisations and enterprises. The Epsilon programme supports industrial applications using new technologies and new materials in energy, environment and transport sectors. The objective of the Competence Centres programme is establishment and operation of centres for R&D&I in advanced fields jointly created by ROs and enterprises. For more details on the programmes of MIT and TACR, see Fig. 13.1.

In the last years the EU Structural Funds represented the most important and complex source for funding the university-industry cooperation as well as other activities supporting the knowledge triangle. In the programming period 2007–2013, these activities were supported mainly through three operational programmes covering whole territory of the Czech Republic except the capital city of Prague. The OP Research and Development for Innovation supported establishment of R&D centres focused on applied research and cooperation with the application sphere, establishment of knowledge transfer offices within ROs and building research infrastructure for university education. The OP Education for Competitiveness focused on support to transfer of R&D outcomes into university study programmes, and the OP Enterprise and Innovation was concentrated on increasing capacities of industrial R&D, support to collaboration of businesses with public research organisations and support to clusters and technology platforms interconnecting industrial companies, public research organisations, professional associations, public institutions and consumers. For the support of R&D and innovation more than €5bn was allocated through the three operational programmes.

Operational programmes dealing with R&D&I in the current programming period (2014–2020) deliver very similar Knowledge Triangle-related measures as in the previous period. The OP Research, Development and Education supports similar activities as the first two mentioned programmes, while the OP Enterprise and Innovation for Competitiveness has replaced the last programme. Through the two operational programmes over €3.7bn should be allocated on measures promoting R&D and innovation.

At the regional level, programmes for the provision of innovation vouchers have certain importance for launching cooperation between research organisations (incl. universities) and businesses. Nevertheless, the overall budgets and the following significance of these programmes are much lower compared to national and European tools. Since the introduction of the first innovation vouchers programme in 2009, regional schemes have gradually spread into almost all self-governing regions (NUTS II level) of the Czech Republic. Programmes for the provision of innovation vouchers are usually introduced as tools enabling realisation of measures defined within regional innovation strategies. Within the majority of regional schemes, the support is intended to small and medium enterprises based on performing their activities in the region. In some of the regional programmes, research organisations providing their services are selected and listed in advance. The maximal amount of subsidy varies approximately from € 4000 to € 12,000. Another type of measure common for the majority of regional innovation strategies stresses the key role of universities for the provision of life-long learning and undergraduate study programmes corresponding with the needs of the business sector. However, promotion of such activities is rather a policy proclamation since no region has implemented own tools addressing these issues so far.

13.5 Knowledge Triangle Policies, Strategies and Activities of Universities

13.5.1 Policies, Strategies and the Governance

Within the university sector the discussion on the Knowledge Triangle issue and especially development of science-industry links started about 10 years ago, although many of the Knowledge Triangle activities belong to usual activities of universities for many years. In the Czech Republic, the universities traditionally interconnect research and education, resp. knowledge generated by research activities is directly transferred into education, and PhD students are involved into research projects solved at universities. Similarly, universities collaborate with companies and other research organisations (mainly with the Czech Academy of Sciences) for a long time. Concerning collaboration with the Academy, in many cases researchers of the Academy are part-time employees of universities.

Since collaboration with companies performs relatively well, universities have not needed to regulate development of science-industry links by some strategies or obligatory documents. Nevertheless, the situation changed when the need for the development of science-industry links had been anchored in national policies and consequently the MEYS began to require that the universities should reflect this task in their strategies.

The main strategic document of universities is the Long-Term Plan of Educational and Scientific, Research, Development and Innovation, Artistic and Other Creative Activities. The obligation of each university to draw up the plan is given by the Higher Education Act. In the plans, universities formulate their aims and measures for the current five-year period with annual updates. One of the aims usually describes the role of a university in its region and planned activities in regional development, interaction with the society and the business sector, etc. Formulation of planned activities tends to be very general indicating that most of the universities are more concentrated on activities encompassing the national level than on regional issues. This is certainly affected by the accountability of universities to the MEYS providing the bulk of their funding. On the other side, representatives of universities often actively participate in working and advisory groups for design and implementation of regional innovation strategies which allows them to integrate university priorities into regional innovation strategies. However, this leads rather to the adjustment of strategies to research and educational needs of universities than to improvement of conditions for the development of science-industry links.

Cooperation with the business sector is usually included in the Long-Term Plans of universities but often in the form of repeating statements and targets set by the ministerial template document. Only several universities use the ministerial long-term plan as a foundation for the formulation of own strategies, going beyond the obligatory Long-Term Plan, e.g. the Technical University of Liberec with its Strategic Development Plan until 2020 (with an outlook for 2030). This strategic document sets strategic goals and measures, which develop cooperation with the business sector and focus research activities towards knowledge transfer at both national and international levels. The cooperation should be carried out through establishment and operation of business incubators, accelerators, start-ups and spin-offs as well as involvement of private firms into educational activities (e.g. lectures of external experts, bachelor's/diploma/doctoral theses focused according to firms' needs, scholarships and sponsorships, etc.). Such focus of the strategy corresponds to the importance of the university as a key knowledge producer in the region. The accent on role of the university within the region is also paid in the Long-Term Plan of the Palacký University. Nevertheless, its targets and activities only rephrase the ministerial template document. The University of Chemistry and Technology as a typical research university concentrates more on research excellence at the international level and does not recognise itself as a regional stakeholder.

In general, the managements of universities pay little attention to interconnection of education, research and innovation. They are usually considered as separate activities and therefore supported by specific measures. Low accent put by managements of universities on support to Knowledge Triangle activities partly results from the method of management election. Rectors, vice-rectors and deans are elected from the academic staff of these institutions. Prevailing inbreeding and low stress on managerial background of the top leadership is typical for the Czech higher education sector as a whole. Involvement of the business sector in management structures (Scientific Board, Board of Governors) is relatively low. The business sector creates a half share on the number of representatives only in the Board of Governors of the University of Chemistry and Technology. Nevertheless, the Board of Governors' role is limited only to approval of internal legal acts, Long-term Plans, university budgets and annual reports.

Management of Knowledge Triangle activities is not completely centralised. Research, education and innovation activities are rather dispersed under the responsibility of vice-rectors. Only the Palacký University, which is rather a general university, has a position of a vice-rector for technology transfer.

Besides, the Long-Term Plan universities do not have any other strategic documents in the field of knowledge commercialisation and collaboration with companies. Universities only elaborate various directives dealing with intellectual property rights. Some universities (e.g. Masaryk University in Brno, Charles University in Prague, Tomas Bata University or VSB—Technical University of Ostrava) established their councils for commercialisation, which are advisory bodies of rectors in the matter of knowledge commercialisation. The councils usually consist of representatives of academic, business as well as financial sectors. The main councils' activities are appraisals of commercialisation projects and elaboration and updating of internal directives for knowledge transfer.

13.5.2 Funding and Revenues from Knowledge Triangle Activities

Development of Knowledge Triangle activities of universities strongly depends on public funding. Since the definition of Knowledge Triangle activities is very wide and covers education and research activities, they can be funded by the both main types of subsidies—subsidies for education and subsidies for R&D. These types together created about 83% of total universities' revenues in 2015. Approximately 1.6% of the revenues consist of public funds from abroad (EU framework programmes). Only 15.4% of revenues is covered by own sources, which, in fact, represent a very heterogeneous group consisting of revenues from rental of buildings, operation of canteens, student dormitories, university farms and publishing houses, study related fees and last but not least revenues from knowledge commercialisation.

As mentioned above, the crucial funding sources for Knowledge Triangle activities are national programmes provided by the MEYS, MIT and TACR and operational programmes co-funded by the EU Structural Funds and institutional funding. The national programmes amounted about 22% of total universities' revenues in 2014. The highest shares of R&D subsidies on total revenues are reached by the largest universities (Charles University in Prague 32%) and specialised technical universities (University of Chemistry and Technology Prague 37%), both of strong interregional and international importance; while regional universities characterised by lower shares of R&D subsidies (University of Hradec Králové 7.8%) are specialised more on education.

An average share of the operational programmes on total revenues reached 25%. Concerning individual universities, the share ranged from 2% (Czech University of Life Sciences Prague) to 48% (Tomas Bata University in Zlin), depending on the current investment activities of universities. However, this funding source cannot be considered as long-term systematic funding source but a disposable tool that allows modernisation of research and educational facilities.

Overall, the least important funding sources are revenues from own business activities. Their share on total university revenues varies significantly among universities. In 2014, it ranged between 32% (University of Veterinary and Pharmaceutical Sciences Brno) and 0.7% (University of Hradec Králové). In general, specialised universities which in addition to R&D provide various commercial services, e.g. university farms, a veterinary clinic, etc., have higher own sources. Specific parts of own sources represent revenues from knowledge commercialisation, which are rather marginal funding sources for further development of knowledge triangle activities. Their share on own sources reached only 20%, whilst the share on total universities' revenues was only 1.4%. The knowledge transfer revenues are closely associated with the amount of R&D subsidies and their share on total universities' revenues, especially in the case of technical universities. On the other hand, the traditional largest universities have rather lower revenues from commercialisation than technical universities. It is caused by different missions of these types of universities and distinct orientation of research activities as well as specialisation on specific scientific disciplines.

Implementation of the above-mentioned new policies and programmes focused on collaborative research and knowledge transfer, including initiatives of individual universities, has led to strengthening of cooperation with the business sector which can be illustrated by increase of R&D revenues from the business sector from €2.2 m in 2008 (i.e. at the beginning of the R&D System reform) to €20 m in 2014 (see

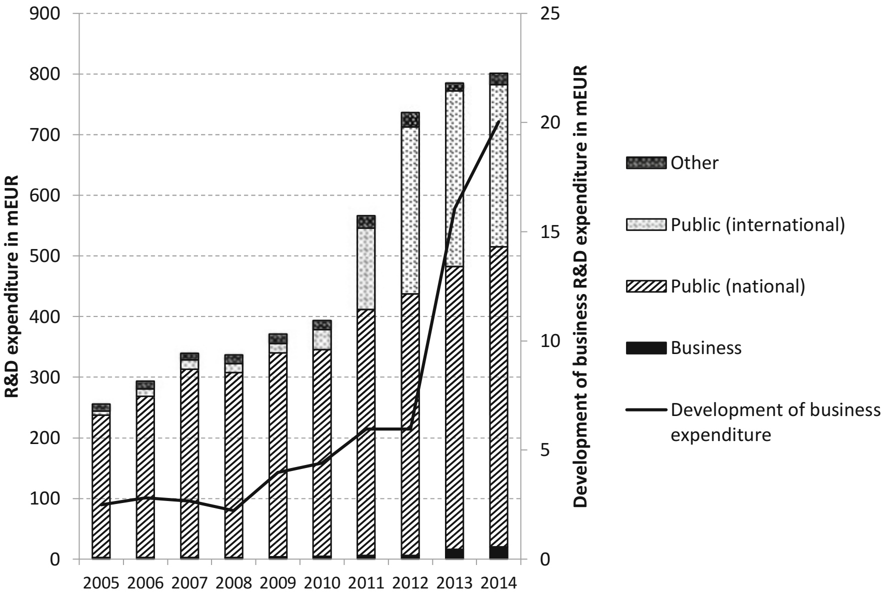

Fig. 13.2 Development of R&D expenditures in the higher education sector. (Source: Czech Statistical Office (2015))

Fig. 13.2). Since 2012 the new programmes have significantly changed the R&D funding structure. Namely international public sources represented by the operational programmes co-funded by the EU Structural Funds as well as national public sources have increased their importance. One part of the national public sources consists of national co-funding of the operational programmes, while the second part comprises the programmes implemented by the TACR.

Knowledge Transfer Revenues (unfortunately realised within projects supported by national programmes and paid from public sources) have become an important source of R&D funding for many universities, as shown by Fig. 13.3. For instance, in the case of the University of Chemistry and Technology in Prague the revenues rose from €2.6 m to €6.3 m in the period of 2011–2014 and reached almost 35% of total R&D expenditure. This high share has been caused by two factors: (i) a long tradition of university-industry collaboration on collaborative and contract research, and (ii) the University of Chemistry and Technology is the only Czech university carrying out research in all scientific fields in chemistry.

In general, the highest knowledge exploitation revenues and their shares on R&D expenditure is a typical feature of technical universities with a high potential for science-industry collaboration and carrying out rather applied research. On the other hand, generally focused universities, covering wide range of scientific disciplines, engage more in basic research. Therefore, their knowledge transfer revenues are relatively low.

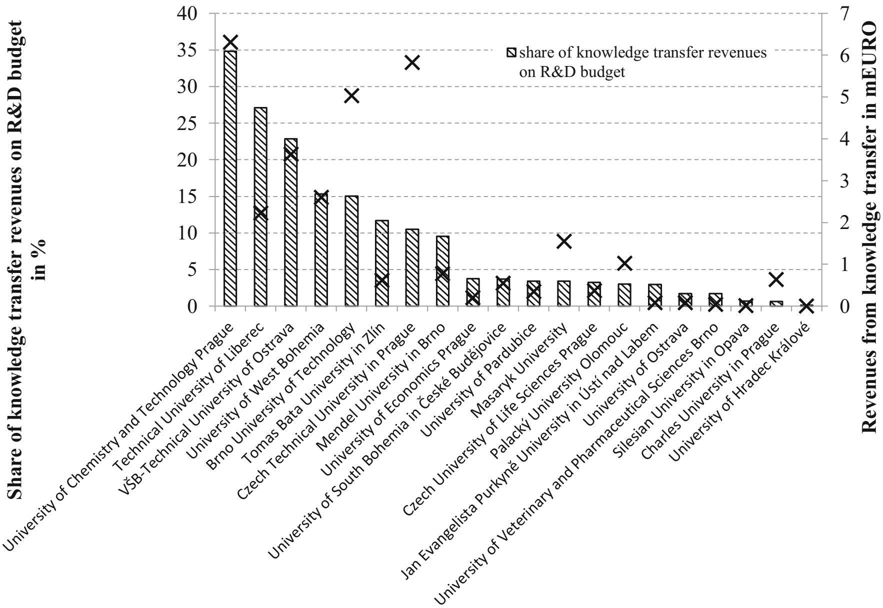

Fig. 13.3 Knowledge transfer revenues of Czech universities in 2014. (Source: Annual reports of individual universities (2014))

13.5.3 Main Knowledge Triangle Activities

The Knowledge Triangle activities can take several forms from firm-needs oriented research programmes and life-long learning to purely commercial technology transfer. Based on interviews with university representatives and researchers and analyses of annual reports of universities we can distinguish some main types of Knowledge Triangle activities.

First of all, there is knowledge transfer. Czech universities distinguish four types of knowledge transfer channels: (i) consulting services, (ii) training courses, (iii) contract research and (iv) licences. The volume and structure of knowledge transfer revenues of individual universities is depicted in Fig. 13.4. The most important channel is contract research—its share on the revenues from knowledge transfer amounted to 81.9%. The share of consulting services was 8% and training courses reached 7.9% share on the knowledge transfer revenues. Surprisingly, the sale of licences was the least important channel generating only 2.2% of knowledge transfer revenues. Because of huge disparities among universities in values of the knowledge transfer revenues, the revenues from the mentioned types of knowledge transfer are highly concentrated. Thus the University of Chemistry and Technology created 21.3% of contract research revenues, the VŠB-Technical University of Ostrava received 30.2% of training courses revenues, the Czech Technical University generated 45.5% of consulting services revenues and the sales of licences from the

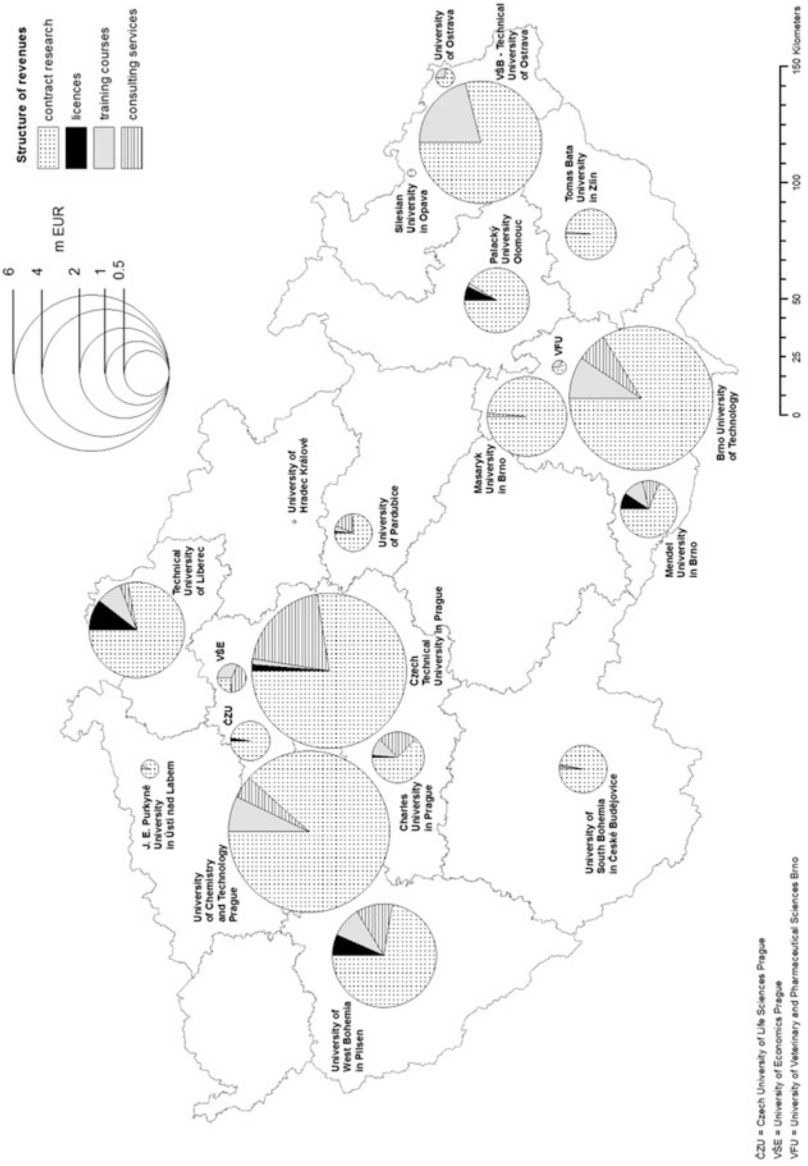

Fig. 13.4 Volume and structure of knowledge transfer revenues of Czech universities in 2014. (Source: Annual reports of individual universities (2014))

Technical University of Liberec was 33.2% of total sales of licences of Czech universities.

New research projects supported by the new national R&D programmes resulted in an increase of contract research revenues, which rose at all universities. The relatively highest growth occurred namely at generally focused universities, whose previous revenues were negligible. A case in point is the Palacký University, whose contract research revenues increased from €0.1 m in 2011 to nearly €1 m three years later.

Knowledge transfer revenues could be used for funding of R&D activities, which have not been supported or could not be promoted by public R&D programmes. According to interviews with university representatives the revenue is usually divided into three parts. The first part belongs to researchers, who created the knowledge commercialised. The scientific department (or team) of the researchers receives the second part. And the last part is centralised for needs of a faculty/ university. Proportions of these parts depend on revenue volume. Generally, in the case of lower volumes the part for researchers is larger and vice versa. Scientific departments usually use the revenue for the modernisation of laboratory appliances. Faculty/university deposits it into a commercialisation fund for proof-of-concept activities and protection of intellectual property rights. Surprisingly, neither the departments nor universities use the revenue for modernisation of facilities for education (including laboratories for students) and study programmes. In spite of that there is a knowledge transfer from research activities to lectures for students, mainly in master's and doctoral degree programmes.

A substantial progress has been made recently in creation of institutional structures for knowledge and technology transfer at Czech universities, mainly due to the funding from the EU Structural Funds. Almost all universities have built technology transfer centres in the last few years using this form of support. Large investments into intermediary research facilities at Czech universities, i.e. into science & technology parks including technology transfer offices (TTOs), contributed to substantial development of Knowledge Triangle activities and lead to concentration of these activities and extension of services provided to researchers. However, long-term funding from own resources of universities is usually not secured. Thus high dependency of universities on external funding and prevailing low incomes from R&D commercialisation hinder a long-term sustainability of these investments (Žížalová and Marek 2012). Furthermore, the newly established TTOs face difficulties with insufficient experience and expertise for identifying convenient cooperation partners for researchers. This shortage has an impact on the trust in TTOs and often leads to independent acting of individual faculties or working groups concerning the design and conclusion of contracts with industry (Hofer et al. 2011). Nevertheless, strategic approaches to the commercialisation of knowledge are very rare among managements of Czech universities, giving preference rather to purely scientific research financed from national public resources and accredited pre-graduate courses (Žížalová and Čadil 2013).

TTOs are actually operating at 16 universities (out of 26 public universities in the Czech Republic), twelve of them being supported by the EU Structural Funds.

University TTOs are pictured in Fig. 13.5, including their regional distribution and the volume of the EU funding obtained. 13 out of 14 Czech self-governing regions (NUTS3 level) are seats of at least one university. TTOs supported by the EU Structural Funds obtained altogether nearly 40 million EUR between 2004 and 2013, largely from the OP Research and Development for Innovation representing 86% of the sum. Two of the supported university TTOs located in Prague were funded also through the Joint Programming Document and the OP Prague—Adaptability, universities in other regions were supported through the OP Education for Competitiveness (implementing "soft" measures aimed mainly at human resources development).

Other widely used form of collaboration with the application sphere is operation of science and technology parks. One of the largest and most successful parks in the Czech Republic is the Science and Technology Park of the Palacký University in Olomouc, which was established in 2000. The park provides office rental, production premises, specialised consulting services and enables utilisation of laboratory equipment and know-how of the university under favourable conditions. Its services include also mediation of custom research, analysis and measurements or expert consultations from Palacký University to businesses, sale of patents, licences and technologies to companies, consultancy in the field of intellectual property rights and assistance to academicians, researchers and businesses in commercialisation of research results, promotion of research results of the university, etc. Through the park, the university provides laboratory equipment and scientific knowledge, namely in pharmaceutics, chemistry, biotechnology, optics, nanotechnology as well as in other fields.

The next important Knowledge Triangle activities are participation of experts from the application sphere (private companies, non-governmental organisations, governmental agencies, etc.) on education and horizontal mobility of researchers. Both activities are often discussed in national policy documents and operational programmes. Experts from the application sphere participate on the supervision and consultations of bachelor's and master's theses, especially at technically oriented universities, and give invited lectures. Some of them also participate in education in the field of knowledge transfer and innovation. The number of experts involved varies substantially among universities. For instance, it reached one third of the total academic staff of the Technical University of Liberec, while at the University of Chemistry and Technology in Prague, which can be characterised by high intensity of knowledge transfer, the number of the external experts amounted to only 5% of the academic staff.

Universities usually participate in various clusters, technology platforms and other associations according to their specialisation. For instance, the Palacký University participates in the MedChemBio innovation cluster, dealing with medicinal chemistry, chemical biology and research and development of medicaments. The cluster has 26 members including universities, public research organisations, scientific associations, private companies or foundations. The MedChemBio cluster has its own labs dealing with measurements and analyses mainly for pharmaceutical companies and realising projects connecting science and industry. The Technical

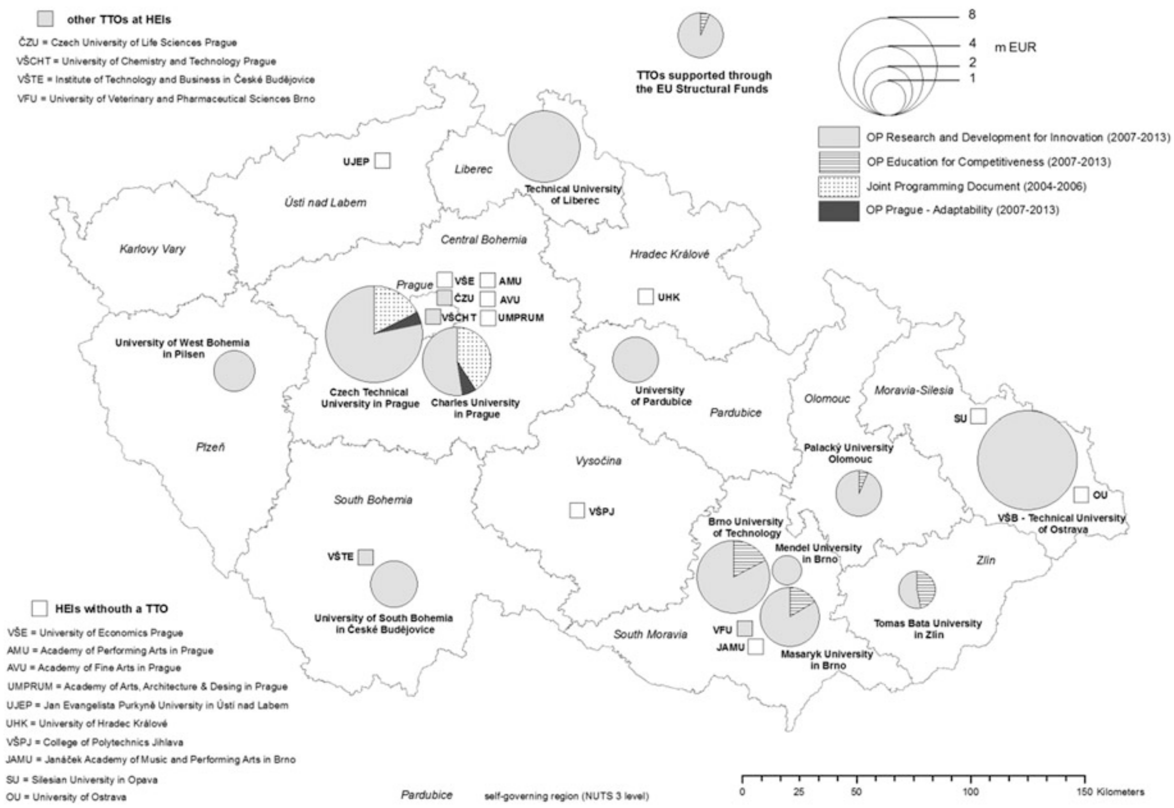

Fig. 13.5 Support to technology transfer offices (TTOs) at Czech higher education institutions (HEIs) through the EU Structural Funds. (Source: Own figures based on MEYS (2016))

University of Liberec is an active player in Cluster of Technical Textiles (CLUTEX) focused on creating optimal conditions for technology transfer, higher levels of innovation and R&D and manufacturing of technical textiles including materials and semi-finished products. Besides that the university in Liberec, closely connected to textiles and manufacturing industry, also participates in the Czech Hydrogen Technology Platform, the Automotive Industry Association, the Czech Technology Platform for Engineering and Czech Technology Platform for Textile (ČTPT). Another example of technically oriented university—the University of Chemistry and Technology in Prague is engaged in several clusters and technology platforms, e.g. the Czech Membrane Platform, Czech Hydrogen Technology Platform or MedChemBio cluster. Such types of collaboration have often also an international dimension. For instance, the Faculty of Chemical Technology of the University of Chemistry and Technology participates in the New European Research Grouping on Fuel Cells and Hydrogen—N. ERGHY. This international association represents the interests of European universities and research institutes involved in the Fuel Cell and Hydrogen Joint Undertaking (FCH JU).

The Knowledge Triangle activities have also various forms in the area of education. Among the most common ways of cooperation, there are jointly realised study programmes, specialised lectures and courses, design of curricula in accordance with the needs of industry, proposition and supervision of topics for students' theses or participation in diploma exam and doctoral theses committees. The existing and newly proposed study programmes are discussed with representatives of the application sphere and potential employees of graduates. Technical universities are often also involved in training of qualified human resources for industrial companies. Such cooperation is strongly developed in the case of technical universities such as the Czech Technical University, VSB—Technical University of Ostrava or the Technical University of Liberec, which is involved in the training of qualified human resources through the Master-school realised by industrial companies. Moreover, the Technical University of Liberec also develops intensive cross-border connections with German and Polish universities, namely through realisation of a joint study programme. Concerning the realisation of joint/double degree study programmes, the Palacký University is the most active in establishing partnerships with foreign universities while the University of Chemistry and Technology has the most intensive cooperation with other Czech universities and public research institutions.

13.6 Conclusions

The post-communist economic transformation from centrally planned economy towards market economy brought radical changes in the higher education sector during the first half of nineties. New economic conditions and privatisation of state-owned companies severed universities' ties with enterprises resulting in technological lag and competitiveness decrease of many firms. The first comprehensive Knowledge Triangle policy—The National Innovation Policy—was launched only

10 years after finding that the radical decrease of the intensity of science-industry links represents a serious weakness of the national innovation system. Despite the proclaimed initialisation and development of science-industry links, the extent and intensity of collaboration of these two different sectors did not change because the policy did not introduce specific programmes directly supporting collaborative activities. However, the main output of the policy was establishment of the TACR responsible for implementation of applied research programmes. The programmes were launched within the framework of the new Knowledge Triangle policy and have caused some significant impacts on development of science-industry links. First of all, a rapid increase in private sector investment in research at universities and contract research has been initialised. Besides, the Knowledge Triangle policy introduced programmes to support technology transfer centres, science and technology parks and created conditions for the establishment of clusters and technology platforms with the participation of universities.

In spite of positive impacts the Knowledge Triangle policy is rather unbalanced because of an accent on contract research, knowledge transfer and collaborative networks (technology platforms and clusters) while omitting other forms of science-industry links, which could be more effective (e.g. human resources development in the form of horizontal mobility of researchers or PhD students engagement in research activities performed by private companies). Moreover, Knowledge Triangle policy implementation is fragmented between two ministries (the Ministry of Education, Youth and Sports and the Ministry of Industry and Trade) and the TACR, whose activities are not centrally coordinated.

As regards Knowledge Triangle policies of individual universities, the Czech legislative framework guarantees the universities a high level of autonomy. In fact, for a long time they did not see the need to elaborate their own Knowledge Triangle policies. They have started to create them under pressure from the Ministry of Education, Youth and Sports. This is reflected in their focus that substantially replicates the objectives and activities of ministerial policies. In the most cases the university Knowledge Triangle policies are very general documents without real measures and tools for development of science-industry links.

At the university level, the intensity of science-industry links depends on specialisation of universities. More intensive collaboration is developed at technical universities while the cooperation is less developed at traditional universities covering wide range of scientific disciplines. A detailed look at the funding structure of universities shows that despite massive increase of private sector investment in research at universities in recent years this source remains rather negligible for funding of research activities of the majority of universities. For many universities contract research revenues are more important. This funding source originates, in fact, from contract research financed by research programmes implemented by national ministries and the TACR.

To foster science-industry links nearly all universities established, with the support of specific programmes of the Knowledge Triangle policy, their technology transfer centres. Their operation is, however, determined by the lack of systematic funding from universities' own funds and experienced technology transfer experts.

In accordance with the national Knowledge Triangle policy universities and their Knowledge Triangle policies do not focus only on contract research and knowledge (technology) commercialisation, but also struggle for active participation in technology platforms and clusters. Their development and activities still depend on public funding from national level programmes (co-funded by the EU Structural Funds).

Relatively long-term stagnation of university-industry collaboration and its later fast development reveal positive influence of the national Knowledge Triangle policy, which has been successfully transformed into actions of individual universities no matter how general their strategies are. Without the Knowledge Triangle policy and its support programmes stagnation of the collaboration is likely to continue since there probably would not be any pressures on universities to go into joint activities with private companies. Stagnation of the collaboration during implementation of the previous national Knowledge Triangle policy also shows that if the policy measures are not followed by specific programmes, the collaboration will not evolve. The current collaboration is thus driven by national programmes while there are no evidences that universities plan to use own sources for development of Knowledge Triangle activities. Therefore future development will probably further depend on national programmes or financial incentives; partly it will be also financed from funds obtained from knowledge commercialisation.

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Place-based Higher Education Policies in Austria

14

Maximilian Unger, Daniel Wagner-Schuster, and Wolfgang Polt

14.1 Structure of the Case Study

This case study deals with the place-based dimension at different levels of Austrian higher education policy making. At the federal level, the main instruments comprise the respective initiatives embedded in the public financing of universities within the three-year performance agreements and are subsumed under the header of "Lead Institutions Initiative" (*Leitinstitutionen-Initiative*). Austria is a federal state, made up of nine regions (*Länder*) that play a decisive role in STI policy and in respective regional knowledge triangles. Their impact is exercised in the provision of relevant funds and programmes as well as in the definition of strategic priorities. The "Lead Institution Initiative" sets out the respective requirements concerning the strategic interaction of universities and their location (region) in order to develop and implement regional STI strategies. The design and implementation of the steps involved in this initiative are described below.[1]

Top-down empowerment of public universities' engagement in the regional knowledge triangle is accompanied by bottom-up coordination of higher education institutions. The emergence of regional higher education conferences (*regionale Hochschulkonferenzen*) was an important step taken by HEI of different types at regional level to operationalize horizontal coordination. Regional higher education conferences are therefore mostly designed to address the needs for coordination of public universities, universities of applied sciences (UAS),

[1] http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/Studien_und_Berichte/Mahr_Kreuzer_Leitinstitutionen-Initiative.pdf, extracted on January 18, 2016.

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university colleges engaged in teacher education, and, in some regions, private universities. Regional higher education conferences act as hubs concerning the implementation of coordinated projects and initiatives (together with other components of the knowledge triangle), both in terms of research and education. At national level, by contrast, the Austrian Universities Conference (UNIKO, for public universities), the Conference of Universities of Applied Sciences (FHK), and the Conference of Private Universities (PUK) mainly act as interest groups and political voices for these three types of HEI by allowing them to adopt a coordinated position concerning questions relating to social or higher educational matters.

In addition to the provision of basic public funds and their respective steering mechanisms, competitive funding is increasingly gaining strategic importance for public universities in terms of profile development and engagement in knowledge transfer and cooperation activities with the business sector. Austria has a variety of funding and support programs and instruments in place for the implementation and strengthening of partnerships between universities and business. A special feature of Austria's support mechanisms for science-industry relations is that they are often based on funding along institutional medium-term and long-term programs, bringing together partners from academia and business in formalized collaborations, e.g. in the form of independent legal entities such as laboratories or research centres, rather than providing funding at a project level (Polt et al. 2015). Prominent examples in this vein are the Austrian Competence Centre Program COMET and the research units Christian Doppler Research Association (CDG). These programs serve to integrate key aspects of the knowledge triangle with the improvement of industry-science linkages by promoting collaborative research and innovation projects and the development of human capital, e.g. via doctoral education and employment mobility. Other funding mechanisms also facilitate knowledge transfer by supporting the commercialization of academic research. The so-called AplusB centres (academia plus business program), located throughout Austria at hosting universities, provide support for the creation of academic spin-offs. The program "Knowledge Transfer Centres and IPR-utilization" (Wissenstransferzentren, WTZ) was launched in 2014 to support universities' patenting activities.

14.2 Structure of the Austrian Tertiary Education System

As a result of structural changes at the beginning of the nineties, the Austrian tertiary education system is now characterized by a great variety of institutions, encompassing a number of diverse objectives, authorities, and responsibilities. Structural change was accompanied by fundamental reforms in university governance and financing mechanisms. This is now described below.

The Austrian tertiary sector is characterized by a high number of medium and small institutions and comprises 22 public universities,[2] 21 universities of applied sciences (UAS, *Fachhochschulen, FH*), 11 private universities, and 17 university colleges for teacher education (BMWFW 2014b).[3] Looking at the figures on student enrolments and research activities (see Figs. 14.1 and 14.2), it becomes obvious that the tertiary sector in Austria, both in education and research, is dominated by public universities. UAS were created from the 1990s onwards to provide the regional labour markets with tertiary business and technology skills and connect the regional economies with applied research. Although universities of applied sciences are legally obliged to perform both teaching and research, their share in total R&D expenditures in the higher education sector, though increasing, is still relatively low compared to public universities.

The university sector in Austria is characterized by a high degree of institutional specialization. There are six universities of art,[4] three technical universities (including the Montanuniversität Leoben), three medical universities, the University of Natural Resources and Life Sciences Vienna, the University of Veterinary Medicine Vienna, and the Vienna University of Economics and Business. Only five out of twenty-two universities, the Universities of Vienna, Graz, Innsbruck, Linz, and Salzburg, offer a broad range of study programs and scientific disciplines (apart from medicine).[5] The University of Klagenfurt covers the following fields: humanities, technical sciences, management and economics, and interdisciplinary research, the latter mainly dealing with social and ecological problems and public goods. The Danube University for Continuing Education at Krems is unique in the sense that it offers only Master and PhD studies as well as diplomas in selected fields and focuses on the needs of working professionals (see Sect. 14.4.1).[6] While the Danube University for Continuing Education at Krems is financed by the region of Lower Austria and through tuition fees, the budgetary contribution of the national government is still allocated via the usual performance agreement—as is the case for the other state-funded universities.

The different institutional profiles are crucial to understanding the Austrian university funding mechanism since it is based on negotiations with each individual university concerning specific funding targets and measures.

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[2] Including the University for Continuing Education Krems (DUK) which in terms of its funding mechanism tends to diverge from the other 21 universities in that it is mainly financed by the region of Lower Austria.

[3] Of which 3 are private.

[4] Sharing the Humboldtian vision of research and research-infused teaching missions with all other Austrian universities separates universities of the arts from academies with a mere teaching focus, and gives them a distinct profile in the international context. The research mission at universities of the arts is called "development of the arts" (*Entwicklung und Erschließung der Künste*).

[5] BMWFW (2014b).

[6] http://www.donau-uni.ac.at/en/universitaet/index.php?URL=/en/universitaet/ueberuns, extracted on February 25, 2016.

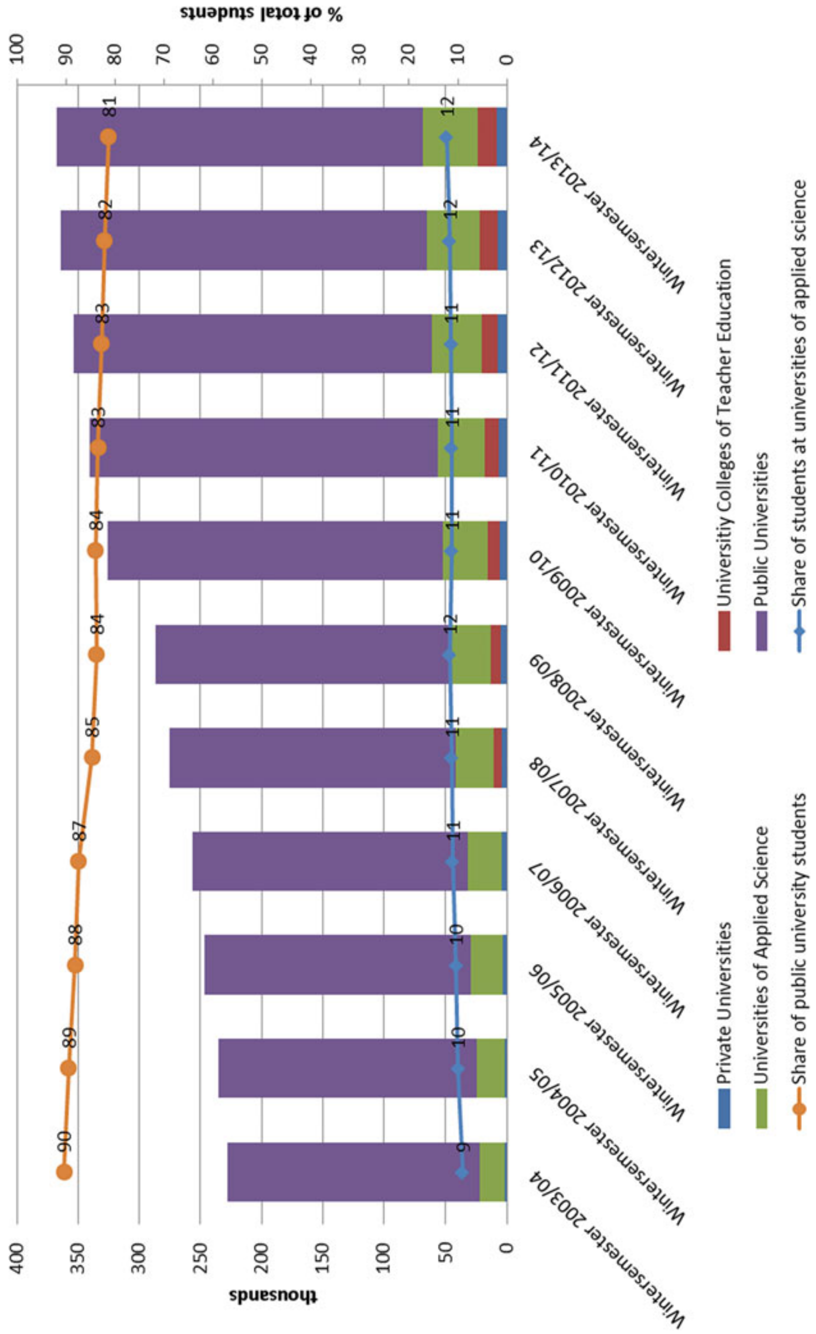

Fig. 14.1 Students enrolled in tertiary education by type of institution. (Source: Statistik Austria (2015))

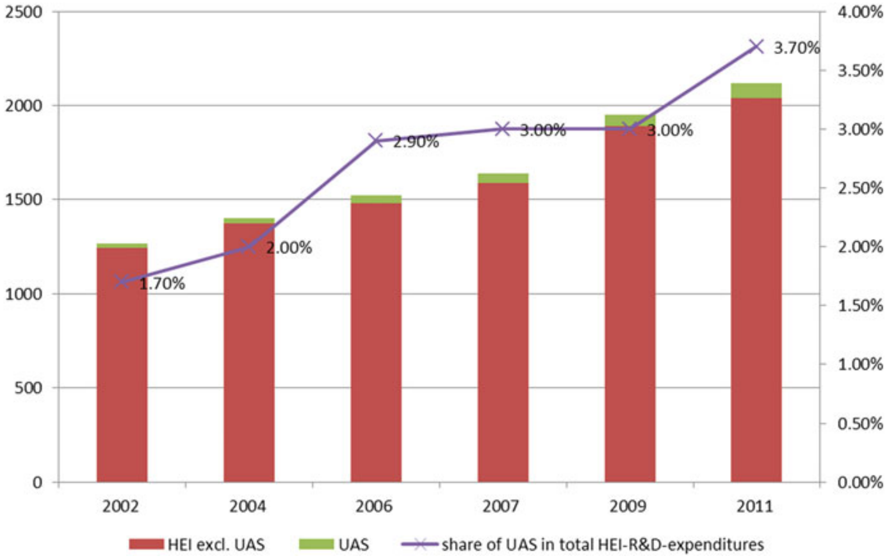

Fig. 14.2 R&D expenditures in the HEI sector in € million and share of universities of applied sciences (UAS). (Source: Statistik Austria (2015), Austrian Research and Technology Report 2014 in Polt et al. (2015))

14.3 Finance Structure of Public Universities in Austria

14.3.1 Legal and Strategic Framework for Financing and Steering Public Universities

As a result of the University Act 2002 (*UG 2002*), public universities gained independent legal status in public law (*Vollrechtsfähigkeit*). They are now in a position to autonomously sign contracts (e.g. concerning various forms of cooperation activity) and to hire personnel on a private law basis. The purpose of the increase in autonomy was to improve the efficiency and effectiveness in the provision of university services.[7] Formal independency also increased the power of universities to position themselves in the "knowledge triangle", e.g. by enabling them to define strategic targets and priorities on their own and to engage autonomously in contracted and collaborative research activities.

The establishment of universities as autonomous administrative institutions was accompanied by the introduction of new strategic financing instruments, including development plans, performance agreements, and related reporting modes, all these serving to reflect the concept of new public management. Since the restructuring and development of higher education steering and policy measures is an on-going

[7] Strehl et al. (2006).

process, the University Act 2002 is frequently subject to adjustment in order to take account of new developments.

The Austrian government's RTI strategy of 2011 provides the central strategic development framework for the higher education sector and embodies the following nine strategic objectives. These apply to both tertiary education and to R&D:[8]

- Fundamental improvements are to be made in conditions of study at universities. This requires the establishment of new finance models for higher education.
- Reforms to mitigate social selectivity (. . .), to implement thorough quality improvements (. . .) in university instruction, to better integrate immigrants, and to offset gender discrepancies in research.
- The proportion of 30- to 34-year-olds who have completed a university degree or have an equivalent educational certificate is to be increased to 38 per cent by 2020.
- Investment in basic research is to be increased by 2020 to the level of leading research nations;
- Basic research is to be improved by implementing further structural reforms in the university system.
- The university financing model is to be reformed. Research financing is to be more competitive and project-based.
- University research financing, in the form of third-party funding from the Austrian Science Fund (FWF) via competitive applications, must be strengthened and given appropriate financing.
- The establishment of individual university profiles is to be supported by creating "Clusters of Excellence".
- The orientation of teaching and research topics at universities, and the collaboration with non-university research institutes, is to be better aligned within an overall strategy.

The Austrian University Plan (*Hochschulplan*) of 2011 and the Austrian University Development Plan 2016–21 of the Federal Ministry of Science, Research and Economy (BMWFW) are designed to translate these long-term strategic objectives into step-wise targets which are then to be operationalized in the form of university development plans and performance agreements with the ministry.

The Austrian University Plan of 2011 initiated the intensification of priority setting and coordination among universities both in research and teaching, "*. . .to further develop higher education in Austria, to increase international visibility, and to ensure the highest quality in teaching and research under the given circumstances and the efficient completion of achievements according to international standards*". Furthermore, the active role of universities as scientific lead institutions in the regional knowledge triangle was emphasized by formulating the necessity of university participation in regional STI and/or "Smart Specialization" strategic

[8] Austrian Federal Government (2011).

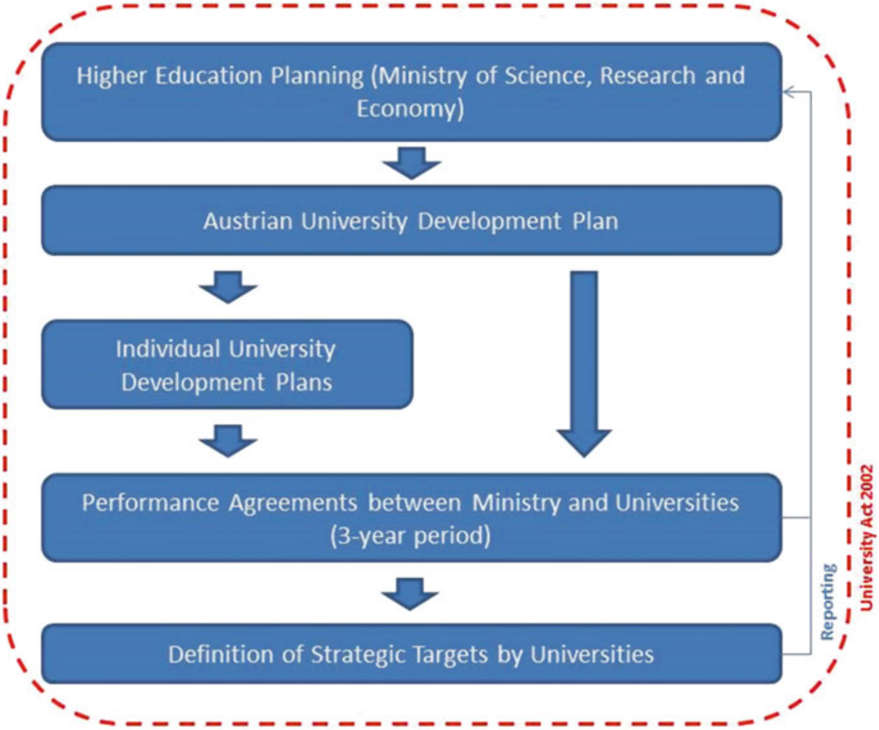

Fig. 14.3 Public instruments for university planning and steering. (Source: Austrian University Development Plan 2016–21)

processes. Initial steps towards these targets were undertaken by the implementation of the so-called Lead Institution Initiative in the performance agreement period 2013–15. This initiative is continued in the targets formulated in Austrian University Development Plan 2016–21. As can be seen in Fig. 14.3, this is also related to the strategic framework for the performance agreement periods of 2016–18 and 2019–21.

14.3.2 Performance Agreements

University budgeting is evolving in Austria. At the moment, the allocation of basic public funding via the so-called global budget (*Globalbudget*) is based on two distribution mechanisms. These are performance agreements (*Leistungsvereinbarungen*), which account for the largest share of funding (about 95% of allocated global budgets in the period 2013–15), and, second, indicator-based higher education structural funds (*Hochschulraumstrukturmittel*). The structure of university funding is displayed in Fig. 14.4.

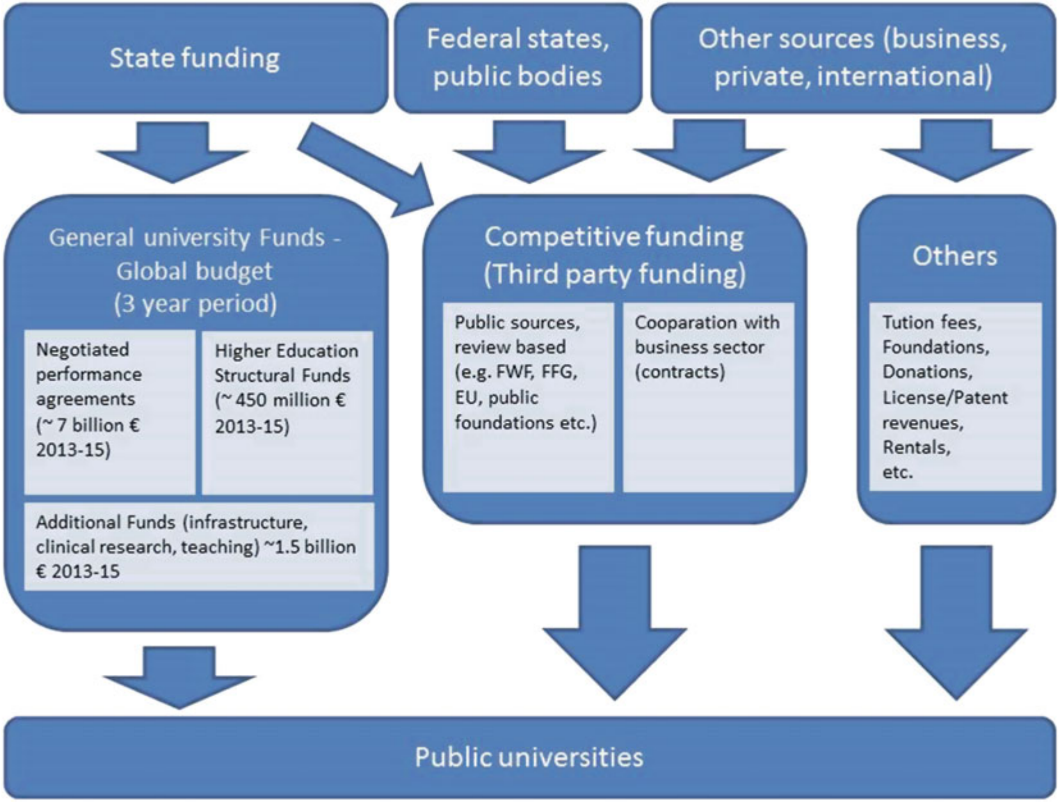

Fig. 14.4 Funding structure of public universities in Austria. (Source: JOANNEUM RESEARCH based on Claes-Kulik, A-L and Estermann, T (2015), Strehl F et al. (2006))

Currently, performance agreements are negotiated between each individual university and the Federal Ministry of Science, Research and Economy (BMWFW) for a planning period of three years. In contrast to more backward-oriented approaches, performance agreements are related to strategic targets and respective measures for a future period of three years (Claes-Kulik and Estermann 2015). The structure of the performance agreements is the same for all universities, covering aspects of strategic and profile development, research and teaching, as well as other areas of university activities reflecting the so-called third mission of universities, i.e. activities designed to foster the societal engagement of universities, or those serving to promote knowledge transfer and cooperation (i.e. between higher education and research institutions, the business sector, and political and societal stakeholders). Furthermore, plans regarding buildings and research infrastructure and targets concerning human resource development and internationalization activities are also included. Strategic targets and measures implemented in the performance agreements are related to the specific development plans (*Entwicklungspläne*) drawn up by every university. Development plans serve as medium-term strategic documents and provide an overview of a university's profile and medium-term development goals. The most important operational targets and themes to be implemented in the 2013–15 performance agreement period were: (i) continuation of topic and priority setting, (ii) intensification of cooperation, (iii) expanding internationalization, (iv) strategic development of research infrastructure, and (v) further development of third-party funding acquisition (BMWF, BMVIT 2013). Although the universities commit themselves to concrete targets and measures in the performance agreements, their global budget is allocated to them as a lump sum. This means that in practice they have a free hand in how funds are distributed internally.

The achievement of the targets is monitored in "performance dialogues" (*Begleitgespräche*) between the ministry and each individual university. These take place frequently throughout the funding period. The procedures and steps that need to be undertaken in cases where targets are not met are also laid down in the performance agreements. Furthermore, universities report their activities in the form of annually updated indicators (*Wissensbilanzen*). The financial situation of universities is also monitored in the annual financial accounts.

The higher education structural funds supplement the performance agreements by tying a certain amount of the total global budget to a predetermined set of indicators linked to the quantity, quality, and performance targets in the performance agreements (Claes-Kulik and Estermann 2015). In the performance agreement period 2013–15, about 5% (€ 450 million) of the global budget was distributed in this way. Of the indicator-based budgets, 60% was distributed based on the number of regular students in tertiary courses (*prüfungsaktiv*), 14% was distributed based on the amount of third-party funding acquired for R&D projects, 10% was allocated, based on the number of graduates, 14% served as public start-up financing for proposed cooperation projects (and is requested by universities on a competitive basis), and finally 2% was distributed based on the amount of private donations acquired by universities. As is the case with the performance agreements, the higher education structural funds-mechanism is also adjusted for every new period. For the period 2016–18, the amount dedicated to higher education structural funds is to be increased by 66%, i.e. to € 750 million.

14.3.3 Finance Structure

Figure 14.5 displays the development of total government funding of higher education institutions (HEI) of all types as well as of total public university revenues, general university funds, and third-party funds of public universities. The largest part of government funding for tertiary education institutions (*Hochschulbudget*) goes to universities (about 84%, 2013). This represents 4.2% of total government spending and 1.2% of GDP in 2013. Since 2003, nominal public funding for universities has increased by 58.4%. Regarding universities' budgets in the performance period 2010–12, 73% of total revenues came from institutional funding by the government, and 16% was acquired via competitive revenues for third-party-financed R&D projects (*F&E-Drittmittel*). Revenues from tuition fees account for just 2% of total university revenues (BMWFW 2014a).

Total university revenues comprise—among other things—competitive revenues from R&D projects ("Third-party funding"). Though these revenues significantly increased in absolute volumes by 47.1% between 2007 and 2013, from € 402.6 to € 597.5 million, their share in total university revenues remained relatively constant over time at around 16%. Furthermore, the largest part of competitive funding is acquired via public sources, i.e. the two national public research funding agencies, the Austrian Research Promotion Agency FFG and the Austrian Science Fund FWF, via national authorities (government, regions, communities), and other public funds (*Jubiläumsfonds*, Austrian Academy of Sciences). This amounted to 43.2%, in 2013, with the FWF alone being responsible for a share of 25%. 13.9% was acquired from EU funding schemes. The share of competitive funding by the business sector increased only slightly from 25.7% in 2007 to 26% in 2013. This followed a sharp decline in 2008 which was probably attributable to the global economic crisis. Only 4% of competitive funding comes from private foundations (BMWFW, BMVIT 2015). A major aim of both the Austrian RTI strategy and of the recently published "action-plan for research" by the Austrian Federal Ministry of Science, Research and Economy (BMWFW) is to increase the share of private funding at universities (BMWFW 2015).

The highest share of federal government funding for HEIs is dedicated to the 22 public universities via general university funds. This is largely a result of the more diverse nature of funding employed in universities of applied sciences which is based on a variety of sources (depending on their ownership structure) and comprises tuition fees, global funding from regional governments and municipalities, student-based funding from the national and regional governments, and public and private research funds (Österreichischer Wissenschaftsrat (2012).

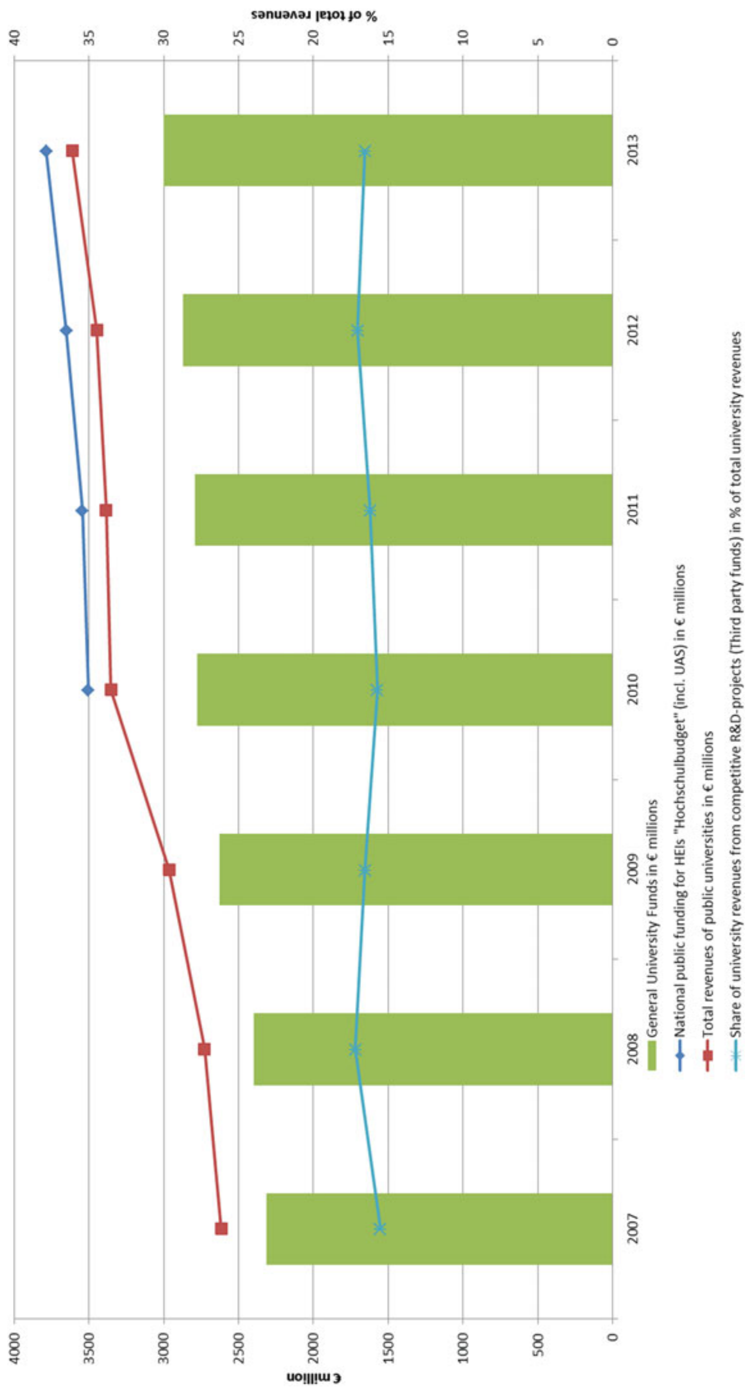

Fig. 14.5 Development of public funding for HEIs and university R&D in Austria. (Source: University Report 2014; Statistik Austria 2015)

14.4 Implementing Place-based Policies in the Performance Agreements: The "Lead Institutions Initiative"

The "Lead Institutions Initiative" (*Leitinstitutionen-Initiative*[9]) of the Austrian Federal Ministry of Science, Research and Economy (BMWFW) follows the policy thought that major steps of planning along the teaching, research, and innovation sides of the knowledge triangle either originate from or show their strongest impact in a regional eco-system. In a HEI context, this insight affects not only the policy interventions related to the alignment of curricula, research profiles of excellence, but also the exploitation of results and cooperation with business or the public at large. Better alignment, particularly in a smaller policy system like Austria challenged to create critical mass and pool resources, suggests a change of perspective, from a mere institutional level of intervention towards the development of competitive knowledge places with an international profile. The Lead Institutions Initiative created an umbrella for two strategic targets that have gained importance over the last years. The first is the on-going process of priority setting among universities. This entails the definition of strategic research and teaching priorities and longer-term objectives, as well as the associated strategic planning of resource allocation. Existing strengths and capacities are to be targeted such as to create critical mass in strong research fields at internationally competitive universities (BMWFW, BMVIT 2015). Second, universities are increasingly obliged to intensify and display their engagement in "third mission activities", meaning their contribution to innovation, economic development, and the solution of overarching social issues. This reflects an active interpretation of their role as regional lead institutions in the knowledge triangle, in accordance with the related conceptual work undertaken by both the OECD and the European Commission (OECD 2007). The integration of different partners' competences in regional innovative eco-systems is seen to be a key asset in increasing the international visibility of universities. The "Lead Institutions Initiative" is embedded in the European concept of *Smart Specialization* and provides universities and research institutions with an explicit mandate to actively use their assets in all three sides of the knowledge triangle to participate in policy development relating to regional innovation strategies for smart specialization (RIS3) (Mahr 2013; EC 2014a, b). *Smart Specialization* encourages a new understanding of regional policy by putting emphasis on knowledge and innovation driven development.

Regional transmission mechanisms facilitating university knowledge transfer take many forms in Austria. For example:

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[9]The name is a deliberate analogy to the well-established notion of "*lead companies*" (*Leitunternehmen, Leitbetriebe*) for Austrian branch leading industrial enterprises with a strong sense of their role as regional key employers. As lead *institutions*, Austrian knowledge institutions should become entrepreneurial partners of companies, politics, and the society at large in using their capacities to shape the profile of their region.

- knowledge transfer that occurs through the provision of highly qualified graduates, the attraction of highly qualified personnel and informal knowledge mobility via local networking activities,
- cooperative ventures, such as those of the COMET programme for competence centres or the Christian Doppler laboratories (see respective section below), as well as contract research services at universities,
- technology centres and shared development facilities, such as the pilot factory "Industry 4.0" of the Vienna University of Technology, funded by public sources and participating companies,[10]
- publication and commercialization activities of the universities, as well as university spin-offs, supported by programs like AplusB, or the recently established Knowledge Transfer Centres (see below),
- direct economic stimulus as an employer, generation of value added, as well as via student and employee spending.

At the same time, university development potential is influenced by local circumstances. Universities profit from their proximity to research and business enterprise partners, clusters, and networks, as well as to other institutions of higher education, and may also benefit from the specific conditions in a locality. Examples of this in Austria include the "Centre on the Mountain" at the University of Leoben in Styria's Erzberg mine, or the hydraulic engineering laboratory DREAM of the University of Natural Resources and Life Sciences Vienna on the river Danube (BMWFW, BMVIT 2015). The Centre on the Mountain is a research laboratory hosted by the Montanuniversity of Leoben and located at the former open-casted mine for iron ore at the Styrian Mount Erzberg. The unique feature of the Centre on the Mountain is that it allows research, development, and testing on the design and installation of tunnel construction and related technical underground power and deep drilling rigs in the oil industry in a realistic environment of a former mine. It is financed by the University, the region of Styria and the federal government.[11] The DREAM infrastructure, located in Vienna directly at the river Danube, will allow for research on sediment transport, flow conditions, ecology, human impacts of the river and the development of future measures on integrated flood management and river engineering. It is part of the Austrian-Hungarian joint project SEDDON on sediment management in the river Danube and co-funded by the European Structural Funds for Regional Development.[12]

The central purpose of the "Lead Institution Initiative" is to channel the several strands of universities' regional engagement into a strategic vision for each individual university and to increase university cooperation with external partners as well as inter-university coordination at the same time. Concrete targets are (Mahr 2016):

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[10] 50% of total cost are covered by the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT); The Vienna Business Agency funds the construction of buildings.

[11] http://zab.unileoben.ac.at/.

[12] http://seddon.boku.ac.at/index.php/en/the-project/project-content.html.

- to position universities as self-confident partners in the development of locations and regions on equal levels with other stakeholders in the knowledge triangle ("turning stakeholders into partners"),
- to increase international visibility of universities as regionally embedded knowledge hubs for scientific and business cooperation,
- to shift the strategic perspective from individual institutions towards the development of knowledge locations leveraging administrative, infrastructure, and competence synergies,
- to increase the quality of cooperation and coordination in management, teaching, research, and innovation activities as basis for the provision of public funds for location oriented projects (e.g. procurement and use of research infrastructure, establishment of joint core facilities, alignment of curricula according to location specific needs, joint appointments by institutions, permeability between different types of institutions at a location, management activities).

The implementation of the "Lead Institution Initiative" covers three periods of performance agreements. Initial steps were undertaken in the performance agreements period 2013–15. With a view to raising awareness and creating a mobilizing effect, two specific milestones were developed for implementation in the performance agreements. For the first, universities were asked to create a so-called location concept (*Standortkonzept*) in which each individual university presents its strategic cooperation and network arrangements with other research institutions, firms, and society with respect to a self-defined radius of vicinity. A location concept is then to be integrated into each university's own development plan (*Entwicklungsplan*) in order to document the institutional impact on its location and to create a basis for the attraction of international partners and the strategic alignment of research priorities. Furthermore, the universities were encouraged to participate actively in RTI and development strategies in their respective regions. RTI priorities developed on the basis of regional potential are in turn an important foundation for the efficient and transparent allocation of public resources, e.g. for the implementation of large-scale infrastructures.

The majority of Austria's 22 public universities agreed to implement measures related to phase 1 of the Lead Institutions Initiative and 11 already drafted location concepts in the 2013–15 period. The University of Klagenfurt, for example, subjected their cooperation structures to an internal analysis that resulted in the definition of three "cooperation orbits", i.e. the regional "orbit" of Carinthia, the Alpine-Adriatic macro-region, and global partnerships. In Upper Austria, the Technology Management and Regional Development Agency, together with the University of Linz jointly developed the concept of the so-called fields of dual-strengths (*Doppelstärkefelder*) in order to highlight scientific and economic growth potential in the region of Upper Austria.[13] The four universities located at Graz chose to

[13] Ibid.

develop a joint location concept, simply because they found they would share the same location where they co-operated anyway (see Sect. 14.4.2).

The Graz approach was taken up by the ministry as a good practice for phase 2 of the Lead Institutions Initiative and integrated into the Austrian University Development Plan 2016–21, defining the "Lead Institutions Initiative" as a project affecting three subsequent periods of performance agreements. With the momentum created in phase 1 (2013–15), phase 2 (performance agreements 2016–18) is dedicated to better coordination and alignment among all types of HEI at one location or region, using the benefits from bottom-up alignment instruments like regional HEI conferences. This bottom-up coordination of institutions aims to serve as a complement to top-down steering mechanisms in connection with public financing. Finally, phase 3 (performance agreements 2019–21) aims at reaching a new quality in the substantiation of investments into knowledge locations. HEI are to be supportive for the government to place smart public investments based on a maximum of alignment among knowledge institutions, and by a clear understanding of the specific knowledge and innovation profile of the region that is also communicated to private partners and investors internationally.

14.4.1 The Role of Regions in STI Policy Making in Austria

In order to fully appreciate the centrality of the "Lead Institutions Initiative" in the multi-level governance of STI policies in Austria one has to understand something of the Austrian federal structure and its highly autonomous regions (*Länder*). Although the Austrian federal government[14] is the main financier of public universities (with the exception of the University of Continuing Education Krems, which receives 24% of its global budget from the region of Lower Austria) (University for Continuing Education Krems 2015), regions still play vital a role in STI policy making and financing. The share of total intramural R&D financed by the Austrian regions lies at around a more or less constant 4%, which represents about 12% of total public R&D expenditures, since the middle of 2000 (see Fig. 14.6). Most of the Austrian regions provide a variety of funding and support mechanisms for R&D and innovation, comprising regional foundations and funding agencies, incubators, cluster programs, and networking initiatives (Stahlecker 2012; Schnabl et al. 2014).

Priority setting procedures and the development of university "location concepts" are embedded in regional STI strategies and prioritization at the regional government level. Existing priorities and areas of strength at universities are essential factors for the STI regional profiles. Vice versa the development of university profiles and priorities is also expected to take into account of local demand and expertise and of future political and social priorities. Public universities are located in seven of the nine regions—Vorarlberg and Burgenland are the two exceptions—and universities

[14] In Austria, the prefix "federal" (*Bundes-*) always refers to the national level, while "state" (*Landes-*) refers to regional authorities.

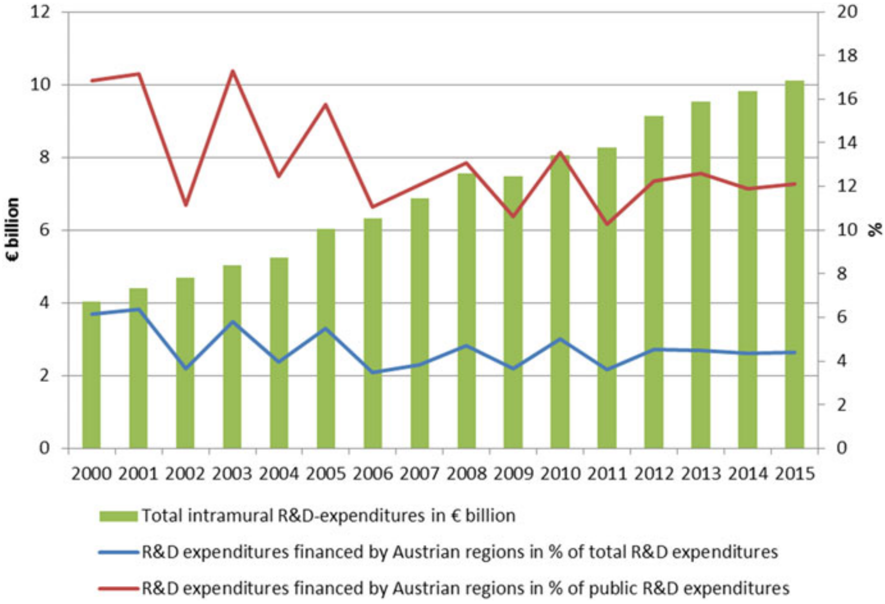


Fig. 14.6 R&D expenditures financed by Austrian regions in %, 2000–2015. (Source: Statistik Austria, Global Estimate 2015)

of applied sciences (FH) are located in all nine regions. This makes the regional nature of the Austrian higher education system quite clear. In Austria's largest region, Lower Austria, the institutional setting mirrors the region's unique position as a result of its proximity to Vienna. While 17 HEI of all types are located in the capital, Lower Austria decided not to compete directly, but to cater for complementary niches. We thus have for example: (1) the Danube University (for Continuing Education) at Krems with a graduate and post-graduate focus, (2) the Institute of Science and Technology Austria (IST Austria) at Klosterneuburg, a young centre of excellence for basic research with only doctoral and post-doc training, and (3) an invitation to Viennese universities to establish research (and education) co-locations in Lower Austria that fit into the region's desire to establish multi-institutional thematic hubs (technopoles).

Current and on-going STI strategic processes at the regional level are related in varying degrees to the concept of "Smart Specialization". Most importantly, however, they reflect the concept of profile formation through thematic priority setting. These strategic priorities are typically based on an analysis of the strengths of a region's economy and the research specializations in higher education institutions (BMWFW, BMVIT 2015). For example, priorities in Upper Austria's STI strategy (The region of Upper Austria 2013) comprise manufacturing, energy, health and ageing, food and diet, as well as questions relating to issues of mobility and logistics. This simply reflects Upper Austria's position as Austria's leading manufacturing and exporting region (Stahlecker 2012). In contrast, Lower Austria places strategic emphasis on agro-technology and veterinary medicine, culture, health and medicine, natural science and engineering, and on issues relating to the environment, energy, and resources (The region of Lower Austria 2015). Styria has developed separate STI and economic strategies, but both reflect the prominent position of the automotive sector in Styria, and the issue of mobility is a clear strategic priority. Other so-called thematic corridors of the STI strategy comprise energy and resources, materials, health and biotechnology, and the "information society" (The region of Styria 2013). In Tyrol, STI strategy focuses on creative industries, material sciences and technologies and on research concerning the alpine area (The region of Tyrol 2013). Burgenland focuses on three broad future areas: sustainable technology (e.g. building, renewable energies), sustainable quality of life (e.g. ambient assisted living, optimization of health care products and services), and intelligent processes, technologies and products (e.g. optoelectronics, mechatronics) (The region of Burgenland 2014). Carinthia's STI strategy emphasizes the development of human resources, ICT, production technologies, and sustainability as core objectives for future STI activities. Furthermore, it explicitly addresses targets for the two higher education institutions located in Carinthia, the University of Klagenfurt and the Carinthia University of Applied Sciences. Both of these are to emphasize education in the fields of engineering and technical disciplines in their current and future activity (The region of Carinthia 2009). Vienna's STI strategy, recently launched in September 2015, has selected social sciences and humanities, life sciences, ICT, creative industries, and mathematics and physics as being the strongholds of the Viennese STI landscape. This reflects the prevailing variety in the research and higher education environment. Specific emphasis is being put on the concept of "Smart City", an attempt to provide innovative solutions to specific challenges in urban areas, for example, concerning questions of public transport or governance (The region of Vienna 2015).

14.4.2 Regional University Conferences

Over the last years, regional higher education conferences emerged as bottom-up instruments in the coordination of higher education institutions within one region. Related activities in this respect may comprise research cooperation in terms of jointly set objectives, the development of regional knowledge hubs, promotion of clusters or incubator programs, and cooperation in teaching programs. Another important issue is joint agenda setting in regional innovation strategies. This is supposed to serve as a central contact point for regional policy makers. The creation of synergies between regional *lead institutions* in knowledge production is seen as an important step towards the creation of internationally visible knowledge locations. This contrasts with the concept of simply enforcing "excellence" solely on the basis of individual flagship institutions.

So far, collaboration in the form of regional higher education conferences has been established in Salzburg, Styria, Tyrol, Carinthia, and Burgenland. In the following, the Styrian higher education conference will be described, as it is believed to be typical of such forms of cooperation.

The Styrian higher education conference, formed in 2012, includes the University of Graz, the University of Technology Graz, the University of Music and Performing Arts Graz, the Montanuniversität Leoben, the Medical University Graz as well as two university colleges for teacher education and two universities of applied sciences. Together, these nine institutions form the so-called Science Space Styria. With the exception of Vienna, it represents the largest cluster of higher education institutions in Austria and comprises approximately 55,000 students, a total of 12,000 employees (second largest employer in Styria), and has an annual total budget of approximately € 700 million (Science Space Styria 2012). The mission statement of the Science Space Styria includes the following objectives:[15]

- Creation of a Styrian higher education area and the generation of activities to raise related awareness.
- Development of a common position regarding strategic questions.
- Shared public relations regarding policy, economy, and society.
- Shared marketing and awareness raising with respect to students and student matters (to direct the student flow).
- Coordination of profile formation and cooperation with a focus on:
  - Projects of concern for universities,
  - "Lighthouse projects", i.e. those of high visibility and appeal in the area of Styrian higher education,
  - General projects aimed at the removal of hurdles and obstacles, which serve to promote cooperation.

  One flagship initiative is the so-called NAWI Graz in which the University of Graz and the University of Technology Graz bundle activities in research and teaching in the natural sciences. Currently, 18 NAWI Graz bachelor's and master's programmes with a total of 4750 students are on offer.[16] Other initiatives, currently in place, also emphasize joint activities in teaching, for example, the Inter-university Initiative for New Media Graz, iUNIg, the joint course of electrical engineering and audio engineering, or the joint provision of guidance for the selection of courses and study programs. The Health Perception Lab (HPL) for applied sensory research was established in 2013, with funding of € 1.2 million from the Austrian Research Promotion Agency FFG for a period of five years. It is located at the University of Applied Sciences JOANNEUM and manages to bundle interdisciplinary expertise in the field with the University of Technology Graz and Medical University Graz. The aim is to provide pioneering work in the German-speaking area (FH JOANNEUM 2015).

[15] http://www.steirischerhochschulraum.at/die-steirische-hochschulkonferenz/.

[16] http://www.nawigraz.at/.

One on-going process concerns the formulation of a joint location concept for the Styrian higher education area. This should reflect the principles of the "Lead Institutions Initiative" which serves as a baseline for Styrian policy making and decisions on the planning and use of research infrastructures for the future (EC 2014b).

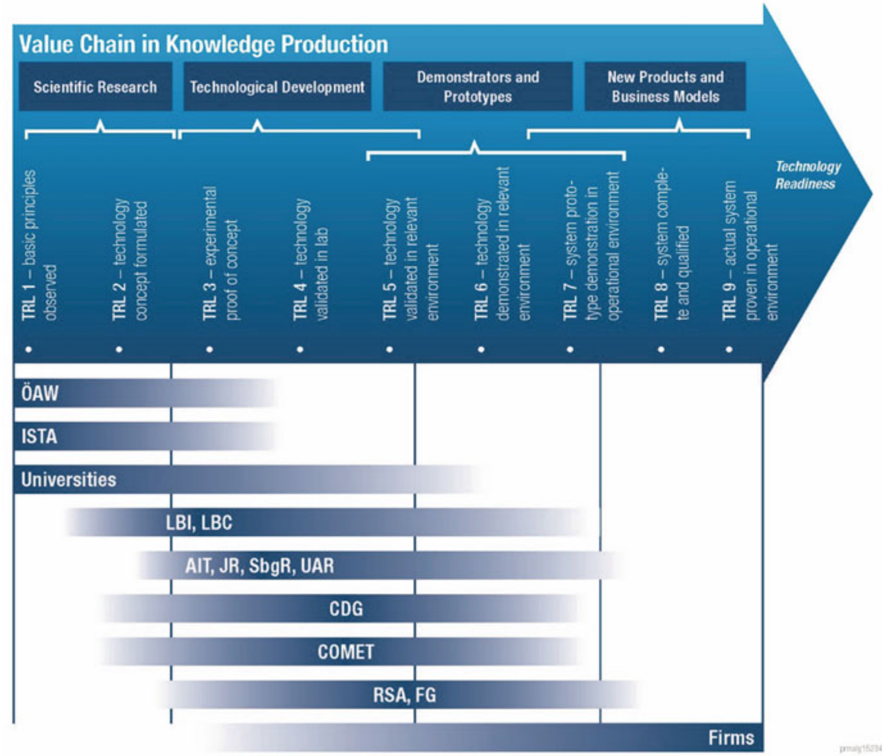
14.5 Support Mechanisms for Science-Industry Relations

The relations between science and industry have always been an important part of innovation systems. Effective linkages between research organizations and industry have finally been recognized as necessary drivers in technological breakthroughs. Awareness of the importance of strong science-industry linkages and the simultaneous realization of respective weaknesses have led to numerous discussions concerning the gaps between scientific output and its translation into innovation. As a result, various policy measures have emerged in many countries over the past two decades which attempt to strengthen science-industry relations. Quantitative assessments on the status of science-industry relations show Austria to perform at competitive levels with many OECD and EU countries. For example, Austria holds the third position behind Finland and Sweden in terms of the percentage of innovative enterprises that cooperate with higher education institutions (22% in 2012) (Schiefer 2015). With about 5.1% (2009–13) also the share of higher education expenditures for R&D (HERD) financed by the business sectors ranges constantly above those of other university centred public research systems such as Denmark, Sweden, or Norway and only slightly below the EU average of 5.86 (2012) (OECD 2013; Statistik Austria R&D-Survey 2013). The latter is driven by the comparatively high levels of business financing of Germany (14% in 2012) and the Netherlands (8.3% in 2012).

Austria has a variety of support programs and instruments in place, aiming at the implementation and strengthening of partnerships between universities and business. A special feature of Austria's support mechanisms for knowledge transfer between science and industry is that the system is very much based on funding along institutional and long-term lines, bringing together partners from academia and business in formalized forms of collaboration and/or in the form of independent legal entities such as laboratories or research centres. Figure 14.7 shows key research providers in the national research system and their contribution to innovation oriented activities along with the so-called value chain of knowledge production in terms of the technology-readiness levels (TRL) of their research.

This following section provides an overview of four central programmes that either result in the establishment of a new research entity or provide support for specific activities to be performed by universities. These are:

- COMET—Competence Centers for Excellent Technologies,
- The Christian-Doppler-Research Labs.



Abbreviations: Austrian Academy of Sciences (ÖAW), Institute for Science and Technology (Austria), Ludwig Boltzmann Institute (LBI), Ludwig Boltzmann Cluster (LBC), Austrian Institute of Technology (AIT), JOANNEUM RESEARCH Forschungsgesellschaft mbH (JR), Salzburg Research (SbgR), Upper Austrian Research (UAR), Christian Doppler Research Association (CDG), Competence Centers for Excellent Technologies (COMET), Research Studios Austria Forschungsgesellschaft (RSA FG). Source: JOANNEUM RESEARCH.

Fig. 14.7 Austrian stakeholders along the value chain of knowledge production. (Abbreviations: Austrian Academy of Sciences (ÖAW), Institute for Science and Technology (Austria), Ludwig Boltzmann Institute (LBI), Ludwig Boltzmann Cluster (LBC), Austrian Institute of Technology (AIT), JOANNEUM RESEARCH Forschungsgesellschaft mbH (JR), Salzburg Research (SbgR), Upper Austrian Research (UAR), Christian Doppler Research Association (CDG), Competence Centers for Excellent Technologies (COMET), Research Studios Austria Forschungsgesellschaft (RSA FG). Source: JOANNEUM RESEARCH)

- AplusB—Academia plus Business, and.
- Knowledge Transfer Centres.

14.5.1 COMET: Competence Centers for Excellent Technologies

The COMET programme was launched in 2006 as successor to the programmes Kplus, K_ind, and K_net. Although the programme was implemented at the federal level, it also has a strong regional aspect as the Austrian regions provide additional funding in order to support their own regional objectives as formulated in their STI policy. The COMET programme attempts to close the gap between science and industry by supporting close cooperation between business and research. Additionally it enables and encourages educational and training possibilities for doctoral students. In terms of annual budgets, the COMET programme is the largest funding scheme for knowledge and technology transfer in Austria. Its current structure was established in 2008 and manages to bundle several successful funding schemes. Between 2008 and 2013, the total volume for funded COMET centres and projects was approximately € 1.3 billion, with about € 405.3 million being financed by the Austrian Federal Ministry of Science and Research, as well as by the Austrian Federal Ministry for Transport, Innovation, and Technology. Additional public funding comes from the Austrian regions. Currently, 5 K2-Centres, 18 K1-Centres, and 21 K-Projects are active. The sixth Call for K-Projects and the fourth Call for K1-Centres are now in progress (FFG 2013, 2014, 2015, 2016; Dinges et al. 2015).

The strategic focus of the COMET programme is the collaborative development of new competences and the initiation and support of top-level long-term strategic research agendas for science and industry, as well as a desire to establish and secure technological leadership in Austrian companies. The programme is intended to make Austria more attractive as a research location in the long run. The following objectives are to be pursued:

- Strengthening the culture of cooperation between science and industry in order to attain top-level research.
- Aligning strategic interests between science and industry.
- Preparing national institutions for increasing international competition by bundling players according to thematic synergies.
- Establishing centres with international visibility through top-level research and thus strengthening Austria as a research location.
- Strengthening human resources by attracting outstanding researchers and supporting the transfer of expertise between science and industry.
- Establishing an appropriate gender balance in research activities (FFG 2014).

The COMET Programme includes three different programme lines, which are characterized by high research expertise and the implementation of this expertise within companies. The different programme lines differ in terms of their degree of internationality, project volume, duration, and infrastructure:

K2-Centres have a stronger focus on long-term bundling of existing national competencies and cooperation with outstanding international partners in science and industry in order to achieve top-level research and increase the attractiveness of Austria as a research location.

Duration: 10 years.

Public funding: 40–55%, max of € five million per year.

Minimum funding of partners: scientific partners 5%, industry partners 40%.

K1-Centres focus on strategic science-industry research agendas with a mid-term to long-term perspective. These centres conduct high-level research and place additional focus on technological developments for future-relevant markets.

Duration: 8 years.

Public funding: 40–55%, max of € 1.7 million per year.

Minimum funding of partners: scientific partners 5%, industry partners 40%.

K-Projects initiate high-quality research through interaction of science and industry and adopt a mid-term perspective. These projects are clearly delimited in terms of the research topic and offer high development potential. K-Projects have to be multi-firm projects (minimum number of 3 companies) which are carried out by science and industry. These types of project can also be set up as preparation for subsequent K1-Centre applications.

Duration: 3–5 years.

Public funding: 35–45%, max of € 0.45 million per year.

Minimum funding of partners: scientific partners 5%, industry partners 50%.

The high international visibility enjoyed by the COMET programme is corroborated by the fact that COMET is considered to be one of the most successful technology policy initiatives in Austria and is named as an example of good practice in the Regional Innovation Monitor (Walendowski et al. (2014). Thus, the impact analysis of the COMET programme also confirmed positive effects of the centres on their region of location by providing economic stimulus through projects and the resulting increase in firms' capabilities as well as by the creation of strong regional networks of companies and knowledge institutions (Dinges et al. 2015).

14.5.2 Christian Doppler Research Association (CDG)

The Christian Doppler Research Association addresses the improvement of science-industry linkages and the promotion of relevant human capital. The main objectives of CDG are

- the strengthening of basic, application-oriented research,
- the support of knowledge and technology transfer between science and industry,
- the strengthening of universities, universities of applied sciences, and other research institutions,
- the improvement of the structure of the national innovation system, and,
- the strengthening of Austria as a competitive and innovative research and industry location for private companies, universities, and researchers.

In terms of the above, CDG's general features and characteristics have remained relatively constant since 1995. Adaptations, when deemed necessary, have nevertheless been made, with the result that CDG now appears to have become a widely accepted and stable element in promoting research and innovation in Austria. It has also managed to gain a significant role in the promotion and training of young scientists (see Fig. 14.8) (CDG 2016).

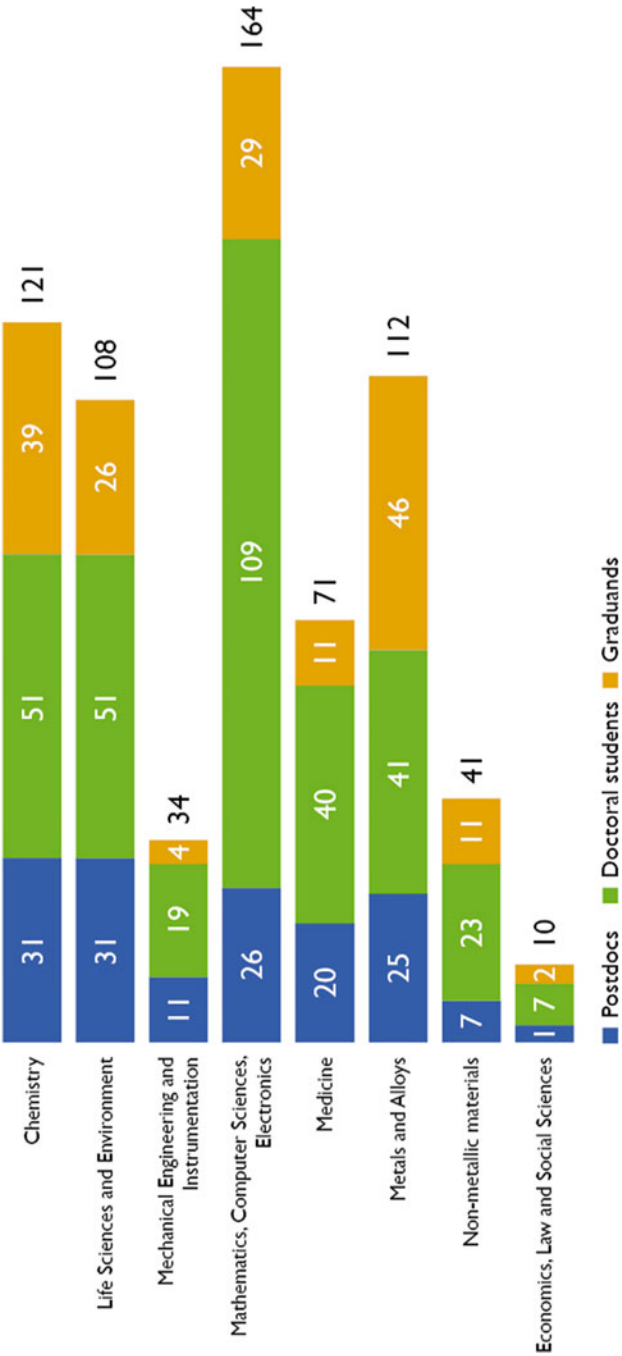


Fig. 14.8 Education in CD Laboratories by thematic cluster 2014. (Source: CDG (2014))

The CDG exhibits two main funding models. These are the Christian Doppler Laboratories (73 active CD Labs in 2015) and the Josef Ressel Centres (7 active JR Centres in 2015). While CD Labs are hosted at universities or non-university research institutions, and focus on application-oriented basic research, JR Centres are hosted at universities of applied sciences and focus on applied research. Both models are established as public–private partnerships which are normally financed 50% by the public purse and 50% by commercial partners. If SMEs are involved, a share of 60% for public funding is possible. The models include the option of internationalization by allowing for a mix of national and foreign partners (one of the partners—either the commercial or the academic partner—has to be Austrian). This may entail, for example, establishing an international CD-Laboratory at a foreign institution, cooperating with international commercial partners or internationalizing certain modules of work (Unger 2014). Some basic characteristics of the two models are:

CD Labs: maximum duration of 7 years (involving a sequence of 2-year, 3-year and 2-year periods, whereby progress to a subsequent period is subject to a process of evaluation), annual budget of minimum € 110 thousand and maximum € 700 thousand, size of research group: 5–15 persons.

JR Centres: maximum duration of 5 years (a 2-year introductory phase, followed by a 3-year extension phase), annual budget of minimum € 80 thousand and maximum € 400 thousand, size of research group: 3–10 persons.

CD Laboratories and JR Centres are based on a strict bottom-up principle. This means that grant applications from various fields are acceptable on the condition that the commercial partner demands high-quality research and that progress is evaluated in accordance with clear scientific criteria. Currently the CDG portfolio comprises eight thematic clusters. These are:

- Chemistry,
- Life Science and Environment,
- Engineering and Instrumentation,
- Mathematics, Computer Science, Electronics,
- Medicine,
- Metals and Alloys,
- Non-Metallic Materials, and.
- Social Sciences, Economics and Law.

14.5.3 AplusB: Academia plus Business

There is high awareness today that academic spin-offs are essential in facilitating effective knowledge and technology transfer across the fields of science and business. This was the impulse for the AplusB programme, with its AplusB Centres, started in 2002 by the Federal Ministry of Transport, Innovation and Technology (BMVIT). The aim was to support business start-ups coming from the academic sector. The AplusB programme focusses on innovative start-up projects. These are typically technology-oriented, relatively complex or demanding in terms of the level of supervision and support needed, and of considerable significance in view of the expected impact of structural change and economic growth on the economy. These projects require a high level of continued development and supervisory support right from the beginning, something that cannot usually be provided by the scientific community or private incubators at the necessary level of intensity. The programme targets students and graduates from higher education institutions, as well as university and non-university research staff, and tries to increase the chances of commercial success of innovative and technologically oriented academic start-ups. AplusB is promoted by the Austrian Research Promotion Agency (FFG) and funded by public federal and regional bodies and private sources. The programme is quite significant since while commercial usage of research results is becoming more and more important for higher education institutions, the latter are unlikely to have access to sufficient resources. Within the AplusB programme, start-ups receive support in the form of specialized knowledge concerning business creation and public relations, they become integrated into the relevant existing networks, and they are supported with business financing and necessary infrastructure, and are advised in patent issues. The importance of a programme such as AplusB has also been emphasized by Ploder et al. (2015), which shows that AplusB businesses are characterized by A higher survival rate, a greater impact on employment, more dynamic revenue growth, higher export rates, and more intensive research and development compared to a control group of start-ups. These results were observed to be constant across regions (Ploder et al. 2015).

Currently, there are eight AplusB Centres with a total of 62 employees. These helped to launch 512 businesses from 2002 to the end of 2014. 86% of these start-ups are still operating. Start-ups supported by the AplusB programme were responsible for the creation of more than 3400 jobs in this period. A look at the distribution of AplusB start-up projects by sector shows that nearly half of all projects are from electronics, IT, software, and telecommunications (47%). Together with life sciences (17%) and environment, energy and transport technology (12%), these account for 76% of all projects (see Fig. 14.9) (AplusB 2016a).

14.5.4 Knowledge Transfer Centres and IPR Utilization

In terms of patenting activity, Austrian universities had to make up considerable ground between the beginning of 2000 and 2013. In this period, university patent applications as a share of total national patent applications increased from 0.5% to 3%. This was mainly due to the measures introduced in the university law UG 2002, whereby all inventions by university researchers have to be reported to university management. The related uni:invent program, administered by the Austrian Business Agency, and financed by the old Federal Ministry for Science and Research,[17] was a

[17] Now: Federal Ministry of Science, Research and Economy BMWFW.

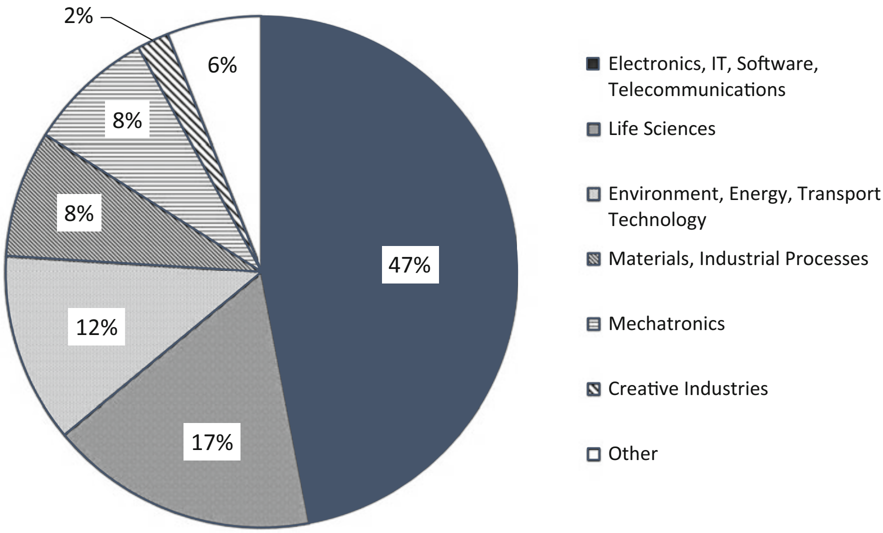


Fig. 14.9 Sector distribution of AplusB start-up projects. (Source: AplusB (2016b), own illustration)

funding mechanism run from 2004 to 2009. It was designed to enforce university patenting activity, first, by providing coaching for universities and researchers in the patenting process, and second, by providing financing for university patents (Polt et al. 2015). The program for *knowledge transfer centres and IPR-utilization* (WTZ) was launched in 2014 by BMWFW as a successor to the uni:invent program. It was intended to help improve the relatively weak commercialization performance of Austrian universities. The program promotes the establishment of regional knowledge transfer centres. These support knowledge and technology transfer by accelerating the commercial and social exploitation of research output as well as the close coordination of related activities among universities, universities of applied sciences, and public research institutions. The support and funding instruments of the knowledge transfer centres are intended to aid the professionalization of commercialization activities and to facilitate the further development of patents towards market maturity and prototype development. Currently, three knowledge transfer centres have been established at the University of Innsbruck, University of Technology Graz, and the Medical University Vienna. As of mid 2015, 20 Austrian universities were involved in 16 joint projects coordinated by knowledge transfer centres.[18] The knowledge transfer centre covering the area of life sciences comprises 17 partner institutions, and the University of Vienna is responsible for coordination. The aim of this specific centre is the implementation of a virtual infrastructure in this

[18] BMWFW, BMVIT (2015).

field in order to improve medical and diagnostic development.[19] The total public budget for the establishment of these centres is provided by the BMWFW up to 2018 and amounts to € 11.25 million.

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Part V

Knowledge Triangle Targeted Science, Technology and Innovation Policy

15 Targeted Science, Technology, and Innovation Policies to Enhance Knowledge Triangle

Leonid Gokhberg and Dirk Meissner

15.1 Introduction

Entrepreneurship and innovation are essential elements of economic renewal and thus development. The well-being and prosperity of societies are dependent on innovation in all its shapes and formats. The latter in turn is not depending on research and the generation of new knowledge only but increasingly relies on new combinations of existing knowledge which form new opportunities for application and thus leading to new and sustainable technology ventures. National Innovation Systems feature a broad range of research bodies and institutions which appear more or less strategically integrated, multilayered in multinodal knowledge grids. This is further enforced by highly interconnected and non-linear as well as increasingly cross-disciplinary science and research.

In line with this policymaking has stressed the importance of innovation for social welfare and economic development for long time. Though known for many decades the term 'science, technology and innovation policy' (STI policy) became a fashionable expression often used by politicians and administrative bodies to interfere in some way into the sole process of science and innovation only recently. Policy programmes aiming at strengthening the knowledge triangle (KT) are characterized by their emphasis on networks and networking as compared to traditional strategies of industrial policy. However, no single entity or institution will possess all knowledge and skills required for dynamic innovation in the twenty-first century. Until recently clusters and networks tend to be segmented by industrial categories' existing relationships, hence although transactions tend to be more global, trust and regional proximity are the significant factors determining clusters' and networks' structures (van der Valk et al. 2011). In this regard policy interventions may be necessary to change these structures, e.g. 'small-world' structures of cluster

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networks which are presumably the main target of public interventions. It also shows necessary to provide special support for SMEs or start-ups, which are suffering from lack of trust and other networking related resources. With this in mind it becomes possible to improve the regional capability and openness by policy intervention.

Thus, globalization has become a crucial issue of national KT-related policies. Consequently, it is assumed that universities and research institutions can lead globalization and wider collaboration based on their expanded networks. Accordingly, the complexity of knowledge and technologies increases and equally important their availability and place of origin becomes more diverse. As a response to global challenges, rising risks and uncertainty, companies find that innovating together might be more efficient than to search for the breakthrough technologies and products solely (Viskari et al. 2007). This led to the widespread diffusion of the Open Innovation model which is also increasingly found in clusters and innovation/technology networks and platforms sharing the ambition to generate innovation and contribute to the economic and societal development or regions (Friesike et al. 2015). In this context, the smart specialization approach emerged which mainly aims at developing sharp profiles of regions and/or sectors with the ultimate goal of innovation (Luoma-aho and Halonen 2010).

Innovation in the Smart Specialization framework is viewed as a force of structural change of regions. But smart specialization is not an approach for regions or even countries only, on the contrary the underlying methodological concept is also well suited for strategy development of institutions. Especially institutions that involve a significant number of units and serve multiple stakeholders are confronted with strategy building activities, which require the involvement of a number of interested parties. The latter is important for implementing strategies and achieving respective performance levels which is difficult to measure in research-based organizations—such as universities—and which also is strongly determined by the individual members of the institution. Furthermore, universities feature a broad range of activities in substantially different fields of science and technology with diverging characteristics of research (time span, resource intensity, applicability, community size among other features). Another relevant feature are university graduates who fulfil different roles and functions such as:

- Universities' ambassadors' roles transporting an image about the universities' educational capabilities to employers.
- Future engagement in educational activities by contributing own experiences and competences to selected teachings.
- Inspirational source for research and consulting with their previous educational institution.
- Influencer at different levels at stakeholder organizations.

Taken together these roles graduates can have a strong powerful impact. It is obvious that graduates will contribute to the lasting and sustainable performance of their 'alma mater' but this requires active graduate work by the institution in different forms. Also, alumni work requires a dedicated sensitive approach by the alma mater providing information to graduates and keeping alumni networks alive. It often appears the alma mater considers all facts and recent developments as being very important for graduates to know and to learn but at this point in time alumnis are spammed with information they do not necessarily care about. In such cases, alumni work even brings a potential of negative perceptions, attitudes and consequently impacts. However, it is important that universities recognize the role and importance of graduates and also former employees and integrate respective responses in their strategic missions and activities.

15.2 Smart Specialization Strategies, Open Innovation and Knowledge Triangle

KT is a relatively new phenomenon in the STI policy discussion although the basic characteristics of the KT paradigm are thought of for years in many knowledge and technology transfer-related discussions at different levels. The STI policy mainly focuses on STI as the basis for lasting economic impact and assumes that impacts on local labour markets and all related other impacts will be a natural consequence of STI. Smart specialization in principle aims at activating R&D and innovation (R&D&I) activities towards future-oriented lead markets which utilize a related variety of cross-cutting competences, supporting industry and test markets. Thus, it addresses the problem of fragmentation, imitation and duplication of (public) R&D&I investments and stresses the role for all actors within KT hence regions, but especially for catching up ones to identify their comparative advantages in specific R&D&I activities domains but not in sectors per se (Foray et al. 2009). Prioritization of R&D&I investments through the bottom-up process of 'entrepreneurial discovery' traditionally relates to investments with little or no applications known at the time of priority setting and decision making. But in light of the KT paradigm it seems recommendable that universities investments are to some extend aligned or at least compatible with private investments in order to generate impact at least mid-to-long term.

This raises the challenge to identify in which domain or activity an institution would benefit from greater specialization in R&D&I. These are the domains where innovative projects will complement other actors' productive assets. Identifying the unique characteristics and assets of each institution by highlighting the respective competitive advantages, means not focusing on sectors per se but on activities, including research activities. Rather than being a top-down strategy, smart specialization involves a bottom-up process bringing together businesses, research centres and universities to identify the most promising areas of specialization, but also the barriers that hamper innovation and mobilizing stakeholders around a strategic vision for the future growth of the institution through each actors' own strength based on R&D&I (Meissner 2014). Although it is a rather novel concept its underlying elements (i.e., specialization, bottom-up entrepreneurial focus) have been around in various incarnations. Fine-tuning priority setting through better diagnostic tools and indicators can help policymakers gather information on market and technology developments inside and outside. It appears that five overarching domains for institutions smart specialization under the KT paradigm can be defined (Carayannis et al. 2016):

- Human resources.
- R&D&I/scientific excellence.
- Innovation culture, awareness for innovation and openness towards risk.
- General framework conditions and equipment/infrastructure.

Human Resources refers to qualified staff in the first instance but also the attractiveness of institutions as employers, which is a key condition for attracting and maintaining qualified people. In addition to standard educational level more and more project management/project work skills in line with competences identifying and describing problems are important skills together with soft skills such as systemic thinking ability, open mindsets, empathy, and cultural openness. *R&D&I/scientific excellence* is a considerable determinant of sustainable innovation performance and thus economic development not only for corporations but also regions and countries. However, this excellence—as it appears at the research side—needs to correspond to the economic environment because not only does research produce technology but also educated talent, which is essential for converting research into innovation. *Innovation culture, awareness for innovation and openness towards risk* form the often-quoted soft skills of people which are hard to train but which develop in when an organization lives these skills by example. Thus, institutional environments providing possibilities to enter new paths and taking risk, stressing learning from failures instead of punishing mistakes feature innovative innovation milieus. These milieus are embedded in the *general frameworks* which set the broader terms for horizontal and vertical cooperation also defining intellectual property regulations, staff mobility regulations (sabbaticals etc.) and migration rules and other related labour regulations as well as quality of life in general.

Such strategy building and priority setting approach implies an implicit coordination mechanism for aligning actor strategies for investments in innovation to tackle huge societal challenges in a decentralized context. Because of the uncertainty and complexity of these innovation trajectories it is a (self)discovery approach: both bottom-up and top-down. Strategic institutional development by means of smart specialization is therefore closely linked to a systemic approach needed for a challenge-driven growth strategy (system innovation) and to new governance mechanisms to align actor strategies. In this light, it appears that institutions should focus on complementarities in finding knowledge-based solutions. Societal challenges require ‘system innovation’, e.g. a transition towards entire new business models for dealing with societal functions such as mobility, health provisioning, energy, city planning among many others. The main challenge remains to make systems innovation sustainable. To achieve this, the focus has to be on adequate governance and mobilising the co-creation power of ‘public-private partnerships’ (De Silva et al. 2021). Therefore, governance has to be considered at system level. Smart specialisation can also be assumed an implicit coordination mechanism for decisions in innovation investments with partnership relations between different actors and entities established.

In this regard roadmapping is frequently used by companies to develop innovation strategies, by public bodies to develop strategic policies and by research and education institutes to develop R&D&I strategies. The resulting roadmaps are strategy documents which clearly express goals, milestones and commitments of all strategic partners that have formed formal or informal relations to engage in an important transition path with the aim of delivering societal and economic value added. The challenge for roadmapping is to develop concrete measures to involve the institutions researchers and teachers and to detect the potential for 'self-creating innovations'. In this respect, the systems innovation thinking is important because it considers new opportunities beyond existing business models systematically while smart specialisation strategies focus on entrepreneurial discovery of these opportunities in regional ecosystems and global communities.

Converting institutional smart specialization strategies and roadmapping into measurable and sustainable KT-related impact requires an understanding of the process of organizational transformation, e.g. change management in a broader sense. Here a knowledge-based SWOT analysis is inevitable to detect needs for institutional development, e.g. issues like the positioning of universities within the regional innovation ecosystems and also at the global level including solid analysis what comparable or potentially comparable institutions are doing, strengths and weaknesses and ambitions as well as concrete measures. Moreover new—e.g. emerging and potentially emerging science fields and technologies including cross-cutting domains and educational concepts—need to be detected and assessed with regard to the current and intended fit with the institutions' profile. This also includes the identification and assessment of respective application potentials and investment requirements, especially financial and human resources needs. Another important measure is the ongoing monitoring of roadmap implementation and related measures including the evaluation of successes and failures, e.g. ex post evaluation of spillovers and absorption of the returns of the investments done.

For roadmap implementation it is recommendable to consider the principles of triple helix thinking, which emphasises the linkages between the different actors and the complementarities between them. However, this approach inherits the potential danger of neglecting the individual researchers' own strategies and imposing a planned top-down approach on them, which will eventually result in lacking commitment and willingness to support implementation. Hence, smart specialization strategies for universities and their development require a well-balanced approach between the actual actors' interest and wishes and the development measures (Carayannis et al. 2016).

15.3 Emerging Demands for and Key Features of a New STI Policy

The KT paradigm affects many different stakeholders, namely research and education-related actors and companies but also policymakers. Until recently KT-related initiatives at institutional level and at policy level aim at strengthening linkages between the actors involved by different means. The tacit knowledge component and related characteristics, however, are less frequently expressed although they are key for efficient and sustainable relations between partners including the personal relationships. These are most important because they ease establishing initial communication and may help overcoming administrative barriers between organizational units eventually. Thus, personal relations can provide an environment supporting partnerships, especially in the early stages of cooperation. Furthermore, personal relations are an important feature for building trustful cooperative relations by means of meeting agreements, sharing information and related issues. In this respect aligning universities to KT is not about top-down imposed openness on university staff, which is very likely to cause a reverse effect. Even beyond this internal governance schemes, namely reporting and performance assessment schemes are becoming even more crucial.

There remains a critical challenge of university staff performance assessment which reflects the different dimensions of performance, e.g. teaching, research and external relations (which includes company and government collaboration but also societal impact and work with alumni's to name a few). Obviously, there are many different features of universities activities, which need to be considered for performance assessment. These activities strongly vary in nature which requires different approaches to capture and measure these by means of using indicators. Accordingly, a broad range of indicators is needed, which are composed from information and date stemming from different sources. The unsolved challenge does not lie with information and data collection only but is about the aggregation of these into indicators suitable for performance measurement. Furthermore, the nature of information and the shape of data vary involving purely quantitative data but also qualitative data resulting from reviews or similar.

Next, practical experience shows that the different activities of universities and their staff, respectively, cannot be viewed isolated from another, especially in light of the KT. It appears that teaching is closely related to research, research is connected with transfer and vice versa. At first sight one might argue that these dimensions overlap and provide inspiration on each other but there is no causal relationship between them, e.g. there is hardly quantitative, e.g. statistical, evidence that one activity is the initial cause and how it impacts the other dimensions. Of course, there is the common believe that research comes first implying that research is performed in a way leading to outstanding results which build the researchers reputation and contribute to the institutions' reputation as well. The latter then is an important determinant for attracting outstanding researchers who are usually well aware of the meaning and importance of the institutions' reputation. Among other benefits, researchers affiliated to institutions with strong and outstanding international reputations will enjoy acceptance within the respective scientific community by means of being approached by colleagues from other institutions more frequently than others simply because of the institutions' reputation. Also, a strong institutional reputation is an often underestimated factor influencing research or teaching-related collaborations, e.g. the search for partners is often easier for institutions with strong reputation. This is because partners will expect the reputed institution to be a strong and reliable partner who is well aware of his reputation and hence will take care of maintaining this positive reputation thus avoid mistakes as much as possible. Furthermore, the institutions' reputation is an important factor for outside organizations when it comes to partner search because a well-known brand might potentially be favourable for other organizations to establish contacts with the institution. The so build reputation clearly is an argument for students to apply for educational programmes at these places since it is assumed that leading-edge research results are also included in the teaching activities and furthermore that besides factual learning research skills are developed which stem from 'learning by doing' inside these institutions.

Eventually there is a remarkable impact of graduates on the reputation of the institution, e.g. graduates act as multiplier and opinion leaders in reputation building in the long term. All these features naturally inherit the danger of hampering the institutions' reputation, which is why these institutions usually are very cautious about their activities and possible consequences. Furthermore, competition between researchers inside the institutions is often above the common level because (1) researchers own strive for excellence, (2) competitive contract schemes, (3) the researchers' awareness that excellence and reputation stem from the individuals' contributions and need to be preserved and (4) the membership in such reputed institution often provides above the normal career prospects in other occupations as well.

Eventually it turns out that reputation results from continuous leading-edge activities along all three dimensions. Yet, it also shows that the research dimension is underlying the other two dimensions by means of long-term reputation building and also by providing a pipeline of knowledge and research results which are subject of teaching and transfer/third-party cooperation at an unspecified point in time. The main weakness of the KT paradigm hence is the neglect of the time dimension, e.g. for teaching and for innovation solutions are needed which are finally understood and developed but this is not always the case for research results. Furthermore, this also holds true for research results published in scientific journals: It is noteworthy that these research results are presented to the academic community with the aim of discussion, the intention of presenting evidence-based knowledge and the strive for additional evidence and validation. Therefore, research results are in the first instance targeted at the community internal discussion, which alone features a special dedicated language and communication style not necessarily shared with other communities.

In conclusion to this chapter and to the overall book, we find that the KT paradigm is a useful approach to looking at universities and their role in the national innovation systems. However, applying the KT lens requires careful interpretation of universities activities and well designed and targeted STI policy intervention meeting the following requirements:

- Universities enjoy the freedom of thought which is one of the key preconditions for leading-edge research and teaching. Against this university stakeholders frequently aim at measuring universities' performance and activities. Thus, developing and implementing a dedicated performance measurement scheme for universities and university employees, respectively, is a challenging endeavour requiring a balanced scorecard approach that suits all stakeholders.
- KT and related themes are often narrowly focused on the interaction of universities with commercial partners. This becomes evident in many academic works which are more or less restricted to considering the meaning of KT and the impact generated by universities by patents filed, the volume of contract research undertaken and similar indicators as well as in the institutions strategic mission statements. This view and thinking however neglects the social impact and the training/education impact resulting from universities activities. Doubtless, these impacts are difficult to measure if at all yet they are in place.
- KT-related awareness is an issue that requires changing mindsets of university employees in order to leverage the doubtless existing potentials and achieve visible impact. Frequently quoted university examples who are considered as good or best practice demonstrate a long-lasting history in occupying their respective place within the KT. These examples have been discussed extensively in literature and at the policy level resulting in repeated attempts by university managers and policymakers to replicate these models expecting near-time visible results. But this attitude neglects that the respective examples are long-established and organically grown which is hardly the case at universities starting to developing towards KT awareness and activities for a decade only. Further, it is not clear and evident how long such institutional transformation will take but given the established institutional self-understanding and perception it is likely that such change takes longer periods.
- KT is mostly related to the research activities and to some extend to executive education by universities. These are valuable assets but it neglects the educational track, which is also relevant to KT awareness. It seems plausible that university students during their educational track also enjoy KT-related educational measures from the very early beginning as central to the respective curriculum regardless of the actual study subject. Attempts for doing so are frequently found in business plan competitions which are in place at many universities but are usually not included in the actual curriculum. By integrating into these it seems more likely to achieve a lasting momentum among the next generation of researchers, engineers and the like for further developing KT-related links during their careers from different angles of the KT.

Summing up we conclude that KT-related STI policies strongly require a broader scope considering the relations between actors' missions but also reflecting the governance schemes, especially the public side, e.g. public research and education actors. This however is missing currently in most related KT related STI policy measure and understood a major barrier to make the relations and cooperations between different actors and missions smoother and more effective and efficient.

Eventually, we find that the book chapters provide a well-suited collection of case studies from different countries, which also allows us to understand universities' initiatives in the respective environment. The editors are grateful to all authors for their contributions.

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