Successful Innovations? Efficient Knowledge and Technology Transfer and International Collaboration

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Foreword

The key factors of successful and effective knowledge and technology transfer (KTT) from universities and R&D institutes to industry are quality research results, forward looking IP management and commercialisation systems and consistent government support offering specific instruments stimulating the interest of both - researchers and businesses to engage in applied research. This monograph analyses literature on knowledge and technology commercialisation issues and related best practices, government policies and support, business environment in Slovakia as well as outcomes of two field surveys at universities and research institutes in Slovakia and one such survey on collaboration of businesses in innovations in Germany and Russia. It takes into consideration the experience of leading universities in this field, i.e. University of Oxford, University of Cambridge in the United Kingdom and Massachusetts Institute of Technology in the USA, as well as experience from Slovak and other universities characterised by underdeveloped innovation culture.

The objective of this study is to outline and analyse framework of collaboration between higher education institutions (HEIs) and industry, explain implementation and management of knowledge and technology transfer with special regard to university spin-offs and suggest conclusions and recommendations on effective management of commercialisation processes and projects through technology transfer offices (TTOs) focussing mainly on technical universities and research institutes in countries with underdeveloped innovative culture. In this context were used the research results of Denisa Brighton on barriers of efficient commercialisation of the intellectual property of universities and research institutes, barriers within businesses to innovate as well as barriers in the business environment as a whole as well as research results of Marian Zajko on KTT in CENTROPE region and university spin-offs and Kerstin Pezoldt on internationalization of inovations.

Drawing upon outcomes of the analyses and surveys we created a summary of the key success factors of knowledge and technology transfer to industry in countries with underdeveloped innovation culture. The final chapter presents a series of recommendations to be adopted in order to achieve benefits for all stakeholders of the commercialisation process. These recommendations may not be considered and followed in isolation since the commercialisation process is a very comprehensive and continuous improvement in this field and requires long-term concerted efforts taken by universities, businesses and governments.

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Bratislava, Ilmenau, December 2014

List of abbreviations

EU	European Union
HEI	Higher education institutions
KPIs	Key performance indicators
KTT	Knowledge and technology transfer
ME	Ministry of Economy of Slovak Republic
MESRS	Ministry of Education, Science, Research and Sports of Slovak Republic
IP	Intellectual property
PE	Private equity
R&D	Research and Development
RIS3	Research and Innovation Strategy for Smart Specialisation of Slovakia
SME	Small and medium sized enterprise
S&T	Science and Technology
STI	Science, technology and innovations
STU	Slovak University of Technology
TTO	Technology transfer office
USO	University spin-off
VC	Venture capital

1. Conceptual frameworks for higher education institution and industry collaboration

Globalization, the universal pervasion of information and communication technologies in the societies and their development into the knowledge-based societies are significant factors transforming our lives and the way we acquire, transform and disseminate knowledge. Thus knowledge production, management and utilization become more essential for economic competitiveness of a country.. This evolution invokes new and urgent needs of society and economy requiring significant changes in the roles of academic institutions in their interaction to their stakeholders, e.g. government institutions, students, industry, to efficiently adjust to these changes. In particular, there is growing pressure on the institutions of higher education and research in developed economies to find and affirm their new role in the national innovation system. Their counterparts in developing economies need to define their role in support of emerging structures of the innovation system.

The concept of cooperation between academia and industry is managed by public policies and there is no satisfactory theoretical explanation or corresponding empirical study to improve the understanding of this concept (Göransson, Brundenius, 2011). Also, there are many studies clarifying the extent and nature of such cooperation, the circumstances under which they were implemented and its economic impact. However, there are three main conceptual frameworks: 1) National innovation system, 2) Mode 2 Production of Knowledge and 3) Triple Helix.

1.1 National innovation systems

The collaboration between Ch. Freeman and A. Lundvall (the IKE-group in Aalborg) in the beginning of the eighties was essential in coining and shaping the concept of innovation system (Freeman 1982 and Lundvall 1985). Later the concept of national innovation system became more widely spread through Freeman's book on Japan (Freeman 1987) through a publication edited by Freeman and Ludvall on small countries (Freeman and Lundvall 1988) and not least through the publication of the Dosi et al book on technical change and economic theory with contributions by Freeman, Nelson, Lundvall and Pelikan (Dosi et al 1988). More recent standard references on national systems of innovations are three books edited by Lundvall (1992), Nelson (1993) and Edquist (1996). Other contributions referring to systems and operating at the national level refer to 'social systems of innovation' (Amable et al 1997) and to 'national business systems' (Whitley 1994 and 1996). Further crucial ideas inherent in the innovation system concept on (vertical interaction and innovation as an interactive process) appear in Porter's industrial clusters as well as in Etzkowitz and Leydesdorff's Triple Helix-concept (Etzkowitz and Leydesdorff 2000).

The national innovation system approach has taken on increased analytical importance in the technology field due to three factors: 1) the recognition of the economic importance of knowledge; 2) the increasing use of systems approaches; and 3) the growing number of institutions involved in knowledge generation. This is reflected in the following overview of the definitions of national innovation system (NIS) stated in the OECD study on national innovation systems (OECD, 1997, p.10):

- *".. the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies."* (Freeman, 1987)
- *".. the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state."* (Lundvall, 1992)
- *".. a set of institutions whose interactions determine the innovative performance ... of national firms."* (Nelson, 1993)
- *".. the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country."* (Patel and Pavitt, 1994)
- *".. that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies."* (Metcalfe, 1995).

The essence of the national innovation system may be summarized as follows:

- technology development and innovation are result of complex set of relationships among actors in the system including enterprises, universities and government research institutes;
- learning and interdisciplinary research are key factors of innovation;
- the flows of technology and information/ knowledge among people, enterprises and institutions are key to the innovation process;
- companies do not innovate in isolation, it is a joint approach which includes other businesses and organisations such as universities, research centres, government agencies etc.;
- innovation capacity of enterprises is also influenced by various institutions, government policies and regulations.

The complexity of linkages in a mature national innovation system is well represented in a scheme shown in Figure 1.

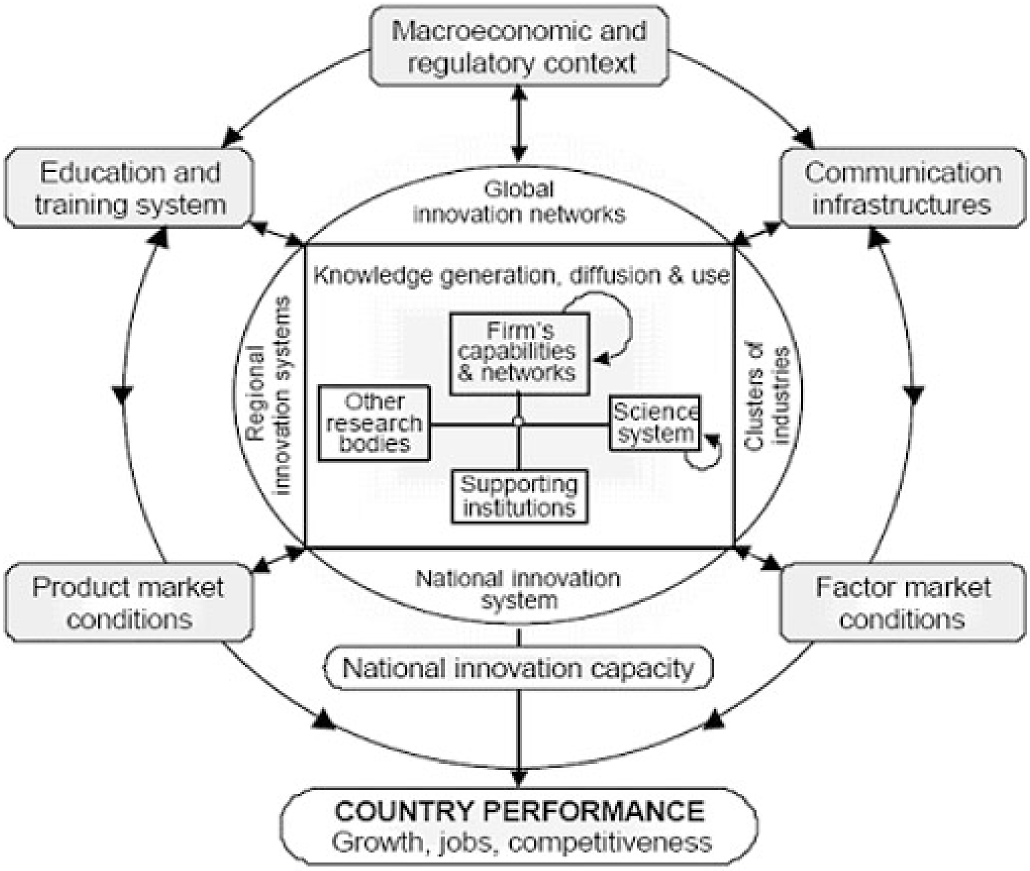

Figure 1: Actors and linkages in the innovation system

(Source: OECD, 1999, p. 23)

The most important contribution of the NIS concept was the shift in what economists and policy makers see as constituting 'international competitiveness' (Lundvall, 2004). It helped move focus on national policy strategies that constitute a win-win situation at international and domestic levels. The positive side has been a move away from a position where regions compete in offering low cost labour and favourable tax rates towards a position where they compete through investing in knowledge and infrastructure.

The study of NIS suggested new approaches for government technology policies (OECD, 1997). Most government interventions in the technology area had been focused on stimulating or supporting R&D spending by industry through R&D tax credits and subsidies in order to correct market failures, or the tendency of the private sector to underinvest in technology development due to the inability of firms to capture all of the benefits from such investments.

The new direction of these policies concentrated on possible systemic failures which might worsen the innovative performance of industry, such as the lack of interaction between the actors in the system, mismatches between basic research in the public sector and applied research in industry, malfunctioning of technology transfer institutions, and information and absorptive deficiencies on the part of enterprises. These policies put emphasis on improving the interaction of actors and the interplay of institutions within NIS via:

(i) networking support, e.g. joint research activities and other technical collaboration among enterprises and with public sector institutions; schemes promoting research and advanced technology partnerships with government, development of innovative clusters
(ii) improvement of absorption capacities of enterprises, e.g. implementation of intellectual property rules, labour market policies and exchange programmes to facilitate such collaboration.

Another policy priority consisted in enhancing the innovative capacity of enterprises, i.e. more investments in corporate R&D, personnel training and information technology in order to be capable to acquire domestic or foreign information and technology, and to absorb it on a running basis. Technology policies should aim not only at technology-based enterprises but also at firms in traditional and mature industries, and in services sectors. Besides boosting the capabilities of individual enterprises, they should enhance the networking and innovative performance of clusters of companies and sectors.

Governments need to play an integrating role in managing NIS by making technology and innovation policy an integral part of economic policy (OECD, 1999). This requires co-ordinated contributions from a variety of policies in order to:

(i) secure favourable framework conditions for innovations, such as a stable macroeconomic environment, a supportive tax and regulatory environment, and appropriate infrastructure and education and training policies;
(ii) eliminate specific barriers to innovation in the business sector and increase synergies between public and private investment in innovation.

Governments can also contribute in building the innovation culture in the country, e.g. by creating favourable conditions for businesses, R&D and education and encourage entreprises of all sizes, to adopt best practices in innovation and business management, by removing the specific factors that restrain the number of entrepreneurial technology-based projects, barriers to their transformation into business start-ups, and weaken subsequent market selection processes to the detriment of firms with high growth potential.

Criticism of the NIS aims at the fact that NIS in many countries may result to be only a structure that, even if influencing economy and innovation, is overlapping more important regional innovation systems. An example of this are the USA, were there are some regions with high innovation rate like Silicon Valley. Key to the Silicon Valley's success lies in its decentralized organizational form, non-proprietary standards, and tradition of cooperative exchange (sharing information and outsourcing for component parts), in opposition to vertically integrated and the more autarkic industrial systems of the Route 128 companies in the US East Coast (Saxenian, 1994).

Switzerland has been very successful in encouraging innovation. It is innovative because *“it does not have an innovation policy”*, says Mauro Dell'Ambrogio, State Secretary for Education and Research and Innovation of Switzerland. Switzerland has created an ecosystem conducive to innovation by focusing on the long term and nurturing framework conditions. It strives to keep government lean, bureaucracy small, and to provide political stability and social mobility. It endeavours to keep school drop-out rates low and provide young people with relevant job skills. It has programmes to allow people at different ages and life stages to acquire new skills and change jobs.

1.2 Mode 2 knowledge production

The combination of reductions in public funding for public universities and other research institutions and pressure from the government and private companies contributed to the formation of the phenomenon of "Mode 2 knowledge creation". This term was coined by M. Gibbons et all in 1994 in their book *The new production of knowledge: the dynamics of science and research in contemporary societies*. Unlike the Mode 1 (academic, investigator-initiated and discipline-based knowledge production) Mode 2 is distinguished by the following characteristics (Hessels, van Lente):

1) transdisciplinarity is a step forward from traditional interdisciplinary research, where scientists are working to accomplish a task in terms of their own professional discipline, i.e. the interaction of various scientidic disciplines is much more dynamic and research results diffuse already in the process of knowledge creation;
2) knowledge arises in a context of application, i.e. scientists work on tasks and issues identified by industry;
3) new forms od quality control, i.e. the traditional peer review systems are amended by additional criteria of social, economic, political or cultural nature;
4) reflexivity, i.e. the researchers conduct research being aware of their social responsibility and actively seek feedback on their results;
5) heterogeneity and organisational diversity of Mode 2 knowledge production, i.e. the scope of the knowledge generation sites comprises beside universities and research institutions also government agencies, research labs, think-tanks and consultancies which may conduct research in mutual interaction making use of communication networks.

Scientists are encouraged to experiment with new forms of knowledge generation, which result in the creation of new institutional forms, such as university research centres, centres of excellence and long-term research programmes (Jacob, 2001). Their aim is to achieve critical mass in a particular area of work that builds networks among multiple sites / departments.

The Mode 2 knowledge production aroused extensive scepticism and criticism of numerous authors (Godin, Weingart, Hicks and Katz, Rasmussen, Etzkowitz and Leydesdorff, Rip, Shinn) which might be briefly summarized as follows (Hessels, van Lente, 2008):

- some of the Mode 2 attributes are heavily disputed, especially the quality control,
- newness of all attributes of Mode 2 is contested, some have existed in modern science,
- no general validity of Mode 2 for the whole science and technology as claimed by the authors,
- lack of theoretical underpinning of Mode 2 sociological framework,
- Mode 2 is a blend of descriptive and normative content, more a political ideology than a descriptive theory,
- the authors of Mode 2 anticipate that *“Mode 1 knowledge production will become incorporated in a larger system called Mode 2”* without a closer explication.

However, there are also polemical views rejecting the criticism of book by Gibbons et all, (Holtz and Holz, 2014). Regardless the justified criticism of Mode 2 a completely new way of knowledge production this work accentuated in its attributes some aspects of the traditional ways of knowledge production (opposites to “ivory tower approach”), which have become neglected to some extent in the traditional research. This view is confirmed by Hessels, and van Lente as well: *“Mode 2 has been successful as a manifesto. Its broad scope and evocative claims have raised considerable attention in the area of science policy. It identifies a number of trends which still deserve further consideration”.*

1.3 The Triple Helix concept

The Triple Helix concept was introduced by Etzkowitz and Leydesdorff in 1995. Many knowledge and technology transfer studies are based precisely on this concept (Etzkowitz, 2008) which constitutes of three components jointly contributing to the development of new competitive industrial forms - universities, industry and government (Beer, Cooper, 2007). The basis of the argument is very similar to Mode 2 knowledge creation – universities are undergoing the process of change and establishing entrepreneurship on their campus is the final stage of the change.

The changing role of universities is embedded in the process of moving from science policy to innovation & technology policy, and this shift represents a broader neoliberal transformation of public policy (Shinn, 2002). One of the most important models dealing with this transformation is the "Entrepreneurial university" (Etzkowitz, 1998). Other important models are: "Academic capitalism" (Slaughter, Leslie, 1997) and „Enterprise University" (Marginson, Considine, 2000). All three models recognise, promote and analyse the increasing role of modern business universities in society. In spite of their contribution to the understanding of the impact of changing political and economic forces on the third mission activities of HEIs, these models do not address the important practical aspects of the development of entrepreneurial universities (Nelles, Vorley, 2011). When analysing the literature on the "Entrepreneurial university" model, one finds a consensus that the more business-oriented universities can contribute to the development of the knowledge economy and economic prosperity with a wide range of initiatives, not only through spin-off companies but also the sale of licenses (OECD, 2008).

Knowledge economy cannot be developed without the support of HEIs, higher education is its integral part. Students, as well as consumers, have high demands on new technology creation at universities and high expectations associated with the preparation for their future job. Although many agree that academic entrepreneurship pushes faculty members in applied research, surveys show that those scientists who are engaged in applied research with businesses also have good publishing results (Stokes, 1997). These findings are consistent with Clark's argument (1998) that research and teaching cannot and should not be disjointed.

The Triple Helix concept of the knowledge economy defines key institutions such as universities, industry and government (Etzkowitz & Leydesdorff, 1995) and these innovation system elements operate in a two layer network: one layer represents institutional relations, in which there are certain limitations on conduct and the other layer consists of functional relationships in which mutual expectations are formed. Relations between universities and industry can work under different institutional arrangements e.g. through the university TTO, by the creation of spin-off companies, and by closing licensing agreements. Institutional relations provide us with a lot of information, but the knowledge economy functions must be analysed in terms of the change dynamics in the institution (Leydesdorff, 2010). The knowledge base of the economy can be regarded as a specific configuration in the structure of expectations which provides feedback in the form of a mechanism of changes in institutional arrangements (Leydesdorff, 2010).

The industry is a key component of the Triple Helix concept, as it is a place where new products are created. A government is the source - the creator of contractual relations, which provide a stable environment for the exchange of goods and services. Universities are a source of educated and talented workers who bring their know-how and new ideas into businesses and the government. Etzkowitz's Triple Helix focuses on universities as the locus of entrepreneurship and new technologies. Despite the fact that not everyone agrees with the view that enterprise and entrepreneurship should be associated with universities (universities should only focus on education and research), interest in R&D results of research universities is growing. There has been an increase in the awareness that knowledge economy is closely linked with sources of new knowledge and that it must continuously and dynamically develop and cannot remain in a stable setting.

The Triple Helix concept was formed based on the analysis of governments–universities- industry relationships in different countries and their different roles in the innovation process. Growth of new companies arising from university research and the placement of industrial companies performing research at universities is a clear sign of interdependence of relationships in the knowledge society[1].

Triple Helix refers to government-university-industry relationship as a relationship of relatively stable, but interconnected institutional domains which overlap and take over some of each other's tasks (e.g. universities provide training in business/technology incubators; the government provides start-up and growth venture capital and/or loans to businesses; firms provide universities with opportunities to cooperate on R&D projects). Previous bilateral relations between the government and universities, universities and industry, and the government and industry have spread to triadic relationships, especially at regional level. A new institutional arrangement emerges with changed societal dynamics - from the initially fixed boundaries between the separate institutional domains and organisations to a more flexible and overlapping system in which each takes on the role of the other.

Such three-way relationships between universities, industry and government are formed in different parts of the world from different institutional starting points, with the common goal to stimulate economic development. It is a new concept of development strategies based on the knowledge obtained from the three spheres. Innovation in the Triple Helix is a process in which the university, government and industry are involved in the mutually beneficial use of resources and they collaborate in creating or discovering new knowledge, technologies and products which are transferred to end-users and meet societal needs. The end-users use the knowledge, technologies or products or they exploit them to make new products and services.

The three components of the Triple Helix are formally considered equivalent, but are markedly different. Universities are institutionally weaker than the other two components (Leydesdorff, 2010), however, they have got specific advantages – they provide governments and industry with a continuous flow of new knowledge from different fields (e.g. studies and patents) and new knowledge holders (students). From this perspective, the university can be considered the main bearer of the innovation system (Godin, Gingras, 2000). The inflow of knowledge constantly changes the dynamic equilibrium sought by the other two components of the economy (government and industry) (Leydesdorff, 2010). Conflicts of interest can be clarified and modified, first analytically and then in practice when finding solutions to problems related to economic productivity, by maintaining wealth and growing knowledge in the respective economy.

The knowledge base of any economy can be viewed as an evolving configuration of functions in coordination mechanisms. There are three main functions in the knowledge economy within the Triple Helix model 1) creation of economic wealth, 2) creation of

[1] E.g. science parks, technological incubators and the presence of venture capital providers.

new products based on new knowledge, and 3) normative governance (e.g. political) (Etzkowitz, Leydesdorff, 2000). Over time, the knowledge base formed this way reduces the uncertainty inherent in that configuration and it becomes stabilised, partially-stabilised, or globalised.

A university which transforms itself into an entrepreneurial university is closer to industry and creates an internal capacity to collaborate with businesses through its TTO. It sets internal procedures for cooperation with businesses and uses intermediary organisations to implement technology transfer (patent agencies, legal advisors, business opportunities search etc.).

Universities are considered entrepreneurial (Gibb, 2005), if they:

- courageously build their autonomy, accepting that government funding will be reduced;
- accept the "idea" of a university which integrates the relevant level of scientism and knowledge and shares it with the wider community;
- do not fear to maximise the commercial potential of their inventions to create wealth in society and do not consider it a significant threat to academic values;
- set up a robust central management of entrepreneurial activities whilst preserving the inherent autonomy of university academics;
- actively promote organisational learning as part of their strategy;
- promote the creation of incubators, TTO and IP protection measures, and science parks, not only as isolated goals, but as an effective tool for developing university activities and relationships (formal and informal) together with relevant community stakeholders;
- support a wide range of interdisciplinary activities, create interdisciplinary departments and R&D centres;
- accept wider responsibility for the personal development of students and staff, particularly in relation to their future social, career experience and also lifelong learning experience;
- recruit business-oriented staff and delegate them as entrepreneurial leaders - agents of change at the university, including opening academic posts for a wider range of external and visiting professors (with business experience);
- build reward systems which take into account other criteria such as achievements in research, publications and educational activities;
- achieve that the concept of entrepreneurship education is adopted and developed at all faculties, by all key personnel who incorporate it into the curriculum.

A modern entrepreneurial university is not an isolated community of teachers and scientists; it has an important role in society as it contributes to economic and social development (Etzkowitz, 1983). In 2011 the revenue from licensing of inventions from

U.S. universities contributed USD 2.5 billion to the U.S. economy, 671 new businesses and nearly 600 new products were created which entered commercial networks[2].

Within the Triple Helix mode, Etzkowitz and Leydesdorff (1998) considered business orientation in universities as the inevitable turning point in their development and a result of the gradual development of relations between universities, industry and government. Clark (1998) likewise recognised the necessity of the business orientation of universities, but argued that universities should be seen differently than businesses, as universities require different institutional approaches, taking into account the strengths and weaknesses of teaching and the research base. Despite all efforts, many universities lack institutional framework strategy and do not create structures supporting the development of all three missions (Nelles, Vorley, 2011).

Based on the results of research on institutional economics in entrepreneurship (North, 2005), there are two types of factors which could facilitate or hinder the development of entrepreneurial universities - formal and informal (Kirby et al., 2011).

Formal factors contributing to entrepreneurial orientation of universities are:

- Development and delivery of courses on entrepreneurship for students, researchers and teachers (education must take into account the needs of participants and use of domestic and international case studies);
- Support of knowledge and technology transfer and new business creation;
- Sufficient human resources - scientists at universities and research institutes;
- Flexible organisational structure;
- Links with industry (through e.g. incubators, science parks) and strategic networking with partners and potential partners;
- Adequate seed capital from public and/or private sources.

A formal factor can also be the creation of a university wide centre/institute aimed at promoting entrepreneurship (Zajko, Grünwald, 2011), e.g. the Robert-Schmidt Institute at Wismar University in Germany provides education and creates awareness of entrepreneurship across the entire university, incl. interdisciplinary case studies, workshops and seminars where entrepreneurs are often invited as guest speakers. The institute also supports students in organising R & D teams, evaluates student business plans in terms of their feasibility, seeks job opportunities for students and promotes cross-border cooperation etc. The institute became a successful central point for the development of business activities and strategic cooperation between Wismar University of Applied Sciences and businesses in the region of Meklenburg - Vorpommern.

The structure of formal business education which comprises of IP protection can contribute to positive change in organisational culture, creation of links between

[2] Research carried out by AUTM in 2011 (Association of University Technology Transfer Managers) www.autm.net

university management, curriculum, labour markets and finances, and therefore it is very important to update the curriculum, recruit postgraduate students from other countries and support multi-disciplinary education (Kirby et al., 2011).

In the knowledge economy universities usually make an effort to promote KTT and business creation (Zaharia, 2002) through their TTO, by providing access to research laboratories, establishing contact points and incubators, etc. (Link, Scott, 2005). Success factors include the adoption of an IP policy. Effective interaction of HEIs with industry requires that management positions in the TTO are held by full-time professionals who are able to identify new business opportunities and that the management structure is horizontal to reduce bureaucracy and to encourage the sharing of intellectual, financial and physical resources (Kirby et al., 2011).

<u>Informal factors</u> contributing to entrepreneurial orientation of universities are:

- Positive attitude of students and faculty members towards entrepreneurship;
- The presence of champions (successful entrepreneurs);
- University IP policy that fosters cooperation with industry and KTT (it specifies the rules for cooperation and includes a motivational reward system for researchers for their achievements in applied research and for commercialised IP);
- Teaching methods (linking theory with practice, e.g. case studies, work on projects commissioned by industry).

Favourable attitude of students can be achieved through various projects, e.g. those who improve the ability to identify opportunities to start a new business etc. (Krueger and Brazeal, 1994). Louis et al. (1989) found that faculty attitudes towards entrepreneurship are another important predictor of academic entrepreneurship. The main difference between academics and entrepreneurs is in their attitudes towards risk. Events and meetings in the university environment provide opportunities to present business champions (successful entrepreneurs) who can positively influence students' business plans. As is true with most efforts to establish change, reward systems – monetary (e.g. bonuses, corporate resources, profit sharing) and non-monetary (e.g. formal recognition schemes), should be strategically linked with any efforts to become an entrepreneurial organisation (Kirby, 2006).

In the last ten years, the respective literature discusses the need of extending the Triple Helix model (Carayannis, Campbell, 2012) (Wilson, 2012) to a Quadruple Helix model in light of globalisation, continuous flow of knowledge and tremendous competition. The traditional Triple Helix model does not consider other elements of society - innovative individuals who are interested in developing innovative ideas regardless of the sector in which they work (also known as "crowdsourcing").

In response to the debate on extending the model by "society" or "public", Leydesdorff and Etzkowitz (2003) argued that the helices represent specialisation and integration in functional systems that evolve from civil society and within it. The multilayer society of today is not centrally coordinated (such as the socialist society), but it works in the context of interactions between groups. Leydesdorff does not propose limiting the model to the original three helices, but for methodological reasons advises to gradually extend the model so that it provides actual value (for example, in Japan, it was necessary to add a fourth helix because along with the relationships between universities, industry and government, internationalisation played a very important role). Triple, quadruple or five-fold helices are essentially topologically equivalent forms with varying degrees of complexity and spatial properties (ranging from three to four and five degrees - government, universities, industry, and then added civil society and the environment (Carayannis, Campbell, 2012). Given that the Quadruple Helix model is not yet well established and widely adopted in innovation research (Füzi, 2013), we used the Triple Helix model for the purpose of this study.

1.4 Examples of entrepreneurial universities

There may be observed a movement away from a system of previous central or regional public funding characterised by a high level of certainty to the current conditions where an increasing part of finance has to be sought from non-direct public sources including research grants, local development monies, fees, alumni, industry and social enterprise, contract research and philanthropy and where the level of funding uncertainty increases (Etzkowitz, 2007).

Thus, their traditional missions of teaching and research are being broadened to include Third Mission activities that: „ facilitate activities concerned with generation, use, application and exploitation of knowledge and other university capabilities outside academic environments“ as shown in the Figure 2 (2002 Science and Technology Policy Research unit at the University of Sussex Report to he Russell Group).[3]

Today governments develop third mission policies, allocate funding streams to its development (the so-called “third stream”), policy-makers and experts are developing indicator systems, and academics lively debate how to integrate the three missions within a coherent university strategy and whether the pursuit of one mission may be detrimental to the others.

The term *entrepreneurial university* is related to several third stream activities in universities. It is open to a broad range of interpretations. As stated above, it indicates differences in understanding “university excellence”, university strategy and focus on occupation of their graduates /relations to businesses and industries. It has been associated with entrepreneurship education and student entrepreneurship support, protection and the utilisation of intellectual property rights by faculty and students of

[3] The Third Mission of Universities – Business and Community Engagement, Outreach and Regional Development. Innovative Research Universities Australia, August 2005. http://www.iru.edu.au/media/15775/sept%2005%20building-case-third-stream-funding.pdf

universities, knowledge and technology transfer through licensing or formation of spin-off companies. It is related to the transfer of science and technology innovation to the business sector, contributing to economic development at regional and national levels.

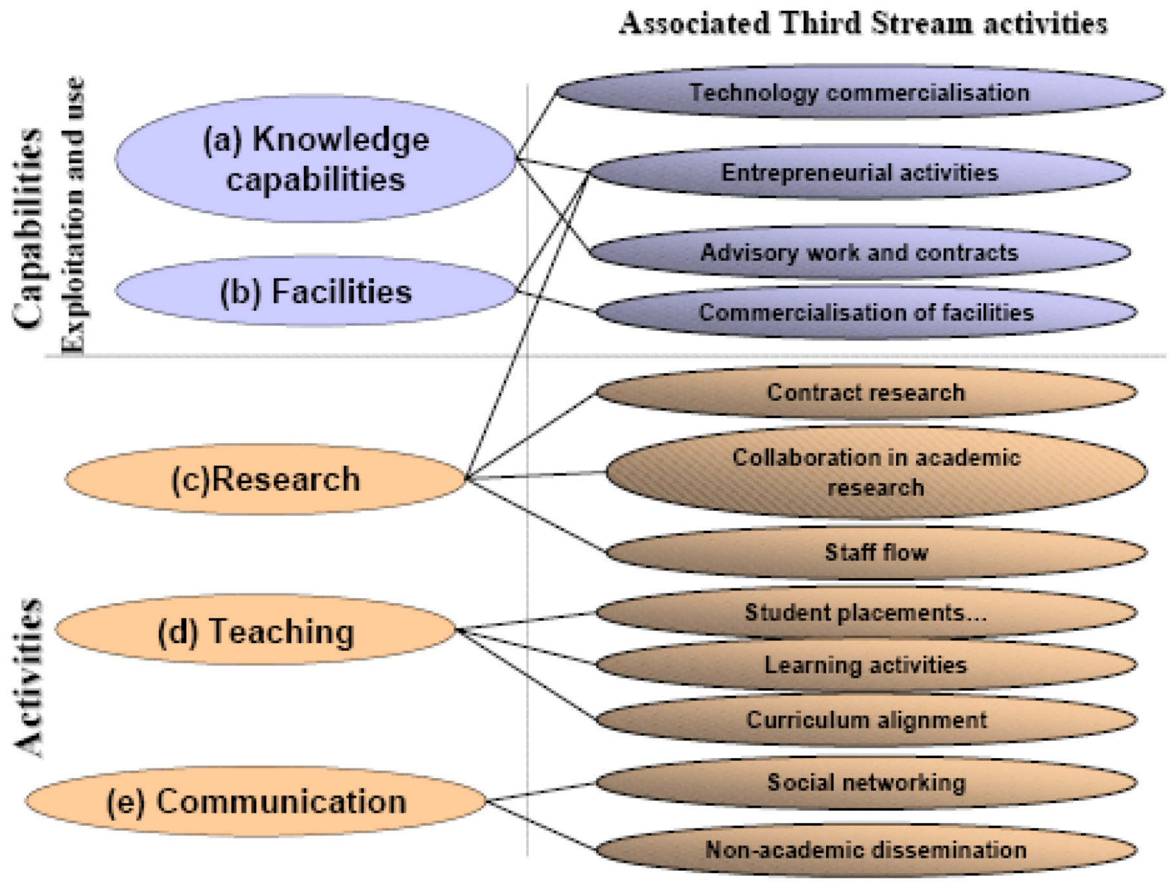

Figure 2: The Russell Report conceptual framework for analysing Third Stream activities

(Source: Molas-Gallart, et al., 2002)

Based on the experience of US universities it is argued that their funding by the federal states and not by the federal government reinforces their focus to the regional and local business issues. In this context the term of entrepreneurial university may be frequently associated with the notion of the university as a regional innovation hub (e.g. University of Oxford, University of Cambridge, Massachusetts Institute of Technology).

The term innovation ecosystem or entrepreneurship and innovation ecosystem is borrowed a from biology. It is an analogy to biological ecosystem understood as a complex set of relationships among the living resources, habitats, and residents of an area, whose functional goal is to maintain an equilibrium state in context to its energy dynamics. An an **innovation ecosystem** models the economic dynamics of the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation. The actors would include:

(i) the material resources (funds, equipment, facilities, etc.);
(ii) the human capital (students, faculty, staff, industry researchers, industry representatives, etc.) making up
(iii) the institutional entities participating in the ecosystem (e.g. the universities, colleges of engineering, business schools, enterprises, venture capitalists and business angels, industry-university research institutes, federal or industrial supported Centres of Excellence;
(iv) and state and/or local intermediaries – organizations for economic development and business assistance, funding agencies, policy makers, etc.).

The characteristics of relationships between the actors may be considered as intangible property (values, climate and behaviour fostering independent thinking, learning, engagement, enthusiasm and risk-taking) which might be denoted as innovation culture within an innovation ecosystem.

The innovation ecosystem comprises two distinct, but largely separated economies, the knowledge economy, which is driven by fundamental research, and the commercial economy, which is driven by the marketplace. These two economies are weakly coupled because the resources invested in the knowledge economy are derived from a fraction of profits of the commercial sector as well as government R&D investments which are ultimately derived from tax revenues. Another feature is that the ecosystem is usually strategically developed around a specific technology. An innovation ecosystem is consideed to be thriving and healthy when the resources invested in the knowledge economy (private, government, or direct business investment) are subsequently replenished by innovation induced profit increases in the commercial economy. (Jackson, 2011).

In the years 2012 - 2014 the MIT Skoltech Initiative commisssioned benchmarking study (i) to draw on the experiences of the emerging leaders group of universities to analyse the conditions and strategies associated with successful transformation of a university towards an entrepreneurial model; and how university-based ecosystems can be nurtured in cultural, economic and socio-political environments that may not be naturally conducive to entrepreneurship and innovation. The benchmarking exercise was carried out on the panel of 83 experts from 23 countries who identified over 200 universities from all over the world. 25% of those invited for interview were Highly-cited research experts in the field with professional experience across multiple regions of the world and the remaing 75% consisted of individuals with direct experience within a technology innovation ecosystem at a well-regarded university and with professional experience across the world (half of them were based at an university and another half were persons from the TTO, entrepreneurs, sponsors or company managers demonstrating established or emerging leadership in entrepreneurship. One of their outputs was the ranking of universities by the qualities of their technology innovation ecosystems as stated in the Figure 3.

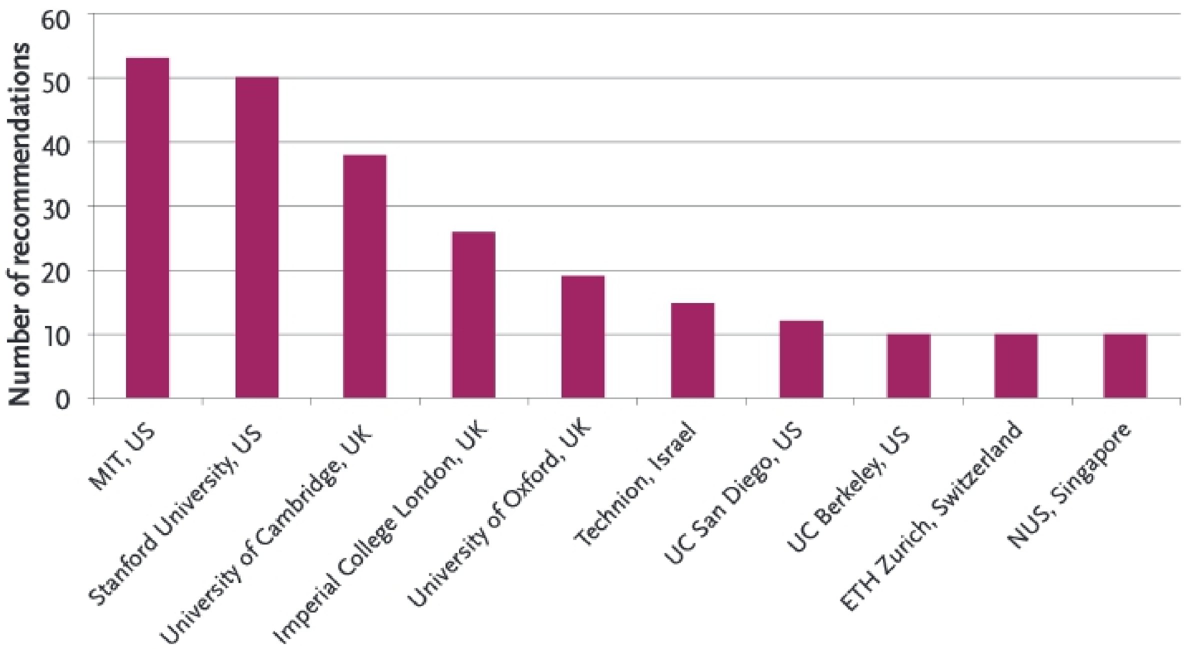

Figure 3: Top 10 universities with most successfull technology innovation ecosystems

(Source: Graham, 2014, p. 40)

Further valuable benchmarking outputs were: (i) metrics of successful university ecosystem, (ii) success factors among the leading universities, (iii) key featurs of the emerging leading universities in entrepreneurship and innovation, and (iv) models of entrepreneurship and innovation development among leading universities.

1.4.1 Entrepreneurial ecosystem of Massachusetts Institute of Technology

Massachusetts Institute of Technology (MIT) consequently follows in its research and pedagogy to its traditional credo „Mens et manus"(Mind and hand) by close collaboration with industry. This private research university has 5 schools, including the renowned **MIT Sloan School of Management** founded in 1914.[4] In 2014 MIT Sloan celebrates 100 years of Course XV, Engineering Administration education at MIT that evolved to become the MIT Sloan School of Management. The Entrepreneurial coursework at MIT Sloane offers three different perspectives to create an effective blend of learning[5]:

- *New and developing research*, taught by MIT Sloan faculty, and exemplified by the course, "Designing and Leading the Entrepreneurial Organisation."

[4] http://mitsloan.mit.edu/about/
[5] http://mitsloan.mit.edu/mba/mit-sloan-community/entrepreneurial-ecosystem/

- *Practitioner-taught courses*, concentrating on aspects of entrepreneurship that depend entirely upon the experience of successful entrepreneurs and venture capitalists. For example, the course, "New Enterprises," lays the groundwork for business plan development for new companies.
- *Project-oriented courses* in which students organise in mixed teams of four or five, including participants from management, science, and engineering, to tackle real problems in entrepreneurial partner organisations, e.g. the very popular Entrepreneurship Laboratory (E-Lab) classes. In these classes, students devise solutions to early-stage problems of select local companies and are advised by a local entrepreneur in residence in tandem with the faculty. The Global Entrepreneurship Lab (G-Lab) allows students to take on problems in developing international markets, while Innovation Teams (I-Teams) give students an opportunity to examine the best ways to bring carefully chosen, MIT-developed technologies to market.

Students who have a strong entrepreneurial interest can follow the more specialised *Entrepreneurship & Innovation (E&I) Track* with required and elective courses, as well as extracurricular activities that are specific to E&I students only.

Figure 4: View of Massachusetts Institute of Technology, Cambridge, Massachusets

In addition to classes a great number of clubs form a key component of this entrepreneurial ecosystem, e.g. *MIT Sloan Entrepreneurship and Innovation Club, Venture Capital Private Equity Club, TechLink* and others. Along with MIT Sloan students, undergraduates, Ph.D., and post-doctoral candidates actively participate in clubs from across all MIT departments. They contribute substantially to creating the unique "passion for entrepreneurship" hroughout MIT.

The scope and impact of MIT's entrepreneurial ecosystem are enormous: A recent study suggests that living MIT alumni have created more than 25,800 currently active companies that employ about 3.3 million people and generate annual revenues of $ 2 trillion — producing the equivalent of the eleventh-largest economy in the world. Many people think that even these numbers are quite conservative.

Entrepreneurship frames the very structure of MIT. This entrepreneurial ecosystem consists of multiple education, research, and social network institutions, such as:

- Twelve developmental centres, including the Martin Trust Centre for MIT Entrepreneurship and the Venture Mentoring Service (VMS), a group of more than 100 volunteer mentors who help budding entrepreneurs with everything from business plans to product development;
- More than 30 entrepreneurship courses, such as the Entrepreneurship Labs (E-Labs) and the MIT Sloan Entrepreneurship & Innovation (E&I) Track;
- Student-run organisations, such as the MIT $100K Business Plan Competition and the Venture Capital Private Equity (VCPE) Club;
- Events and networking opportunities, including the Entrepreneur Bash and the Bio Bash;
- Alumni-organised structures, such as the MIT Enterprise, with chapters worldwide.

In 1990 the **MIT Entrepreneurship Center** was established at the Sloane School, one of the few in the world focusing on high technologies with the aim to introduce entrepreneurship education at MIT these days. It was the first effort of „dual education" of students as potencial entrepreneurs by knowledge transfer from academic professors and coaching and mentoring by extraordinary professors of business practice – successful entrepreneurs and venture capitalists. This teaching method was further improved and extended in MIT and currently it is applied in entrepreneurship education in nearly all leading business schools across the world. In 2011 this centre was renamed to **Martin Trust Center for MIT Entrepreneurship**. The MIT Sloan MBA Program - Entrepreneurship & Innovation Track is taught there.

The **MIT Global Founders' Skills Accelerator (MIT GFSA)** is the premier university student accelerator in the world. It takes the best teams with an interesting idea or proof of concept focused on creating impactful, innovation-driven startups. Teams are chosen from across MIT's schools as well from select global university partners. Throughout the three-summer-month duration of GFSA, founders are granted a monthly stipend, allowing them to make a full-time commitment to working on their ventures. In addition, each team has the opportunity to earn up to $ 20,000, equity free, based on the progress against monthly milestones. Selected students participate in a rigorous, educational curriculum that integrates learning by doing, mentorship and access to resources. Teams make significant progress towards identifying their eachhead market, building the right product and securing initial customers or partners so that they are ready to hit escape velocity by Demo Day[6].

MIT recognises and rewards student excellence in entrepreneurship through several awards overseen by the Trust Center: the McGovern Award, the Heller Grant, the Anderson Fellowship. The Monosson ’48 award recognises entrepreneurship mentors who have committed their time, energy, and/or capital to future generations of entrepreneurs.[7]

The Center sponsors the MIT t100K Entrepreneurship Competition and popular and unique courses Entrepreneurship Lab and Global Entrepreneurship Lab which enable the MBA students work in start-ups all over the world. It collaborates closely with the MIT Venture Mentoring Service and represents **the core of the MIT ecosystem of innovative entrepreneurship**, encompassing the following institutions described in more detail below:

- MIT 100K Entrepreneurship Competition
- MIT Deshpande Centre
- MIT Enterprise Forum MIT Media Lab
- MIT Global Startup Workshop
- Legatum Centre for Development and Entrepreneurship
- Sloan Entrepreneurs for International Development
- Lemelson MIT Program
- MIT Venture Mentoring Service
- MIT Technology Licencing Office
- On-line publication The MIT Entrepreneurship Review.

MIT 100K Entrepreneurship Competition – annual educational programme encouraging MIT students and researchers to develop their talents, ideas and invest efforts in a future successful company. It has taken place since 1992 and provided through its financial prizes (originally $ 50,000, later $ 100,000), startup founding services, mentor and investor networks an important assistance to MIT student teams and their spin-offs.[8]

MIT Deshpande Centre was set up at the Faculty of Engineering in 2002 on the base of a donation by the founders of successful high tech company Sycamore Networks Inc. to boost academic research and technology innovations in collaboration with industry, as well as early stage technology start-ups.[9]

MIT Enterprise Forum focuses on technopreneurship and its clusters all over the world through its educational programmes (more than 400 events a year) via its 28 subsidiaries on three continents. Unique is the supply of course content of nearly all

[6] https://entrepreneurship.mit.edu/accelerator/
[7] https://entrepreneurship.mit.edu/about/
[8] http://www.mit100k.org/
[9] http://web.mit.edu/deshpandecenter/about.html

courses taught at the MIT bachelor and master study programmes over the Internet free of charge by means of MIT OpenCourseWare.[10]

MIT Media Lab is orientated to teaching of interdisciplinary entrepreneurship in the media, sciences and engineering fields. It helps students transform their promising business ideas into lab prototypes and marketable products with support of sponsors and MIT Mentoring Service.[11]

MIT Global Startup Workshop came into being in 1998 as a response and consulting to numerous queries from abroad on the organisation of the MIT $ 100K MIT Entrepreneurship Competition in 1997. Since 2007 it has been organising workshops on building ecosystems of innovative entrepreneurship all over the world.[12]

Legatum Centre for Development and Entrepreneurship was founded in 2007 thanks to a donation from the global investment company Legatum Group as a highly competitive scholarship and grant programme for MIT students, who intend to start up their businesses in a developing country with low income per capita.[13]

Sloan Entrepreneurs for International Development is a student organisation striving for sustainable development through entrepreneurship. Its members get business education, start new companies and involve themselves in solving problems of companies in emerging markets.

Lemelson MIT Program bears the name of an extraordinary productive and successful American independent inventor Jerome Lemelson, owner of 605 patents in the fields of industrial automation, electronics and robotics and founder of the philantropic foundation fostering inventions and innovations. It anually awards the MIT Lemelson Prize amounting to $ 500, 000.

MIT Venture Mentoring Service complements the educational objectives of the MIT Entrepreneurship Centre by providing the early stage start-ups at the MIT campus advice and assistance of voluntary mentors with business experience in the form of team mentoring, where 3 to 4 mentors concurrently provide professional advice and coaching to a group of entrepreneurs.[14]

The **MIT Technology Licencing Office** fosters commercial investments in development of inventions and discoveries by providing the inventors from the MIT and Lincoln Laboratory legal advice on protection of technologies and intellectual property as well as in selling patent licenses and technology copyrights to established

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[10] http://www.mitef.org/s/1314/interior-2-col.aspx?sid=1314&gid=5&pgid=468
[11] http://www.media.mit.edu/ventures
[12] http://mitgsw.org/workshop/
[13] http://legatum.mit.edu/aboutus
[14] http://web.mit.edu/vms/

companies and start-ups. Its portfolio contains more than 1,000 US patents and each year it produces 60 to 80 license contracts.[15]

On-line publication The MIT Entrepreneurship Review is a student-run, online publication that examines the intersection of science, technology, and entrepreneurship. It is considered as a venue *"where Einstein meets Edison", or where "thinkers" meet "doers"*. It brings cutting edge knowledge, innovative ideas and practical experience to entrepreneurs.[16]

The MIT graduates founded and developed such important corporations as Arthur D. Little Inc., Hewlet Packard, Genentech, Gillette, Raytheon, Teradyne and others. The overall MIT entrepreneurial environment, consisting of multiple education, research and social network institutions, contributes to this outstanding and growing entrepreneurial output. Highlights of the findings include:[17]

- An estimated 6,900 MIT alumni companies with worldwide sales of approximately $ 164 billion are located in Massachusetts alone and represent 26 percent of the sales of all Massachusetts companies.
- 4,100 MIT alumni-founded firms are based in California, and generate an estimated $ 134 billion in worldwide sales.
- States currently benefiting most from jobs created by MIT alumni companies are Massachusetts (estimated at just under one million jobs worldwide); California (estimated at 526,000 jobs), New York (estimated at 231,000 jobs), Texas (estimated at 184,000) and Virginia (estimated at 136,000).
- MIT is very important to the Massachusetts economy, since without MIT, most of these companies would never have been located in Massachusetts.

Besides the research and entrepreneurial universities stated above there are many renowned universities all over the world following the strategy of entrepreneurial university with success and having relevant experience in technology transfer and spin-offs, e.g. Harvard Business School in Boston, Stanford Graduate School of Business, University of Cambridge, Imperial College in London, University of Technology in Munich, ETH in Zurich, IESE Business School within the University of Navarra, Nanyang Technological University in Singapore, Technion - Israel Institute of Technology in Haifa and others.

1.4.2 Innovation ecosystem of University of Oxford

Oxford is the biggest research-based university in the UK, with research expenditure of GBP 542m in 2013. It has a strong commitment to building lasting relationships with the business world, and its level of interaction with the local, national and international

[15] http://web.mit.edu/tlo/www/
[16] http://miter.mit.edu/about/
[17] http://www.kauffman.org/uploadedFiles/MIT_impact_brief_021709.pdf

business community grows each year. The Oxford University innovation ecosystem comprises elements of, i.e. organisational units and events described below, fulfilling the following functions: entrepreneurship awareness raising, entrepreneurship and innovation education and training, wealth creation and supporting activities. Their interplay jointly supports and develops research, teaching, entrepreneurship and innovations.

The ecosystem of the University of Oxford consists of the following elements (Zajko, 2010):

- Oxford University Divisions and Departments;
- Research Services;
- Isis Innovation Ltd.;
- Oxford Innovation Society;
- Oxford Saïd Business School;
- Oxford Entrepreneurship Centre;
- Skoll Centre for Social Enterprise;
- Oxford Spin-out Equity Management;
- Oxford Science Park;
- Oxford University Begbroke Science Park;
- Oxford Entrepreneurs;
- Knowledge Exchange Community.

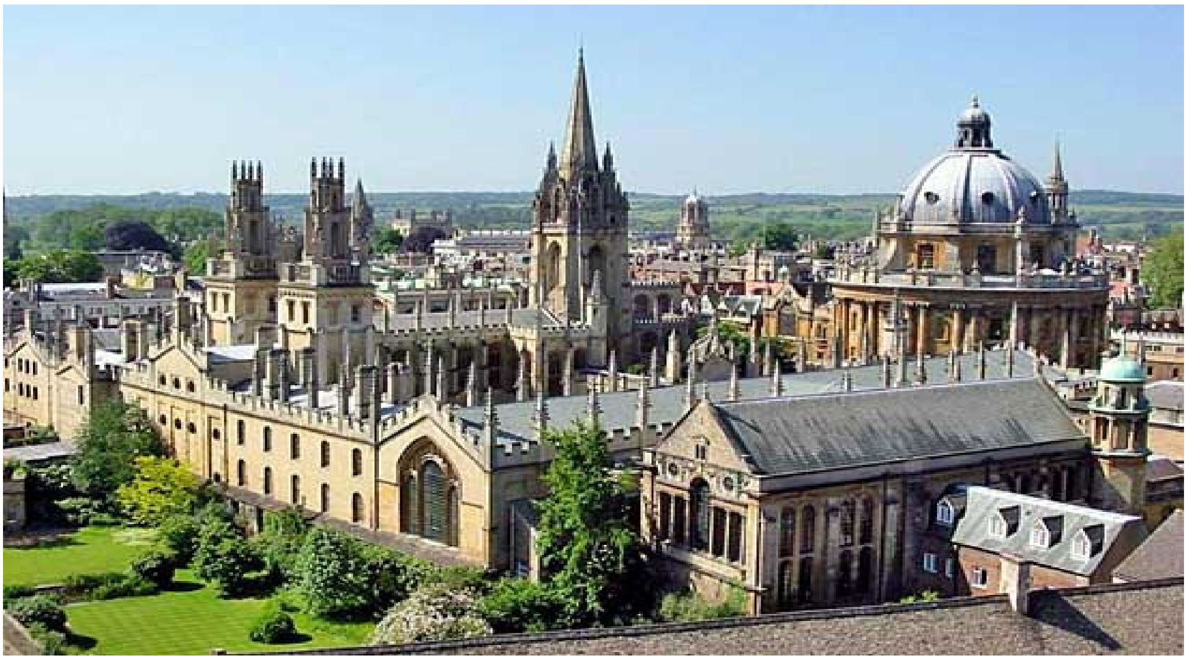

Figure 5: View of Oxford University, Oxfordshire, UK

Oxford University Divisions and Departments perform internationally renowned research. There are four academic divisions: Humanities, Medical Sciences, Mathematical, Physical and Life Sciences, as well as Social Sciences. They may be further subdivided into Faculties, Departments and Institutes. The development of external research income in the period 2003-2013 is stated in Table 1 below.

Table 1: External Research Income in the period 2003/04 to 2012/13

Academic Year	Amount in £M	Increase in %
2003/04	173	7
2004/05	184	6
2005/06	213	16
2006/07	248	16
2007/08	285	15
2008/09	340	19
2009/10	367	8
2010/11	377	3
2011/12	409	9
2012/13	437	7

(Source: http://www.admin.ox.ac.uk/researchsupport/reports/income/1213/)

The steady income influx from externaly funded projects and contracts is a precondition for the growing flow of knowledge from the University to relevant external entities through its rich knowledge transfer intermediary network. The purpose, main tasks and key results achieved by the individual intermediaries follows.

Research Services department works in partnership with academic divisions, departments/faculties, University Administration and Services and Isis Innovation Ltd to support Oxford's researchers and facilitate world-class research and knowledge exchange. Its aim is to facilitate world-class research and knowledge exchange. It has three main client groups:

- Academic Divisions, their Departments/Faculties and researchers;
- Senior Officers of Oxford University;
- Oxford´s Research Sponsors and Collaborators.

Its major responsibilities include:[18]

- advice and information on funding opportunities, reviewing and authorising research grant applications, accepting new awards, and sponsor liaison;
- negotiating research-related contracts and agreements;
- advising on the costing and pricing of research at Oxford;
- supporting University and Divisional research-related planning;
- supporting the development of the University's knowledge exchange/knowledge transfer activities and its partnerships with key external organisations;

[18] http://www.admin.ox.ac.uk/researchsupport/about/#d.en.33743

- facilitating knowledge transfer and supporting the work of Isis Innovation Ltd.

Isis Innovation Ltd. founded in 1987 by the University of Oxford covers three main activity fields:

- Technology Transfer Group helps Oxford University researchers to commercialise intellectual property related to their research results in the forms of patenting, licensing and spin-out companies and organise the material sales from University to industry customers;
- Oxford University Consulting which helps Oxford University researchers find and manage consulting opportunities and also enables clients access experts from this world-class, interdisciplinary research base;
- Isis Enterprise formed in 2004 provides consulting expertise and advice in technology transfer and innovation management to clients across the public and private sectors all over the world.

Isis Innovation Ltd. is an integral part of the entrepreneurial architecture at Oxford University. It has strong links with all the parts of the University involved in technology commercialisation and enterprise: Research Services, Begbroke Science Park, and Oxford Centre for Entrepreneurship at the Saïd Business School**.** Isis cooperates only with University members who wish to make use of its expertise and services due to their high quality, Isis business networks and mutual benefits of such collaboration[19]. Summary of key results of the Isis Innovation Ltd. achieved in the years 2009 - 2014 is stated in Table 2 below.

Commercialisation of Oxford research undertaken by Isis Innovation contributed more than £0.4Bn gross value added to the global economy in 2012/13 from spin-out and licensing activity alone, according to a report from Biggar Economics, an independent consultancy. The report found that Isis´ activities support almost 5,000 jobs globally, of which 3,400 are in the UK and 1,600 in Oxfordshire alone.[20]

The steadily expanding *Isis Angels Network* (over 100 members) arranges meetings, where early-stage technology investors can hear investment pitches from early stage spin-out teams. *The Isis Spinners club* provides opportunity for the CEOs and University nominee directors of the University´s spin-outs to meet and share experience or discuss presentations of invited professional speakers. Isis has sponsored and organised Oxford´s international fair for entrepreneurs, *the Venturefest* for nine years. It is known as one of the most influential forums for the advancement of high-tech and knowledge-based enterprise.

[19] http://isis-innovation.com/about/
[20] Isis Annual Report 2014, p. 15

Table 2: Key results of Isis Innovation Ltd. achieved in the period 2009 – 2014

Activity indicators	2014	2013	2012	2011	2010	2009
Revenue (£M), thereof:	14.5	11.5	10.2	8.4	7.5	5.6
Technology Transfer Group	8.7	6.7	6.4	5.4	N.A.	N.A.
Oxford Uni. Consulting	2.9	2.5	1.9	1.2		
Isis Enterprise	2.4	2.1	1.6	1.4		
Amounts returned to University (£M)	6.7	5.6	5.3	4.8	4.5	2.9
Annual subvention by OU to Isis (£M)	3.1	2.5	2.5	2.5	2.5	2.5
Annual compound growth rate over 10 yrs (in %)	20	20	20	N.A.	N.A.	N.A.
Translational research funding won (£M)	19	22	4.4	N.A.	N.A.	N.A.
Spin-out shareholdings (£M)	49	43	45	N.A.	N.A.	N.A.
New spin-outs: investments (£M) / number	5/8	0.5/4	4.9/5	1.4/4	N.A.	N.A.
Software start- ups in the ISI	27	21	15	12	start	
Deals signed (Technology Licence and Oxford Uni. Consulting)	503	395	356	292	290	220
International offices	4	4	4			
Patents/patent applications managed	2333	2015	2000	N.A.	+73	+64
Staff	72	N.A.	N.A.	N.A.	62	N.A.

(Source: Isis Innovation Ltd. Annual Reports 2007 to 2014 - adjusted)

Oxford Innovation Society was established in 1990**.** It is managed by Isis Innovation Ltd. It is a business network linking together its members, Isis and University researchers to discuss new technologies and open innovation business opportunities. Current members come from multinational and local companies (engineering, health care, materials, life and physical science technology companies) and the professionals (patents, banks, accountants, lawyers).

Oxford Saïd Business School was established in 1996 within Oxford University[21]. The Business School has acquired a reputation for high quality business education with strong emphasis on entrepreneurship in its teaching and research and viable links between businesses and academia. Saïd Business School also organises regular seminars and guest lectures providing a stream of networking opportunities under the heading Speakers on the Campus. The Business School also hosts a number of major annual conferences, including the *Skoll World Forum*, the leading forum for social entrepreneurs around the world, the prestigious *Oxford Private Equity Forum,* and a gathering of key

[21] http://www.sbs.ox.ac.uk/school/about

Silicon Valley business leaders. In addition, *the Distinguished Speakers Seminar* series brings CEOs and entrepreneurs to the School to give masterclasses

Since 2010, Isis Innovation has run at the Saïd Business School *the Isis Software Incubator (ISI),* designed to support very early-stage software ventures from students, staff and alumni of the University of Oxford. It offers to start-up physical space and IT facilities as well as commercial mentoring, funding support and business networking facilitation. Since 2013 the ISI offers each year also *Accelerator Programme* for early-stage ventures and a *GROW @ Green Park* - pop-up coworking space for the starting entrepreneurs from the Thames Valley.

The *Saïd Business School Venture Fund* provides entrepreneurs with seed and early-stage capital for new ventures. The annual competition is open to students and alumni of Saïd Business School, as well as members of Oxford Entrepreneurs who are University of Oxford students or alumni. Each year between 8 – 10 MBA students are recruited from the current class to serve on the investment committee that manages the fund with help from University and external advisors. To date the Fund is in its fourth year and has invested a total of £520,000 in five businesses.

The Oxford Entrepreneurship Centre[22] is the focal point for entrepreneurship research, teaching and practice at the University of Oxford. It is based at the Oxford Saïd Business School. Its mission is to create awareness and encourage entrepreneurship in the University´s science and technology communities. It offers training and support in knowledge and skills needed for early stage businesses and new ventures. Since 2002, it has brought together academics, spin-outs and student-entrepreneurs, for the study and practice of entrepreneurship. It is the gateway to the over 2,000 high-tech companies in and around Oxford and has an extensive international network of almuni. It shares an open space with the Skoll Centre for Social Enterprise, known as *Oxford launchpad,* where members - students, faculty and the wider Oxford community and stakeholders - meet to ideate and strengthen ventures, as well as to share knowledge, practices and connections. The Centre´s programmes and events combine research on and practical teaching of entrepreneurship to support entrepreneurs and high-growth companies and have been attended by over 22,000 people. The Programme comprises:

- entrepreneurship and business skills courses, e.g. „Building a Business Course";
- entrepreneur events, e.g. workshops on patents and business planning;
- special seminars organised as meeting and discussion venues for business and science participants on innovation opportunities in specific technology-based disciplines or on research issues from the industry view;
- Oxford University Business Plan Competition is an annual contest of businesses based on the use of science, technology, medicine or design in new ways. It is open to science researchers, inventors, small enterprises and entrepreneurs from any country in the world. It is the largest event of this type in the UK. As a

[22] http://www.sbs.ox.ac.uk/ideas-impact/entrepreneurship/about-us-hub

result of this competition many successful launches of new ventures and alumni companies financed by venture capitalists have taken place.

The Skoll Centre for Social Entrepreneurship was founded in 2003 at the Saïd Business School with a generous grant from Jeff Skoll, the founding President of eBay known for launching businesses aimed at positive social change. It was the largest funding ever received by a business school for an international programme in social entrepreneurship. It is a leading global entity for the advancement of social entrepreneurship aimed at innovative social transformation through education, research, and collaboration. The first Skoll World Forum on Social Entrepreneurship took place in 2004.

Oxford Spin-out Equity Management (OSEM)[23] manages the University's shareholdings in its spin-out companies after they have been spun-out by Isis. OSEM is a unit within the University reporting to the University's Director of Finance and works closely with Isis. OSEM has three main roles:

- Strategic: identifying opportunities to optimise the return on the University's investment and provide professional assistance to companies as they develop;
- Tactical: supporting companies by dealing with immediate or short-term issues such as funding or access to other support networks;
- Procedural: dealing with documentation relating to consents, fund-raising and exits.

In fulfilling this role, OSEM calls on its own expertise, its extensive networks of contacts in the financial, commercial and scientific worlds and its own investment fund which it manages on behalf of the University of Oxford. Its portfolio of 63 companies is currently valued at around £49 million (October 2014).

Since 1997, Isis Innovation has been responsible for creating spin-out companies based on academic research generated within and owned by the University of Oxford, and has spun-out a new company every two months on average. Over £266 million in external investment has been raised by Isis spin-out companies since 2000, and five are currently listed on London’s AIM market.[24] These new spin-out companies also bring back millions of pounds into University research and benefit regional economic development by creating many new jobs.

[23] http://www.osem.ox.ac.uk/whatwedo/index.html

[24] London's Stock Exchange AIM sub-market serves as a mechanism for companies, especially for SMEs seeking access to capital to realise their growth and innovation potential and, since launch, has helped over 3,100 companies raise over £67 billion through new and subsequent capital raises.

The University of Oxford has created three investment funds accessible to University researchers for the development of technologies for commercialisation. They are the following:[25]

University Challenge Seed Fund (UCSF) – founded in 1999 as a part of the UK government's University Challenge Seed Fund Scheme. The UCSF has invested in 126 projects so far, ranging in size from £2,500 to £250,000 pursuing the overall objective to enable university researchers to access seed funds in order to assist the successful transformation of good research into good business. This early funding is the riskiest stage of the venture process.

The Oxford Invention Fund (OIF) was set up in 2003 as a continuation of the UCSF. The OIF provides an opportunity for donors to support innovation and enterprise in Oxford, and to see a return to the University from successful new business ventures. The Fund is an integral part of Oxford Thinking, a united campaign to raise a minimum of £1.25 billion for the collegiate University.

The Proof of Concept Fund was set up in 2004 following a successful collaborative bid by the Universities of Oxford, Cambridge, Imperial College, and University College London to the Government's Higher Education Innovation Fund. It is fully commited now.

The aim of the **Regional Liasion Office (RLO)** is to enhance University business links with regional organisations and businesses for the benefit of the regional economy. It is responsibile for developing a University´s regional strategy and collaborates closely with University departments and organisations in its implementation. At the same time it is the key contact point with several regional organisations such as SEEDA (South East England Regional Development Agency) and the GOSA (Government Office for the South East).

The Oxford Science Park as a joint venture between Magdalen College, Oxford and financial services group Prudential. There are over 60 companies at the Park, 31 % of them being active in computer hadware or software, 43 % in bioscience and 26 % in other areas[26].

Since 1999 **Oxford University Begbroke Science Park** has been operated by the University's Department of Materials and quickly attracted new venture companies seeking access to research at the University. It offers a new approach to research - the creation of multi-disciplinary centres of excellence which bring together experts in related fields to answer specific needs or explore specific areas. These centres of excellence are focused on working with industry partners to turn ideas into wealth-generating enterprises. Currently they are working in five major interdisciplinary areas: Industrial Materials and Manufacturing, Aerospace and Automotive, Nanotechnology,

[25] http://www.isis-innovation.com/researchers/UCSF-1.html
[26] http://www.oxfordsp.com/

Environmental Technology, and IT & Communications Engineering. Oxford University Begbroke Science Park offers spin-out and start-up companies working from inside and outside the University a home in incubation facilities with practical start-up help. Both new enterprises like these and established businesses working with novel technologies will benefit from its unique networking opportunities, laboratory facilities as well as access to ongoing academic research.

There are around 30 companies and over 20 research groups currently at Begbroke. Researchers from the Mathematical, Physical & Life Sciences and Medical Sciences Divisions of Oxford University work in inter-disciplinary groups, to tackle some of the major societal issues facing our 21st century world. Companies are science and research based, many of them university spin-outs, and they have links with either Oxford University or other research based organisations[27].

Part of the Begbroke Directorate is the *Knowledge Transfer Partnership (KTP) Office*. This boosts knowledge transfer between the University and business through initiatives such as the *DTI's Knowledge Transfer Partnerships scheme*. Knowledge Transfer Partnerships are part-funded by the UK Government, which reimburses a proportion of the University's costs and the company pays the rest, e.g. a small and medium sized enterprise (SME) covers one third of the project cost and its own business overheads. Projects last from one to three years. The KTP Associate is employed by the University but works full-time with the company.

Oxford Entrepreneurs is a student society for entrepreneurs at the University of Oxford started in 2002. **Its mission** is to **encourage** and **support** student **entrepreneurship** by providing **inspiration, education, networking** and the chance to **learn by doing** at The University of Oxford **and beyond.** They help each other to start companies and host talks with renowned entrepreneurs. It has become the largest free business and entrepreneurship society at Oxford University and also in Europe with over 10,000 members.[28]

The purpose of the **Knowledge Exchange** community at Oxford University is to accelerate the impact of research on the world. This community has fuelled people with passion for their subject and a real 'can-do' attitude, commitment, professionalism and academic rigour of community activities, and an innovative culture.

Oxford Business Alumni Network (OBA) is the official global business alumni network of the Saïd Business School covering more than 10,000 alumni in 129 countries. Launched in 1998, the OBA Network has been organised to build a world class business and management network for the Saïd Business School and Oxford University. Frequent events, forums and reunions held by the Alumni Relations Office and OBA Chapters

[27] http://www.begbroke.ox.ac.uk/home/whos-here/
[28] http://www.oxfordentrepreneurs.co.uk/about/

around the world give alumni and current students opportunities to meet, exchange ideas and support one another through the OBA Network.[29]

Oxford Business Networks (OBN) are part of the framework of the Oxford Business Alumni Network as industry, interest or geography specific networks for students, alumni, academia and professionals. They exist to promote the exchange of ideas and knowledge surrounding an industry, interest or large geographic region. The core OBNs include: entrepreneurship, social entrepreneurship, finance, managing consulting, and private equity.

1.5 Entrepreneurial architecture

The concept of entrepreneurial architecture introduced by Burns (2005) in relation to corporate business was applied by Nelles and Vorley (2011) in their model for the development of academic institutions. In the corporate context, the concept of entrepreneurial architecture brings together a wide variety of factors encouraging entrepreneurial behaviour which are divided into 5 categories/dimensions. It is then analysed how these categories interact in order to establish how innovation can be effectively implemented in the organisation. The entrepreneurial architecture is based on relationships, knowledge and information, and a strong dominant logic, which helps to understand the context and to establish further directions of development (Burns, 2005). Although the concept of entrepreneurial architecture was created in the corporate context, the five dimensions of business architecture (structure, strategy, systems, culture and leadership) can be applied to any innovative organisation, including HEIs.

Successful adaptation of a university to the third mission requires the presence and coordination of all five dimensions. The elements of the architecture support each other and the absence of one aspect may contribute to a weakening or failure of the adaptation process. Favouring or excessive support of one element of the entrepreneurial architecture at the expense of others can create an imbalance which could completely compromise the effectiveness of the other activities of the third mission (Nelles, Vorley, 2011). Figure 6 shows what affects the organisational architecture (all elements are related to each other and the leader has a responsibility to form the organisational structure and culture, and thus the whole architecture).

[29] https://www.oxfordbusinessalumni.org/page.aspx?pid=1926

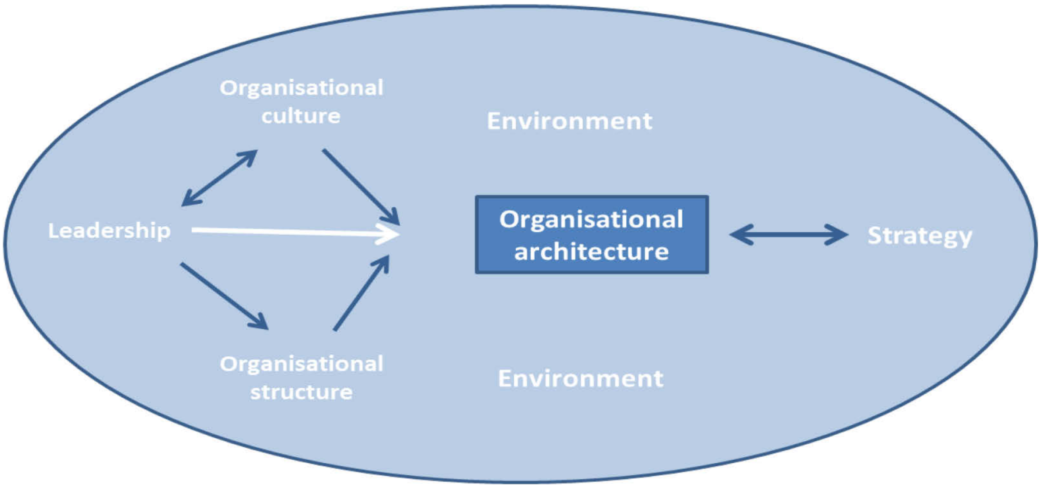

Figure 6: Entrepreneurial architecture

(Source: Burns, 2005)

The concept of entrepreneurial architecture shows that the third mission activities are not only a result of the implementation of structural changes, such as the establishment of a TTO. A survey of 33 universities in the UK and 15 universities in Germany and France demonstrated (Nelles, Vorley, 2009) that although the university TTO is often the cornerstone of the structure of the third mission in universities, it is neither the only nor the most important determinant of the performance of universities in the area. The concept of entrepreneurial architecture stresses that the successful implementation of the third mission also requires that control systems are overseen by the HEI management, in line with the HEI development strategy. The strategy has to create an environment which encourages innovation in the long term (e.g. structures through which faculty, staff and university students communicate with other organisations and vice versa). The most common structures are TTOs, others are science parks, incubators, contact points at faculties, departments of continuing education and professional development and programmes promoting cooperation between HEIs and businesses. Their effectiveness is partly determined by their ability to successfully engage and cooperate with each other (Bercowitz, Feldman, 2000). Table 3 presents an overview of dimensions of the Entrepreneurial architecture. Successful implementation of the third mission depends on the degree of integration of the entrepreneurial architecture in the HEI structure.

Table 3: Dimensions of Entrepreneurial architecture in the context of HEIs

Dimensions	Characteristics
Structures	Entrepreneurial infrastructure incl. TTO, incubator, science park, online portals for entrepreneurs
Systems	Communication networks, structure of links between organisational units – faculties, departments, administrative support etc.
Strategies	HEI aims and objectives worked in the organisational strategy and plans, incl. Internal motivational reward
Leadership	Qualifications and attitude of key HEI leaders (chancellor, vice-chancellors, senate, leading scientists) towards the third mission
Culture	Within the HEI, at faculties and departments, , incl. the attitudes and values of individual s towards the third mission

(Source: Nelles, Vorley, 2009)

The University of Oxford is an example that illustrates the successful development of the third mission activities and the extension of the entrepreneurial architecture from corporate sphere to HEIs (Figure 7).

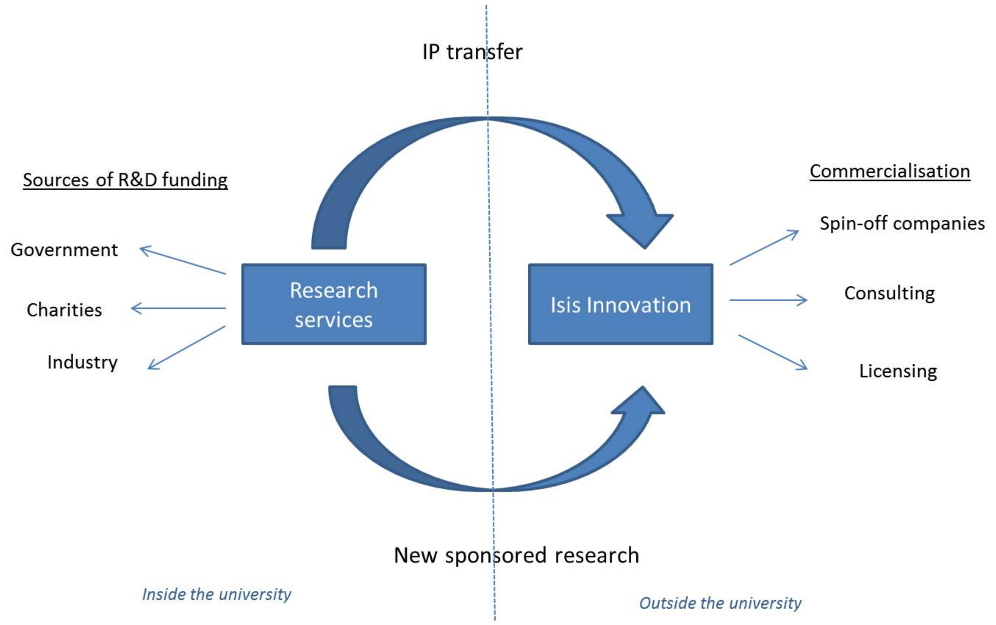

Figure 7: Entrepreneurial architecture at the University of Oxford

(Source: Nelles, Vorley, 2009)

The central point of the architecture is a TTO (Isis Innovation), other elements include: research services office which secures financial resources for research projects from various funding programmes (Research Services), Regional Liaison Office, Continuing Professional Development Centre, science enterprise support centre which provides training, seminars and events (Oxford Science Enterprise Centre) and a science park (Begbroke Science Park). Success of the structures and systems at the University of

Oxford and the business architecture in general, is the result of the synchronisation between members of the HEI management and the HEI development plan.

Entrepreneurial architecture provides a framework of variables which can be analysed in a wide range of cases to determine the internal dynamics of a HEI. This is particularly useful for analysing the development of adaptation to the third mission within the university over a certain time period, or for comparing the development among a number of universities at the same time. Such analysis not only provides an assessment of the variables, but also highlights institutional weaknesses and shows the interaction (positive or negative) of the various factors in practice. Given that the concept does not require a specific organisational starting point, it can be applied to a wide range of HEIs and can take into account the very different initial conditions and political contexts, for example: array of knowledge, characteristics of the regional economy, influence and political position of the university, or the heritage of different institutional priorities for teaching and research programmes. Utilising the concept of entrepreneurial architecture is of great importance when analysing organisational changes at research-intensive universities, as well as for universities with weaker research base (Nelles, Vorley, 2011).

1.6 Application of the Triple Helix conceptual framework in Slovakia

Successful innovation (at corporate or macro level) depends on government policies and legislative frameworks enabling KTT and commercialisation. A good set of innovation policy instruments can create fertile ground for the development of cooperation between HEI and enterprises (innovation eco system).

Analysis of economic reform in Slovakia devised in 2012 by the European Commission (Assessment of the 2012 National Reform Programme and the Stability Programme for Slovakia, 2012) identified, inter alia, the lack of coordination of the research and innovation system. Slovak HEIs do not systematically cooperate with the business sector, there is limited interest of businesses to collaborate with HEIs in order to innovate their products and processes. Furthermore, the government is not very successful in stimulating co-operation between business and academia. The various government instruments have not adequately supported interactions between innovators and the diffusion of innovation. Due to the continuing economic difficulties, the expert community does not expect any significant improvements and predicts that the government will support KTT and innovation mainly by using EU Structural Funds.[30]

[30] Opinions presented by speakers at the Europe 2020: „ Research, innovation and digitalization“in November 2011 and at an event entitled „Workshop – Innovation in the Union” in May 2011, both in Bratislava.

The Research and Innovation Strategy for Smart Specialisation of Slovakia[31] (RIS3 SK strategy) is the key document forming the Slovak Innovation policy for the period of 2014 - 2020. It is based on recommendations of the Guide to Research and Innovation Strategies for Smart Specialisations, Regional Policy from May 2012, issued by the European Commission. Its strategic objectives are to:

1) deepen integration and embeddedness of key major industries, increase local value added through the cooperation of the local supply chains and to turn local supply chains into embedded clusters;
2) increase contribution of research to the economic growth via global excellence and local relevance;
3) create a dynamic, open and inclusive innovative society as one of the preconditions for improving the quality of life;
4) improve the quality of human resources (skills and knowledge) to create innovative Slovakia.

The Strategy includes measures to stimulate private investment in R&D and promote innovation in the public sector. The aim is to dedicate the resources to the most promising areas of comparative advantage, i.e. existing sectoral or cross-sectoral projects, eco-innovation, markets with high added value and existing networks or specific research areas. The most important measures are to support innovation, collaboration between academia and industry, they include:

- Creating consortia to solve multidisciplinary problems and supporting industries through clusters and other forms of networking in order to build innovation capacities;
- Establishing applied research & innovation centres and supporting existing applied research & innovation centres in Slovakia (allowing HEIs to have ownership of shares in such organisations);
- Devising strategic projects of long-term cooperation between enterprises and HEIs with a view to develop long-term partnerships in priority areas;
- Using financial instruments supporting start-ups and spin-offs and instruments to promote innovation;
- Protecting and exploiting IP, raising awareness of IP protection and commercialisation, including required changes in legislation to reflect needs based on previous experience.

The preparation of RIS3 had involved all relevant government departments as well as the business sector. Implementation of RIS3 priorities will be accomplished by processes that will harmonize and mutually synchronize programmes, plans, projects, and actions. Some important support tools mainly for the business sector include the system of measures for improving the business environment, improvement of law

[31] Research and Innovation Strategy for Smart Specialisation of the Slovak Republic. Ministry of Economy of Slovak Rep., 13 November 2013.

enforcement, improvement of public administration, etc. These tools consist of changes in tax legislation (e.g. tax incentives), a support for venture capital or direct subsidies focused on the highest possible co-financing of private sector. Reorganisation of the research and innovation system will involve increased application of R&D results in the business practice. This will lead to change in the ratio of support for applied and basic research to: 70 % for applied research and 30 % for basic research.

1.6.1 Knowledge and technology transfer

Slovak universities suffer from a lack of financial resources and a lack of young and talented scientists as they do not provide adequate compensation and an environment which fosters high quality science and commercialisation, and retains top scientists. KTT takes place mostly at the level of individual departments, usually through research contracts. Universities have very limited funding for IP protection and patent maintenance and limited experience with IP commercialisation.

In 2009 and 2010 several projects financed by EU Structural Funds (Operational Programme Research and Development) were launched, which enabled the establishment of TTOs, e.g. at the Slovak University of Technology, Comenius University in Bratislava, the Technical University of Košice and the Slovak Academy of Sciences. None of the universities managed to properly establish and implement processes necessary for successful operations. These projects suffered from excessive administration and complex rules, and restricted some of the most important aspects of KTT, e.g. international networking at conferences, training of TTO managers abroad, co-financing IP valuation and protection). Not only did they not have the resources to fund some important aspects of their job, neither could they recruit experienced KTT managers. Some progress has been achieved since mid 2013 when the Slovak University of Technology, Comenius University in Bratislava, the Technical University of Košice and Žilina University received funding to build a science park incorporating KTT operations.

The reward system at HEIs does not provide incentives for applied research; traditional forms of knowledge transfer such as publishing, presentation at professional conferences and teaching are preferred. Rules of projects financed from the Operational Programme Research and Development also present a barrier to KTT, they do not allow for the equipment purchased from the project budget to be commercially utilised, i.e. for collaboration with industry (without facing subsequent financial penalisation if some profit was made).

Some success has been achieved at the Slovak Academy of Sciences through its TTO (SAS Institute of Technology) following the adoption of their IP policy. Several projects were completed and together with the Mathematics and Physics school at Comenius University in Bratislava they won an award at the eighth annual international exhibition of inventions and technologies "Taipei International Invention Show and Technomart" 2012. International patent applications were filed on all presented technologies.

Despite the initial success, uncertainties continue to burden the TTO due to the lack of finance – all activities and human resources which helped to establish the office are only funded for a short time period, based on specific projects financed by EU Structural Funds. The Slovak Academy of Sciences does not dispose of adequate resources to run the TTO and finance IP protection. In 2014 the centre employed three emplyees (two consultants and one administrator), but is heavily reliant on public funds from the National Infrastructure project (National Infrastructure project for Supporting Technology Transfer in Slovakia).

TTO established at the Slovak University of Technology was in decline following the closer of the project which financed its establishment (Operational Programme Research and Development), but thanks to funding received from the National Infrastructure project and EU funds to develop a University Science Park, it has been able to provide researchers with IP protection advice and fund patent and utility model applications. In 2014 the centre had one employee, lawyer specialising in IP protection.

The Institute for Competitiveness and Innovation at Žilina University received funding from the 7th Framework Programme to improve cooperation among the selected institutions in Žilina, Moravia and Silesia and the Upper-Silesian Region. The institute focuses on supporting applied research projects undertaken by students of Žilina University as part of the study course. Both, Žilina University and Technical University in Košice have bee developing their TTOs thanks to EU funds aimed at building a science park. In Žilina the TTO is supported by several employees who share their time between different projects. TTO at the Technical University in Košice had 4 emploeyees in 2014.

Given the fact that the establishment of a TTO takes at least 5 years even at top universities in the U.S. or in the UK, it is impossible to secure the sustainability of TTOs at Slovak HEIs based on a 2-year project without a follow up.

Since 2010 the National Infrastructure for Supporting Technology Transfer in Slovakia, project financed from EU Structural Funds, has financed several patent applications and promoted KTT across Slovakia. The project is implemented by the Centre of Scientific and Technical Information in Bratislava and has been extended to run until October 2015. Thanks to this initiative, a number of conferences and seminars have taken place and useful manuals have been developed to assist TTOs at Slovak HEIs (Balog et al., 2013). The project has helped to create KTT infrastructure - supported individual TTOs in establishing a TTO and in building its know-how. The project also facilitated advice on the implementation of various policies and procedures related to IP commercialisation.

In addition, the National Infrastructure Project provides patent searches, facilitates evaluation of the commercial potential of IP originating from Slovak universities and Slovak Academy of Sciences, promotes their IP and seeks partners from industry. Several of these services are subcontracted to Neulogy, a joint stock company which specialises in commercialising R&D results, including the creation of spin-off companies. Until October 2013 the National Infrastructure Project supported 38 projects related to IP protection, of which 23 were submitted by the TTO at Slovak Academy of Sciences. A follow-up project is planned to start in 2016, however, details have not been confirmed as yet.

As long as Slovak HEIs cannot maintain their TTOs from their own budget, the services of the National Infrastructure Project will not get fully used. It will also be important to ensure that the National Infrastructure Project focuses only on financing those patent applications which have a potential for commercial exploitation. It is not yet known whether the National Infrastructure Project will continue to be supported by the Slovak government beyond 2015.

1.6.2 Government support for applied research and commercialisation

The 2005 "Act on Organisation of the State Support to R&D" laid down a system of public financial support for R&D spenders, and indicated rules for evaluating their performance. Multi-annual S&T policy concepts and annual budget cycles are major principles of Slovak research policies. The main document on research policy is the 2007 Long-term Objective of the State S&T Policy up to 2015 setting out horizontal (cross-cutting) and vertical (thematic) levels of priorities. Policy objectives are detailed in the 2008 Strategy of implementing the "Long-term Objective of the State S&T Policy up to 2015" and the 2013 Smart Specialisation Strategy.

The Slovak R&D and innovation system consists of the following parts:

1) **R&D governance bodies** include the Ministry of Education, Science, Research and Sports (MESRS), and Slovak Government Council for Science, Technology and Innovations (SGCSTI);
2) **Intermediaries (funding)** include (i) agencies directed by the MESRS: Scientific grant Agency (VEGA), Structural Fund Agency (ASFEU) and Research and Development Agency (APVV) and (ii) agencies directed by the Ministry of Economy (ME): Slovak Innovation and Energy Agency (SIEA) and Slovak Business Agency (SBA, former NADSME) and State Agency for Development of Investments and Trade (SARIO); Slovak Gurantee and Development Bank (SZRB) and its funding programmes for SMEs has a specific position among the intermediaries;
3) **Research performers** include (i) the Slovak Academy of Sciences (SAS) and other governmental research institutes; (ii) 36 higher education institutions; and (iii) industry research institutes, commercial research organisations and R&D departments of businesses.

Most research was performed in the business sector (41.3 % of total expenditure in the R&D), public research facilities (24.5 %) and higher education facilities (34.0 %) in

2012. Private non-profit sector accounted for less than 0.1 % of total outlays in the same year. Data on research by businesses are quite scarce in Slovakia. The 2006 – 2013 EU Industrial R&D Investment Scoreboards included no Slovak company.

The responsibilities for the research and innovation policies have been divided between the MESRS and ME since 2007. Innovation policy measures are implemented by the ME and its agencies. The ME drafted the 2007 Innovation Strategy and 2008 Innovation Policy and the 2011 Innovation Policy documents. It also established the Slovak Innovation and Energy Agency in 2007. This organisational division was prompted by introduction of the Structural Fund programmes. The ME implemented the Operational Programme of Competitiveness and Economic Growth (OPCEG). The MESRS implemented the Operational Programme Research and Development (OPRD) and the Operational Programme Education (OPE). In order to manage the OPRD and OPE, the MESRS established the Agency for the Structural Funds of the European Union (ASFEU).

The R&D intensity in Slovakia had been in decline from 1989 and began to rise in 2010. In 2012 public and private investment accounted for 0.82 % of GDP (up from 0.48 % of GDP in 2009), which was mainly due to capital investment in equipment and instruments from projects funded by EU Structural Funds. In the period of 2007-2013 Slovakia received € 1.1 million from EU Structural funds for research, innovation and entrepreneurship (81.2 % share of the total state budgetary expenditure and subsidies for R&D). In 1989 R&D expenditure constituted 3.88 % of GDP (The Innovation Union Competitiveness Report, 2011). In comparison with other European countries Slovakia has below average R&D spending by private sector companies (The Innovation Union Competitiveness Report, 2013). In 2010 the share of private funding of R&D r. 2010 fell by more than two percentage points and in 2012 accounted for only about 0.25 % of GDP, while in the Czech Republic it was 1.11 % of GDP and in Hungary 0.75 % of GDP.

In 2010 and 2011 the Slovak Ministry of Education did not contribute significantly to support R&D. There has been a long-term issue on Slovakia´s not taking advantage from opportunities provided by the EU Framework Programme (FP) for R&D. The participation of Slovak entities in FP7 was lower than in FP6 and has also been low in comparison with the Czech Republic and Hungary. Slovakia is the fifth from bottom on the list of EU Member States in terms of allocating funds from FP. Project participants from Slovakia accounted for only 0.4 % of all participants and 0.7 % is the turning point from which Slovakia would get back the investment it contributed to the joint pot[32].

National science and technology policy is prepared and coordinated by the **Ministry of Education, Science, Research and Sports** in the co-operation with other ministries, the Slovak Academy of Sciences, higher education institutions and associations of employers, and industrial research organisations, respectively. The MESRS is

[32] Information provided by a representative from BIC Bratislava at an event organised by Centre of Scientific and Technical Information in Bratislava on 30.5.2012.

responsible for policy- and decision-making in the field of R&D and S&T. The ministry uses a range of methods and instruments for policy making and coordination:

- consultation of all R&D and S&T policies drafted by the ministry with other bodies of central government and most important R&D policy stakeholders;
- regular evaluation of the performance of State R&D programmes;
- annual reporting on R&D policies in Slovakia in the international context since 2005
- technology foresight exercise (based on ERAWATCH, 2014).

The MESRS also administers the top body for co-ordination of S&T and innovation policies - the **Government Council of the Slovak Republic for Research, Development and Innovations (GCSRST)** re established by the Slovak Government in September 2011. The GCSRST is chaired by the Prime Minister and has 34 members (several ministers, chairman of the Slovak Academy of Sciences, president of the Slovak Rector Conference, and also representatives of employer associations and R&D associations). According to our views the GCSRST plays a prevailing passive role (discussing and approving documents prepared by other bodies) in directing development of science, technology and innovation (STI) . To better fulfill its purpose it should have an independent status, consist of STI experts and play much more active role in the STI.

For instance the Canadian Science, Technology and Innovation Council (STIC) is an independent advisory body mandated by the Government of Canada to provide confidential advice on STI policy issues. This advice helps in government policy development and decision making. STIC is also mandated to produce biennial, public State of the Nation reports that benchmark Canada's STI performance against international standards of excellence.[33]

Another example is the Swiss Science and Innovation Council (SSIC) - the advisory body to the Federal Council on issues related to science, higher education, research and innovation policy. As an independent consultative body, it promotes the framework for the successful development of the Swiss higher education, research and innovation landscape from a the long perspective.[34]

The overview of the Slovak R&D and innovation system is represented in Figure 8.

[33] http://www.stic-csti.ca/eic/site/stic-csti.nsf/eng/home
[34] http://www.myscience.ch/directory/federal_administration/swir

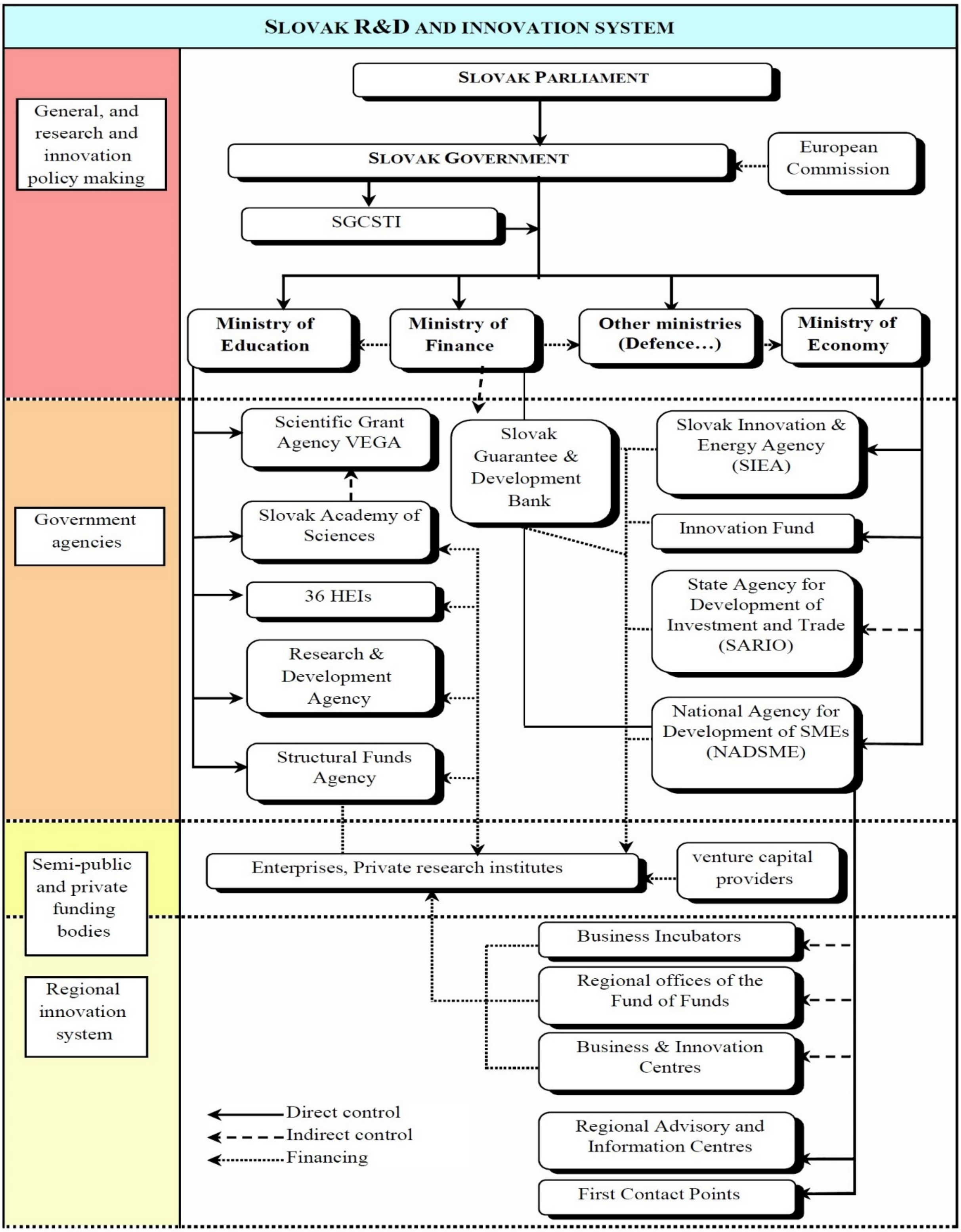

Figure 8: National R&D and innovation system of Slovak Republic

(Source: Erawatch, 2014, p.8)

The MESRS presently provides support for R&D via three projects funded mainly from EU Structural Funds: 1) National Infrastructure Project, 2) project aimed to build electronic information resources for R&D and 3) project building an R&D data hub (storage and processing complex information for R&D and provision of application support services). All projects are implemented by the Centre of Scientific and Technical Information (CVTI) in Bratislava and run till the end of 2014 or October 2015.

The Scientific Grant Agency (VEGA) was set up by the MESRS for grant funding of basic scientific research of the HEIs and the SAS. In 2012 the VEGA allocated € 13.34m to 1,803 research grants.

The main objective of **the Agency for Structural Funds of EU (ASFEU)** is to provide assistance for the implementation process of EU Structural Funds under Operational Programmes Education and Research & Development. The assistance is mainly aimed at public organisations. The Agency will publish calls on mobilization of excellent research teams in the specialization areas of the RIS3 SK in 2015.

R&D infrastructure, are often used to fund human capital and basic research. APVV approves only about 13 % of the funds applied for through a competitive selection process and there is no constancy in providing financial resources. In 2012 state aid amounting to € 2.2 million was granted to 34 businesses (42 % decrease in comparison to 2011) and in 2013 it accounted for € 1.9 million was granted to 22 businesses (16 % decrease in comparison to 2012)[35].

The Slovak Academy of Sciences (SAS) is a research institution providing the bulk of basic research in Slovakia. It comprises of 56 research institutes (15 in nature science and engineering, 21 in life science and chemistry, and 20 in social sciences and humanities) and 8 other units (service organisations and infrastructure facilities). It employed 3,281 people in full-time equivalent (thereof 1,812 holding a scientific degree and 419 PhD students, the rest of employees were technical staff) in 2012. The SAS had budget of € 58.99m in 2012, € 60.08 in 2013 and € 60.80m in 2014.

The Institute of Technology (IT SAS) has been formed within the SAS in 2008 as a specialized unit for integration of SAV interdisciplinary activities (10 partner SAV institutes with more than 200 researchers) in applied research, development and innovation carried out in four competence centers (CC) focusing on of the multifunctional materials and nanotechnologies:

CC NANO – Nano-materials and nano-technologies;
CC ELEKTRO – Materials of electronics and electrotechnology;
CC MATER – Construction materials;
CC EXTMATER – Materials for extreme conditions.

[35] APVV Annual Reports, 2012 and 2013.

Its competences include management of IP and commercialization of knowledge and technologies created by the researchers.

Slovak Innovation and Energy Agency (SIEA), agency of the Slovak Ministry of Economy, provides financial support for innovation through projects of industrial research and experimental development using EU Structural Funds. SIEA implements the Operational Programme for Competitiveness and Economic Growth which focuses amongst others on technology transfer and innovations in companies. Support is primarily aimed at SMEs outside the capital of Bratislava, but it does not preclude large enterprises. The minimum contribution is € 30 thousand and the maximum is € 2 million. SIEA also provides businesses support for introducing innovative and advanced technologies to industry and service sectors in regions with high unemployment. The minimum contribution in this case is € 20 thousand and the maximum is € 6 million. To promote product innovation, innovation of technological processes or services the Ministry of Economy had prepared (in cooperation with SIEA) a pilot scheme[36] which in the second half of 2013 provided innovation vouchers[37] to 21 businesses. These could use the services of 43 registered research institutes. The vouchers for SMEs were worth € 3,500 and those for large companies were worth € 10,000.

A year later, in 2014, a follow-up scheme was implemented[38] which offered vouchers to SMEs in the value of € 5,000 and to large enterprises in the value of € 10,000. Businesses could use the services of up to 54 registered research institutes. SMEs could cover up to 100 % of their R&D expenditure with the voucher, where the large enterprises could cover only up to 45 %. The total budget for the 2014 scheme was € 235,000.

The Slovak Business Agency (SBA, former National Agency for the Development of Small and Medium Enterprise up to March 2014) has focused mainly on organising seminars and formulating national policies and strategies in recent years. Thanks to government initiative and the EU PHARE programme between 1992 and 1995, network of Regional Advisory and Information Centres (RAIC) and network of Business Innovation Centres (BIC) was set up including their top body the National Association for Development of Business Enterprise (from 1995 until 2014 National Association of Information Centres & Business Innovation Centres). The Regional Advisory and Information Centres are non-profit organisations providing subsidized consulting and educational support to persons interested in entrepreneurship and SMEs. Business Innovation Centres provide entrepreneurial and innovative advice and facilitate international technology transfer and financial advice. They also offer support to those interested in EU framework programmes for research, development and innovation (through FP and CIP programmes).

[36] According to the SIEA website http://www.siea.sk/inovacne-vouchre-2013/

[37] Innovation vouchers - usually provided to SMEs to purchase know-how or services which are not commonly available and which will strengthen their competiveness on the market.

[38] According to the SIEA website http://www.siea.sk/inovacne-vouchre-2014/

BIC Bratislava, s.r.o. is a key member of the BIC network. It has been a co-ordinator of the Enterprise Europe Network representation in Slovakia since 2008, operating the information portal www. Enterprise-Europe-Network.sk. It played a main role in elaboration of the Research and innovation strategy for intelligent specialization of Slovakia RIS3 SK.

Slovak Guarantee and Development Bank (SZRB) was founded in 1991 by the, Slovak Ministry of Finance. It focuses specifically on the development needs of Slovak SMEs, towns, municipalities, owners of apartments and non-residential premises as well as apartments' trustees by: (i) providing bank guarantees for financial loans, mainly for entrepreneurs, (ii) fast bank guarantees for SMEs to improve SMEs access to financing, (iii) lending programmes, especially microloans to SMEs, women entrepreneurs and young entrepreneurs (iv) loans to SMEs within the EU initiative JEREMIE.

The Slovak Investment and Trade Development Agency (SARIO) is an organisation directed by the ME with indirect influence on the R&D and innovation system. Its strategic objectives are: (i) applying an effective framework for the support of foreign investors and increasing the portion of investors with high value-added production, (ii) supporting such export activities of Slovak enterprises that would significantly increase the turnover of Slovak foreign trade, (iii) qualified and effective administration of EU Structural Funds providing support for activities within the framework of Foreign Direct Investment and Foreign Trade (infrastructure development, intensification of international cooperation, and image-building of the Slovak Republic). In 2013 SARIO agency assisted in 18 successful investment projects leading to creation of at least 3,678 direct new jobs compared to 16 investment projects with creation of at least 3,055 direct new jobs in 2012. The total planned investmentsin 2013 accounted for € 442.1m (thereof 8 new facilities and 10 expansions of the existing facilities) compared to € 473.2m in 2012.

As of 2013 there were 23 public and 13 private higher education institutions in Slovakia. Public support to HEIs amounted to € 443.4m in 2013. Estimated share of public expenditure on the university system in GDP was 0.62 % in 2011, 0.62 % in 2012 and 0.61 % in 2013.

Traditionally, research and innovation policies were considered matters of central government in Slovakia. Slovak regions have no legislative power in the field of research and innovation. No explicit regional R&D and innovation programmes and/or policy measures have been developed in Slovakia. However, the Regional System of Innovation (RSI) concept has grown highly popular mainly due to the emergence of identifiable regional clusters of industrial activity, more policy making competences and responsibilities assigned to regions, policies advanced by the EU for regional development such as the European Cohesion Policy as well as globalization and increased societal challenges. The current self-governing regions in Slovakia have been in existence since 2001. They bear responsibility for regional development, economic performance, competitiveness and innovation support to be translated in enterprise creation in the region in order to increase productivity, optimise the economic structures, create new and protect vulnerable jobs. Thus they make efforts to promote new technologies and innovation within their territory while respecting the regional specifics.

Unlike the regional authorities from Western Europe they miss sufficient experience in stimulating and managing business and economic development and innovation. Furthermore, they neither receive any funding for this purpose, as it is the case in the Czech Republic, nor do they have a strategy to promote it. One of the exceptions is the Regional authority of the Žilina Region which has been actively promoting entrepreneurship and innovations making use the appropriate EU funds. This regional authority collaborates with institutions in the Silesian Duchy in Poland to support innovation in the fields of transport, energy, tourism and environment. Since 2006 it has organised the annual conference "Innovative Development of Regions – The Day for Ideas and Innovation".[39] The conference is organised in partnership with other key players in the region - Junior Achievement Slovakia (provider of entrepreneurship education), IPA Slovakia (consulting and training institute focused on the development of industrial engineering, cooperating with the German Fraunhofer Institute), University of Žilina and the Žilina Science Park.

In the Innovation Union Scoreboard 2014 Slovakia ranks among the weaker part of the group of moderate innovators with with innovation score 0.328 at the level of the 59 % of the the EU-27 average score of 0,554. According to the NUTS classification (Nomenclature of territorial units for statistics) used in the EU for elaboration of the Regional Innovation Scoreboard is Slovakia represented by four NUTS 2 regions (basic regions for the application of regional policies): Bratislava Region, Western Slovakia, Central Slovakia and Eastern Slovakia. Regional Innovation Scoreboard classifies 190 regions of the EU, Norway and Switzerland in four performance groups:

a) regional innovation leaders are those regions which perform 20 % or more above the EU average (34 regions, e.g. Zürich Region, Stockholm Region or Noord Brabant Region);
b) regional innovation followers are regions performing between 90 % and 120 % of the EU average (57 regions, e.g. East Austrian (Vienna) Region , London Region or Bremen Region);
c) regional moderate innovators are regions performing between 50 % and 90 % of the EU average (68 regions, e.g. Central Bohemia, Veneto Region or Maloposkie Region);
d) regional modest innovators perform below 50 % of the EU average (31 regions, e.g. Hungarian South Danube Region, Adriatic Croatia region or North-East Bulgarian Region).

[39] http://inovacie.regionzilina.sk/inovacie/irr/

The innovation performance of these Slovak regions (European Commission, 2014, p.50) ranges from the regional innovation follower (Bratislava Region), through regional moderate innovators (Western Slovakia and Central Slovakia) to regional modest innovator (Eastern Slovakia) thus confirming the country innovation performance. Within the period of 2004 to 2010 only Bratislava Region advanced in 2010 among the group of innovation followers, the remaining Slovak regions stayed in the same performance group inspite of their improvements in some innovation performance indicators. In comparison to the Czech Republic divided in 8 NUTS2 regions during the period of 2004 to 2010 the Prague Region worsened its status from regional innovation follower to regional moderate innovator in 2010 and the other 7 regions kept their innovation performance as moderate innovators.

1.6.3 Cooperation of innovative companies and with HEIs

Low R&D expenditures do not create sufficient capacity to develop the commercial potential within the R&D system. In 2008 36 % of Slovak enterprises undertook innovation of some kind and out of those only 6.4 % of the implemented products or process innovations were based on new technology. The number of patents granted decreases from year to year, in 2007 574 patents were granted and in 2011 only 317, out of which 50 were national (89 national patents in 2007.[40] According to a statistical survey “Inov1-99” from 2008 only 1.4 % of firms applied for a patent and 1.9 % of firms applied for a utility model (Zajko et al., 2011). The disadvantage of Slovakia is also low enforceability of IP rights.[41]

Large international companies operating in Slovakia, usually undertake R&D in other countries and cooperate with Slovak HEIs only to a limited extent. Slovak SMEs do not focus on activities requiring R&D, hence their investments in the area are very low. According to data from the Slovak Statistical Office published in 2012 Slovak SMEs mainly provide services (almost 50 %) and SME group is most represented by micro-enterprises (96 %), having up to 10 employees. According to statistics, in the last 10 years the share of services has been increasing at the expense of industry and trade. As a result of an unfavourable economic situation only 56 % of Slovak SMEs made profit in 2011.

Industry share of investment in R&D accounts for approximately 50 % (80 % of those innovations are implemented by large companies). SMEs usually only invest in organisational and marketing innovations, not technology. Decline in private investment in R&D is particularly striking in comparison with other countries in Central and Eastern Europe (CEE region), such as the Czech Republic, Hungary and Slovenia. This

[40] 2011 Annual Report of the Slovak Office of Industrial Property

[41] Based on the information provided by a senior associate, head of IP practice, at a Slovak law firm Ružička Csekes in association with CMS.

jeopardises economic growth and scientific and technological convergence with the European average in the long term, particularly if existing infrastructure investments would be discontinued. If Slovakia continues to suffer from a lack of government supported instruments for innovation and venture capital, innovation intensity of enterprises will not rise. Entrepreneurial universities will need to consider focusing more on global markets.

It is also important for HEIs to pay attention to the needs of businesses buying externally developed technologies. Studies have shown that there is often a mismatch between the needs of businesses and activities of HEI intermediaries (TTO). Technology must be available at a stage where it can benefit businesses. Technology development should be considered as a combination of knowledge, skills and know-how of the organisation (MacDonald, 1992), not just as an object of buying and selling. According to the conceptual framework for the technology transfer (Seaton, Cordey-Hayes, 1993), firms must also have the capacity and ability to a) recognise - discover new useful technologies, b) estimate their value for the future development of their enterprise, c) to carry through implementation of selected projects internally, d) utilise new technology and realise its maximum potential for a productivity gain.

One of the prime examples of HEI-industry cooperation is the long-term relationship between the Slovak University of Technology and Volkswagen Slovakia (VW SK). The two organisations have been working together since the 90s. Initially VW SK funded new laboratory equipment at the Faculty of Mechanical Engineering and later both, VW SK and the Faculty of Mechanical Engineering developed a joint study programme for automobile production. Part of the course is delivered at the VW manufacturing plant. First students graduated in 2013.

Master study programmes are delivered also in cooperation with the Faculty of Electrical Engineering and Faculty of Materials Science. VW SK offers internships and scholarships to students, and proposes subjects of dissertation theses. In 2014 STU and VW signed a framework agreement to collaborate on educational and R&D projects.

Technical University Košice collaborates with industry partners among others through the local information and communication technology (ICT) cluster called Košice IT Valley. The University is of its founders. In January 2014, Košice IT Valley together with some of its members and other ICT companies and with significant support from SAP Software & Solutions decided to develop new a new programme - SAP Academy which will deliver educational projects and create new jobs in the region Similar activites are organised bythe Institute for Competitiveness and Innovation at Žilina University.

1.6.4 Innovation infrastructure

Clusters

Industrial and scientific research clusters are an important instrument to support business enterprise, co-operation, innovation, creation of new networks, formation of start-ups and spin-offs etc., in other words – they contribute to the development of an innovation ecosystem in the region. They bring together private and public sector companies, universities (including their science and technology parks and technology incubators), and provide a wide range of services for its members. Cluster initiatives in Slovakia are relatively weak especially due to the lack of state support mechanisms at national and regional level, limited availability of venture capital and the continuing weak innovation performance of Slovakia.

With a commitment to common goals in 2010, the most significant clusters established a joint union called the Union of Slovak Clusters. In 2013 eight of the strongest Slovak clusters joined the European Cluster Excellence Initiative[42]. Many Slovak clusters included in the directory of European cluster organisations however do not comply with the cluster definition; they are groups of organisations active in the respective sector which cooperate in some form, but do not have the characteristics of well-developed European clusters.

The Automotive Cluster-West Slovakia, Slovak Plastics Cluster, the First Slovak Engineering Cluster and Kosice IT Valley Cluster can be rated as prosperous industrial clusters. They bring together businesses, schools, universities, regional governments, city councils and relevant agencies, and implement projects co-financed by the EU to widen their scope of activities.

European projects preparing policies for cluster development have been coordinated by the SIEA and the Slovak Business Agency. These projects however did not have funds to directly support individual clusters or cluster initiatives. In 2013 the Ministry of Economy launched a scheme under de minimis rule with a budget of approximately € 200,000 to support industrial clusters by facilitating professional advice, training, cluster promotion, including support to participate in international projects and international networks. The scheme allowed clusters to apply for projects with 60 % match funding and receive IP to € 40,000[43]. Six industrial cluster organisations were supported by the scheme. Further funds were released in 2014 for similar activities and for increasing the effectiveness of collaboration within clusters. The second programme with a budget of € 113,000 enabled clusters to apply for projects with 70 % match funding and receive up to € 20,000.

[42] More information is available here: www.clusterexcellence.org and www.cluster-analysis.org
[43] According to the SIEA website https://www.siea.sk/dotacie-pre-klastre-2013/

Science Parks

Services provided within science parks in developed economies (e.g. Great Britain, Finland, Sweden) typically include support for innovative ideas from the point when laboratory results start to emerge and there is commercial potential. Teams of consultants working at science parks, which often include a technology incubator, usually provide specialised professional advice and pre-incubation mentoring. Parks which provide proof of concept funding for products or services, market analysis services, IP protection and commercialisation support often dispose of a special pre-incubation office space for start-ups.

Many science parks in the United States focus on specific areas (Battelle Technology Partnership Practice, 2007). Their philosophy is: if the region wants to compete in the development of selected technologies, it must strengthen those areas in which it may become a world leader. Consequently, it is now common practice that science parks concentrate on supporting recognised technological fields or industrial clusters. In recent years, the importance of international partnerships in university science parks has significantly increased and it is expected that in the future parks will need to think global.

Incubators in Slovakia have so far been gaining their income primarily from renting[44] office space, but in 2013 a number of university science parks started to be built (Brighton, 2013) - Park Technicom in Kosice and two at STU (Bratislava, Trnava). The science park at the University of Zilina should be completed in 2015. All parks should also incorporate technology incubators which would offer pre-start-up and start-up advice and support for innovative SMEs aiming to build new R&D centres using local professional workforce.

The science park in Zilina includes an incubator for start-ups from the University of Zilina and in addition to providing office space, it facilitates accounting advice and consulting in the field of IP protection in cooperation with the Slovak Industrial Property Office. Originally, the science park in Žilina was to be completed in 2001, but the plans failed due to a lack of funding.

Several business and technology incubators were established thanks to the initiative of selected universities and city councils and financed by the PHARE programme. They were set up to encourage technology-based start-ups. Since the closure of the programme, due to a lack of funding, the incubators offer more or less just office space (the number of technology-oriented companies as residents markedly decreased), advice on preparing a business plan, breakfast seminars, and facilitate contacts from various advisory companies (e.g. training, networking).

[44] Based on annual reports, websites interviews undertaken in October 2013 with the manager of the STU Technology incubator, consultant at the Business incubator of Zilina University, and TTO manager at Technical University in Kosice.

Established science parks use different mechanisms to build connections between HEIs and industry. The following are regarded as the key success factors (Battelle Technology Partnership Practice, 2007):

- Employing experts who actively develop partnerships between HEI departments and companies;
- Offering the use of HEI laboratories, equipment, facilities and other equipment;
- Offering the exchange of human resources - student internships, work experience and other cooperation programs;
- Offering the services of their own TTO which collaborates with the HEI.

It will be very important for the newly built Slovak science parks to offer the above services. Given that TTOs at Slovak HEIs do not have adequate know-how and capacity in terms of human resources or finances for their operation and development, the question arises whether the science parks will be able to sustain themselves and provide added value following the closure of EU projects that financed their creation.

An interesting fact remains that past research of measurable added value of science parks did not bring conclusive results (SQW, 2009). Studies have frequently compared the performance of companies in a science park with a suitable sample of companies located outside parks and examined whether there were statistically significant differences in performance (e.g. changes in employment, turnover, profitability, R&D intensity, the number of patent applications, introductions of new products and services on the market, links with universities, the survival rate or company wind-up). Most studies concluded that the evidence that companies in the science parks perform significantly better than those outside, was inconclusive, even though they acknowledged science parks had a higher quality business environment for stimulating creation and growth of new technology companies. Positive impacts of science parks on local and regional economies are mainly of an indirect nature. Some of them can be quantified in terms of contributing to the improvement of business performance, e.g. companies located in science parks in areas with a strong knowledge-based economy have submitted nearly twice as many patent applications in comparison to companies in science parks in areas with a weaker knowledge-based economy (UKSP, 2003).

Technology Innovation Centres (TIC)

TICs are organisation focused on utilising new technologies through infrastructure which spans across a wide spectrum of activities from research to commercialisation of technologies (Department for Business Innovation & Skills, UK, 2010). TICs are established to support existing as well as emerging technologies and they have become an important part of government policies and strategies to promote innovation. Most TICs are built from public funds, and later financially supported by public funds to cover investment costs associated with starting and developing new activities or to assist with obtaining and implementing funded R&D projects. Additional funding needed for their operation TICs seek from contract research and by applying for national and EU grants.

Like science parks, TICs are normally built near leading universities and provide equipment and services to businesses based on new knowledge and technologies. Their objective is to develop their own know-how and ability to cooperate with universities and other TICs. Similarly to universities TICs work on R&D projects as part of innovative programmes financed from public funds, they provide access to technological infrastructure and customised research services. Additionally, they help businesses by allowing them to share R&D costs, access to facilities and expertise in order to reduce their risks, shorten the time from lab to market and utilise synergies in the know - how throughout the value chain. Typical activities and outputs of TICs include expansion of manufacturing processes and production of technology and application demonstrators (Andersen, Le Blanc, 2013). They help businesses to get beyond their abilities and what they could achieve with their own resources by providing a range of support services while carrying the risk associated with inventions in the early stage of their development. TICs acts as catalysts to build new markets, innovative industries, clusters and networks.

Most countries surveyed by the OECD in 2007 (OECD, 2007 Policy Brief) highlighted the importance of TICs, considered them to be very effective infrastructure for stimulating innovation. Since TIC's work primarily with industry requirements, the risk of wasting resources and time is minimal. TICs mostly use the strengths of their region in one industrial or technological sector, they tend not to invest concurrently in several areas, as in the case of the German Fraunhofer Institute, where this approach has been very successful. An important aspect of a successful TIC is the weight and priority the public and private sectors assign to innovation in their country.

An example of a well-functioning innovation centre is the South Moravian Innovation Centre[45] in Brno. The centre is funded by city and county councils and also raises funds from various grants. It includes an Innovation Park and Technology incubator with a pre-incubation programme and offers individual counselling and mentoring for new entrepreneurs[46]. The centre management organises various professional meetings and facilitates access to innovation vouchers[47] worth up to approximately € 3,850 (the financial guarantor is Brno City council). Vouchers must be used by collaborating with a HEI in Brno. The centre management closely works with TTOs at surrounding HEIs and provides business brokerage services, helps to find investors and sell technologies or licenses. The centre has a Patent and License Fund which helps companies in the park to protect their IP.

In Slovakia, there are several university based competency centres (centres of excellence) (Brighton, 2013) which were set up through EU funded projects (EU Structural Funds). It is expected that in the long term (10 years and over), these centres

[45] South Moravian Innovation Centre www.jic.cz

[46] According to information obtained from a personal interview with Mr Ondrej Petrášek, commercialisation specialist at the South Moravian Innovation Centre (JIC) in April 2013.

[47] www.inovacnivouchery.cz

should grow and transform themselves into science parks. Centre of Excellence SMART (for technologies, systems and services) was established by research teams from partner organisations STU, Slovak Academy of Sciences and the International Laser Centre in Bratislava. Initially it focused on increasing the level of scientific research, educational activities and international cooperation. Where possible, innovative technologies will be applied in manufacturing processes in Slovak companies.

Technology centre for energy saving Wolf runs trainings and presentations and also a training center for energy efficient Wolf systems in Slovakia and the Czech Republic. It is the most advanced facility of its kind for heating, ventilation and air conditioning in the country. It is also a place where customers can not only see the products and systems, but where they acquire the necessary knowledge and guidance on the principles, installation, commissioning and maintenance of new German technologies.

Technology Centre Púchov (TCP) established with the support of Continental AG in June 2014, opened in November 2014 (€ 7.5 million investment.), The centre offers ample space for strategic development of activities and TCP researchers, new test centre for drum durability tests in tires, tire analysis, etc. The project also aims to expanand the production of car tires.

Within the EU, competence centres are viewed as an instrument for promoting joint applied research (HEI is the centre's main administrator and industrial enterprises are partners). Among the impact indicators of the projects which financed the centres IP creation (e.g. Competence centre for intelligent technologies for computerisation and informatisation systems and services at the Slovak University of Technology has to match its indicators within 5 years after the project closure). In May 2013 contracts were signed to build a *Research Centre of advanced materials and technologies and Centre for Applied Research of new materials and technology transfer* at the Slovak Academy of Sciences and *Research Centre* at the University of Žilina (Research and innovation strategy for smart specialisation in Slovakia, 2013). There is however a persistent issue with projects financed from EU Structural Funds – the rules do not allow HEIs to use equipment purchased through these projects for commercial purposes and generate revenue from it. Failure to comply leads to financial penalties by the managing authority (e.g. the responsible ministry).

1.6.5 Venture capital market and startup support abroad and in Slovakia

Venture capital and startup support in the international context

Venture and private equity capital markets with investment companies and angel investors on its supply side and innovative start-up companies or established companies in need of development capital on its demand side create positive socio-economic effects in developed economies, such as creation of new innovation-driven businesses with high added value, restructuring of economy by creating new sectors in it, e.g. clean technologies, biotechnologies or ICT , new jobs, innovations. The **early stage financing** of companies comprises (i) the seed financing (provided to research, assess and develop an initial concept before a business has reached the start-up phase) with very high risk level and long capital payback periods for an investor, and (ii) the start up financing (provided for product development and initial marketing to companies that may be in the process of being set up or may have been in business for a short time without having sold their product sofar) associated with high risk level. The **later stage (ramp up) financing** is related to companies already backed by VC firms, it is provided for the expansion of an operating company, which may or may not be breaking even or trading profitably). It is less risky and the capital payback period for an investor is shorter. It may comprise development financing or mezzanine financing of companies. The importance of the VC industry for the economy may be best demonstrated on the example of the USA.

The activity level of the US venture capital industry in 2013 was roughly 50 % of its peak levels in the 2000-era. For example, in 2000, 1,050 VC firms each invested $ 5 million or more during the year and in 2013, there were only 548 VC firms.

Venture capital under management in the U.S.A by the end of 2013 decreased to $ 192.9 bn. However, the industry has been contracting since the 2004 high of $ 288.9 bn. The peak capital under management that year was a statistical anomaly caused when funds raised at the height of the 2000 tech bubble were joined by new capital raised post bubble.

Measuring industry activity by the total dollars invested in a given year shows that the industry has remained generally in the $ 20 bn to $ 30 bn range since 2002. In 2013, $ 29.5 billion was invested in 3,382 companies through 4,041 deals. The number of deals was 4 % higher than 2012 counts, but was essentially the same as 2011. The number of first-time fundings increased in 2013 to 1,334 companies from the previous 1,275, but it remains near the top of the healthy range of 1,000 to 1,400 first-time fundings in a year.

In 2013, there were identified 342 growth equity deals in the USA. This compared with 406 deals in 2012, but was very much in line with the several past years. A disclosed $ 12.3 billion in equity investment was reported for 2013. The structure of the VC investments, especially initial investments in 2013 is represented in the Table 4.

The industry breakdown of shows the following sectors as major recipients the VC investments: software (37 %), biotechnology (15 %), media & entertainment (10 %), IT services and medical devices & equipment (7 % both), industrial/energy (5 %) and consumer products &s ervices (4 %).

The analysis of the VC investments by the life cycle stage shows that only 3 % were directed to seed stage, however, 34 % went to startup stage, 33 % to expansion stage and 30 % to later stage.

Table 4: Venture capital investments in the US by industry group in 2013

	All investments			Initial investments		
Industry group	No. of companies	No. of deals	Investment amount ($ bn)	No. of companies	No. of deals	Investment amount ($ bn)
Information technology	2,360	2,784	20	1,009	1,009	3.5
Medical/Health/Life Science	649	816	6.9	167	167	1.2
Non-High-technology	373	440	2.7	157	157	0.4
Total	3,381	4,041	29.6	1,334	1,334	5.1

(Source: Thomson, Reuter, 2014, p. 12)

The start up support in the USA has become a matter of national interest recently. **The Partnership Startup America, LLC** was launched in 2011 as an independent alliance of companies (sponsors, such as: Microsoft, NYSE Euronext, American Airlines, American Express OPEN, Dell, Intuit, partnering companies and members – startups), physical entities - regional champions, foundations (Case Foundation a Kauffman Foundation), universities and other leaders focused on support of American innovative startups with high growth potencial. It was launched in 2011 at the incentive of the US Administration, however, it is not overseen or funded by it (Zajko, 2013).

The US Administration and members of the Partnership concentrate their activities in the following five action areas:

1) Make easier access to capital for startup growth (5 measures);
2) Link mentors and education with entrepreneurs (5 measures);
3) Reduce startup barriers, so that administration works for their benefit (6 measures);
4) Accelerate the way from lab to market for the disruptive technological innovations (8 measures);
5) Make easier business conditions for entrepreneurs in the sectors: health care, clean energies and education (5 measures).

All measures stated above are augmented by concrete commitments of the US Administration to representatives of private sector on their implementation. The course of implementation of these measures is monitored in a transparent way in implementation reports and on the website of the US Administration. The comprehensive support of startups in the USA is a part of the anti-crisis measures and is reflected in the national startup initiative supported by the Obama administration and in the rapid development of business incubators/accelerators and startup communities.

The Partnership is represented by the national network of startup communities orientated on fostering success rate of startups in the USA. The Partnership drivers are hundreds of enthusiastic founders, business leaders, investors, mentors and top managers in the roles of startup champions, who work together on strenthening their local communities and fostering organic growth of young innovative companies. Their goal is building up in each federal state a strong startup ecosystem. Champions also build up and maintain positive public perception of startups as innovators and new job creators and celebrate entrepreneurship as a key American value. They also contribute to the image of the USA as the most attractive place in the world for launching and growing startups.

Venture capital and startup support in the EU

According to the (EVCA, 2014) overall private equity investments in European companies remained stable. More than 5,000 companies were backed in 2013, similarly as in 2012. Equity investments decreased by 3 % to € 35.7bn. More than 40 % of the companies that received investments in 2013 were backed for the first time. The overview summary of these investments is stated in the Table 5.

- The total amount of **venture capital invested** had increased by 5 % to € 3.4bn. More than 3,000 companies were funded. Start-up stage investments were prevailing venture capital activity by amount (55 %) and number of companies (59 %). The life sciences, computer & consumer electronics, communications and energy & environment sectors accounted for over 70 % of all venture capital investments.
- More than 800 companies received **buyout investments**. The related equity amount invested reduced by 2 % and the number of companies by 9 % compared to 2012. More than half of buyout investments concentrated on companies active in business & industrial products, consumer goods & retail, business & industrial services and life sciences.
- As in 2012, more than 1,000 companies attracted **growth investments**. This represented an increase of 6 % by number of companies and a 10 % decrease in the amount of equity invested. About 50 % concentrated on companies active in business & industrial services, business & industrial products, computer & consumer electronics and communications.

The private equity investments were directed mainly in the following sectors: business & industrial products (14.1 %), consumer goods & retail (13.8 %), life sciences (13.1 %), consumer services, business & industrial services (9.4 % both), communications (9.0 %), computer & consumer electronics (7.4 %), energy & environment (6.8 %) and financial services (6.2 %). Analysis of territorial structure of private equity investments (in €) showed the following structure: France & Benelux (28 %), UK & Ireland (27 %), Germany, Austria & Switzerland (18 %), Nordics (14 %), South Europe (11 %), Central & Eastern Europe (2 %).

Table 5: Private equity investments in the EU by life cycle stage in 2013

Stage	Seed	Startup	Later	Growth	Rescue/ Turn around	Replace ment	Buy-out
% of investment	0.3	5.2	3.9	10.0	1.0	2.1	77.4
Investment amount (€)	VC amount: 3.4 bn			3.6 bn			27.7 bn
% of companies	7.9	34.7	16.7	21.8	1.3	1.9	15.7
Number of companies	3,034			1,132			812

(Source: EVCA 2014, p. 30, adjusted)
Note: Private equity investments include: VC investments and invesments in growth, rescue / turnaround, replacement and buy-out.

The **Entrepreneurship 2020 Action Plan** of DG for Enterprise and Industry in January 2013 responded to the fast development pace in business environment for startups, which is already a reality at the national and regional level in USA, some EU countries, e.g. Denmark could offer inspiring best practices in this field, and in some other countries of the world (e.g. BRICS countries). It set out three action pillars:

1) Entrepreneurial education and training to support growth and business creation;
2) Create an environment where entrepreneurs can flourish and grow;
3) Role models and reaching out to specific groups.

Within the 2nd pillar the following measures on elimination of startup barriers in the business environment were recommended to member countries:

a) better access to finance for entrepreneurs, e.g. iniciative in microfinancing of SMEs (JASMINE), support in programmes COSME and Horizon 2020 for the period 2014 - 2020;
b) support of businesses in crucial phases of their life cycle and helping them grow, e.g. more favourable tax regulation for early stage businesses, new businesses in loss, for innovation projects and business projects of commercialization of R&D results;
c) reinforcing national and regional support of digital/internet startups by means of ICT innovation vouchers schemes, launch specific actions for web entrepreneurs such as: i) Start-up Europe Partnership to unlock expertise, mentoring, technology and services, ii) Web Entrepreneurs Leaders Club to bring together world-class web entrepreneurs and strengthen the web entrepreneurial culture in Europe; iii) European network of web business accelerators; iv) work with European investors in order to increase the flow of VC and crowd-funding in to web start-ups; and v) fostering web talent by

stimulating the emergence of Massive Online Open Courses and the setting up of platforms for mentoring, and skill building,

d) simplification of legal, administrative and tax aspects of transfer of businesses to new owners, to avoid unnecessary termination of businesses and job losses;

e) bankruptcy and restructuring procedures and support of the second chance for honest entrepreneurs, who got into bankruptcy, e.g. advisory services on preventing bankruptcies and and successful business restructuring;

f) reduction of regulatory and tax burden of businesses, e.g. savings from support of electronic invoicing, full implementation of the European Code of Best Practices facilitating SMEs' access to public procurement by 2013,

g) improved access of SMEs to national and cross-border public procurement tenders, extend the Points of Single Contact to more economic activities and make them more user-friendly.

Venture capital and startup support in Slovakia

The capital (VC) and private equity capital (PE) fields are underdeveloped in Slovakia, particularly for early stage enterprises. The total amount of investments from to Slovak companies was approximately 14 times lower than in the Czech Republic and Hungary, and 20 times lower than in Poland (Zajko, 2011). It is due to underdeveloped capital market with low liquidity, underdeveloped legislation on VC and PE and low number of investors and business angels.

In Slovakia is venture capital (VC) mostly provided from public sources (e.g. state budget, EU funds, funds from international organisations, such as EBRD, EIF, etc.). Slovakia is generally viewed as a small and insignificant market, and the presence of major foreign VC funds in the Slovak market is too costly. However, some Czech, Polish and Austrian private VC investors operate in Slovakia, e.g. Arca Capital, Credo Ventures, Enterprise Investors, 42 angels, Genesis Capital,.or Penta Investments.

The Slovak Business Agency runs several venture capital funds under the umbrella of National Holding Fund, s.r.o. (former Fund of Funds, s.r.o.): Slovak Development Fund, and Slovak Growth Capital Fund, both for business expansion financing of established SMEs, and Innovation and Technology Fund focussing on companies in the seed stage as well as on start-ups and spin-offs. This fund is managed by professional investors and provides financing from € 20K to € 1.5m as equity investment for 4 to 6 years to Slovakia-based entrepreneurs at preferencial conditions, as well as coaching and counselling to startup entrepreneurs.

JEREMIE (Joint European Resources for Micro to Medium Enterprises) is a joint initiative launched by the European Commission (DG Regional Policy) and the European Investment Bank Group to improve access to finance for SMEs in the EU within the Structural Funds framework for the period 2007 - 2013. JEREMIE enables the EU Member States and Regions to put money from the Structural Funds and also national resources into holding funds that can finance SMEs in a flexible and innovative way.. The

European Investment Fund (EIF) manages a total of 14 JEREMIE Holding Funds within the EU, 7 at national level and 7 at regional level.

In Slovakia, the JEREMIE Holding Fund was financed from the European Regional Development Fund within the framework of the Operational Programmes "Competitiveness and Economic Growth", "Research & Development" and "Bratislava Region", which together have contributed € 100m. **Slovak Guarantee and Development Fund, s.r.o.**[48] ("SZRF") was set up in March 2009, within the framework of the implementation of the JEREMIE initiative in Slovakia, to be a local state-owned entity through which the EIF would perform the JEREMIE activities. The operations of this company, principally venture capital fund investments and guarantees on portfolios of SME loans, are carried out by EIF independently under a separate management agreement. Based on the guarantee agreements signed under JEREMIE with Slovak Guarantee and Development Bank (SZRB), Tatra banka and UniCredit Bank investment loans and working capital totalling € 170m may be provided to Slovak SMEs at preferential conditions. Under the EU Competitiveness and Innovation Programme (CIP) were provided loans, micro-loans and guarantees through Czechoslovak Commercial Bank (CSOB) which has so far provided over € 85m of loans to Slovak SMEs and microenterprises at reduced collateral requirements:

- micro-loans might amount to up to € 25K for micro and small enterprises (with up to 49 employees and turnover up to € 10m.);
- credit guarantees might cover investments in the equity of small and medium-size enterprises (with up to 249 employees) and an annual turnover of up to € 50m: investment of seed capital, start-up capital, mezzanine finance etc. in SMEs

EIF has signed an agreement with OTP Banka Slovensko to provide over € 10m of micro-loans to Slovak micro-entrepreneurs, including young and self-employed entrepreneurs with no access to traditional banking services. In cooperation with Neulogy Ventures, a.s. is provided support to the ICT startups under the JEREMIE initiative.

In 1995 several financial institutions operating in Slovakia decided to establish the **Slovak Venture Capital and Private Equity Association** (SLOVCA), member of the European Venture Capital Association (EVCA). Its primary purpose was increasing awareness of the public on private equity and venture capital available to entrepreneurs, represent the interests of its members towards government and other related institutions or agencies and provide education and training for them. Among its members are e.g. Neulogy Ventures and Investment Club G4.

Neulogy Ventures, a.s. has launched an Innovation Fund targeting seed investments (from € 50K to € 200K), as well as an Entrepreneurs Fund for supporting

[48] http://www.szrf.sk/en/szrf

the international ambitions of established, but growing companies (investments from € 300K to € 1.5m, with the possibility of multiple investment rounds per company up to € 4.5 million). They primarily focus on the ICT, new energy and medical diagnostics fields. Neulogy Ventures will be managing approximately € 23m**.**

Investment Club G4 comprises a circle of private investors providing equity and project investments and loans to internationally orientated start-ups or real estate businesses from an investment pool of € 10m (from € 200 K to € 2m, investment horizon to be negotiated).

Newly established **Limerock Fund Manager, s.r.o.** can provide € 12m for investment to companies in the growth stage through its co-investment fund (with syndicated private partners,) increasing the total funding over € 24m. Limerock Fund Managers have a generalist sector approach, and target mainly companies outside of Bratislava region with a scalable product/service, a competitive advantage and the potential to penetrate international markets.

Informal venture capital - **business angels or angel investors** also play an important role in the development of innovation-driven entrepreneurship. They are high net worth persons who usually provide smaller amounts of finance (€ 25k to € 500k) at an earlier stage than many venture capital funds are able to invest. They are increasingly investing alongside seed venture capital funds and in many countries they are the largest source of external funding, after family and friends, in newly established companies. In addition to the necessary funding, they can share with startup entrepreneurs their industry and business expertise and networks which are as valuable for an early stage company as financial resources. That is why the **Slovak Business Angels Network** was launched as a joint informal initiative of Slovak Business Agency, Young Entrepreneurs Association of Slovakia and Slovak Economic daily (Hospodarske noviny). The main activities of this network are:

- providing a network for business angels, focusing the supply of informal venture capital to a single point, in cooperation with its partners, actively seeks for potential venture capital recipients,
- organizing investment fora and other events to mediate the business angels' capital,
- providing primary business plan evaluation as a filter in the relationship between entrepreneurs and investors, and improves the investment readiness of entrepreneurs,
- promoting examples of successful businessmen, positively influencing the public opinion and increasing awareness about the activities of business angels.

The main barriers (Freňáková, 2011) to the VC and PE development are as follows:

- businesses do not regard innovation as a necessity, e.g. in terms of becoming more competitive;
- lack of start-ups and investment opportunities in the high-tech sector;

- lack of high-tech companies with a feasible business plan;
- investors do not want to bear the risk associated with the initial phases of R&D (these activities are largely financed from own resources also at HEI in developed economies).

One way of overcoming or mitigating these barriers are valuable valuable bottom-up iniciatives boosting entrepreneurship and startups in the past few years, such as:

- organisation of business plan or startup competitions, such as StartUp Weekends (based on the proven international format of the US Kauffman Foundation) , Business Idea of the Year (Young Entrepreneurs Association of Slovakia and J&T Bank), Slovak Startup Awards (Neulogy, a.s., KPMG and West Slovak Energy), Woman Entrepreneur of the Year (Slovak Business Agency), Young Innovative Entrepreneur of the Year (Junior Chamber International, Entrepreneurs Association of Slovakia, Ministry of Economy);
- informal initiatives in support of startup communities inspired by the ideas of the U.S. Startup Accelerators or Startup Cities,i.e. providing equipped space, mentoring, education and networking events for startup enthusiasts, such as The Spot or Connect in Bratislava or the Slovak Association for Internet Economy (SAPIE).

1.7 Academia-industry collaboration in the CENTROPE region

CENTROPE is the name of the cross-border region in Central Europe covering about 6.6 million people (2010) living in eight bordering federal provinces, regions and counties of four countries (Figure 9):

- Austria: Federal Province of Burgenland, City of Eisenstadt, Federal Province of Lower Austria, City of St. Pölten, Federal Province and City of Vienna;
- Czech Republic: South Moravian Region, City of Brno, Vysočina Region (observer);
- Hungary: Győr-Moson-Sopron County, City of Győr, Vas County, City of Sopron, City of Szombathely;
- Slovakia: Bratislava Self-Governing Region, City of Bratislava, Trnava Self-Governing Region, City of Trnava.

CENTROPE remains a European region of growth. Since 2000, the growth rate of the four-country region has exceeded the European average; it has recovered from the recent economic crisis to growth figures higher than the EU-27 average (GDP growth of 1.9 %) again. The comparison between CENTROPE and other EU regions with regard to foreign direct investment shows that the four-country region remains an attractive FDI target out of 261 EU regions. According to the evaluation of the Fdi Intelligence

(Financial Times)[49] based on the 2014 data in the ranking Top Eastern European Cities Brno ranks #6 and Bratislava #9 and Vienna ranks #5 in the ranking Top Western European Cities. As for the number of current FDI projects[50]. Vienna ranks # 1 in Austria with 55 projects out of 125, Bratislava ranks # 1 in Slovakia with 20 projects out of 103, Brno ranks # 2 in Czech Republic with 16 projects out of 210 and Győr ranks # 3 in Hungary with 6 projects out of 160.

The agglomerations of two capitals Bratislava and Vienna – the "twin cities" – are only 60 km away from each other. Brno, Trnava, Sopron and Győr as additional cities of supra-regional importance, as well as numerous other towns, are the driving forces of economic and cultural expansion in this European region. Growing prosperity, efficient and export-oriented industries, globally networked service hubs and a highly educated workforce are among the trademarks of the Central European Region. CENTROPE thus defines itself as a hub at the heart of Europe. Among other aspects of the CENTROPE Region are relevant to those characterising it as a learning region and technology region[51].

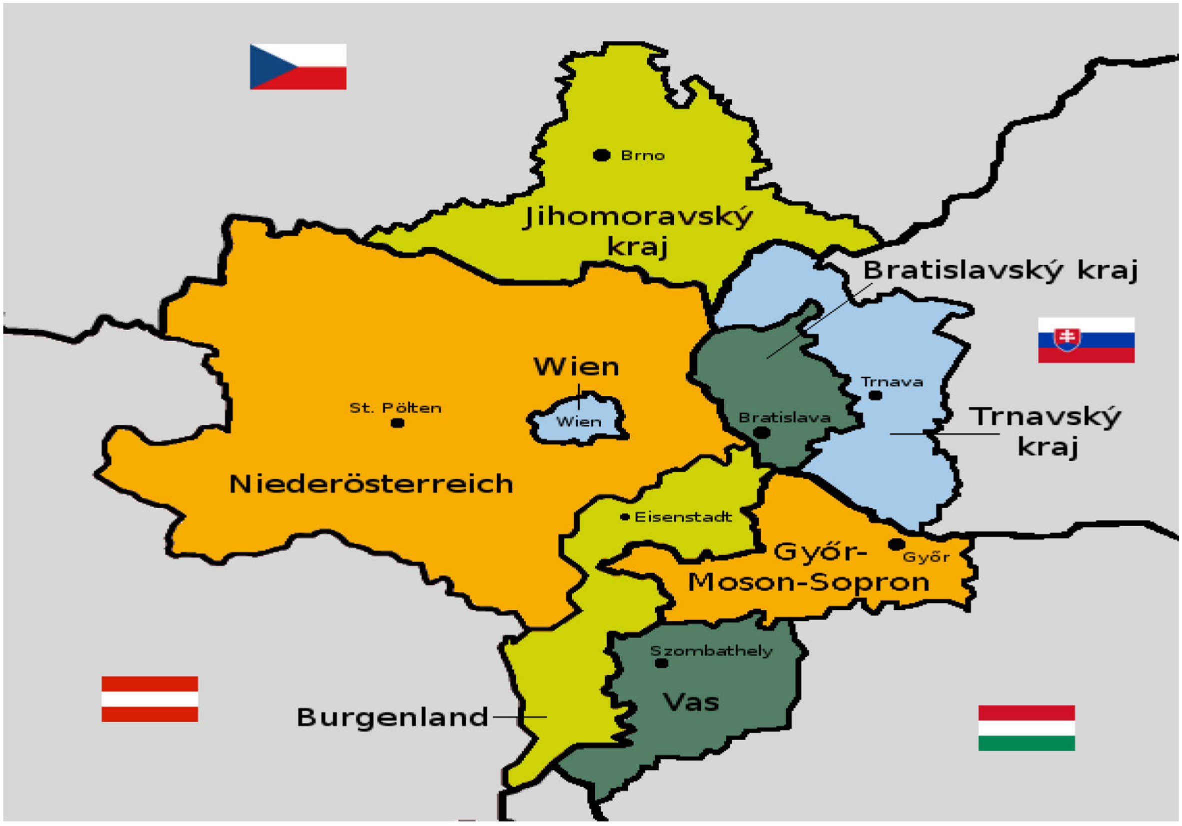

Figure 9: CENTROPE Region

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49 www.fdiintelligence.com/Locations/Europe/European-Cities-and-Regions-of-the-Future-2014-15
50 www.fdimarkets.com/explore/
51 www.centrope.com/repository/centrope/downloads/centrope%20Location%20Marketing%20brochure.pdf

The coordinated collaboration of these bordering regions within the CENTROPE formation has progressed since 2003 and led to the completition of a multitude of successful projects of cross-border collaboration in various areas, such as CENTROPE CAPACITY, centrope_tt, CITT and others.

CENTROPE as a learning region

The large number of students in CENTROPE is a main asset of the regional innovation system. In 2011, more than 420,000 students attended one of the 58 institutions providing higher education, including public and private universities, academies of art, as well as ten universities of applied sciences. All are situated across the entire region and thus not only in the three agglomerations - Bratislava, Brno and Vienna, but also in cities like Győr, Krems, Sopron, Trnava or Znojmo. Furthermore, several hundred non-university research institutions and enterprises nurture the scientists and researchers of tomorrow.

Many universities in the Region have a long history record, e.g. the University of Vienna was founded in 1365 and currently with about 90,000 students ranks among the biggest European universities or the Central European Institute of Technology (CEITEC) in Brno focuses on R&D in biomedicine, advanced materials and technologies: 1,200 students and 560 scientists are working on a broad spectrum of innovations, such as nanorobots, special medicinal hydrogels or self-cleaning coats for buildings, to name but a few. The Institute of Science and Technology (IST) Austria in Klosterneuberg is a new centre of excellence offering facilities for up to 1,100 researchers. The high density of educational and scientific institutions within CENTROPE is an excellent basis for its evolution into an internationally attractive R&D hub.

CENTROPE as a technology region

With 13 automotive manufacturing sites within a radius of 300 kilometres, the CENTROPE has the highest density of car plants in the world. The *automotive sector* accommodates many global automobile manufacturers like Volkswagen, General Motors, PSA Peugeot Citroën or Audi, to name but a few.

Another great potential of the Region rests in its growing *life science sector*, in particular biotechnologies. More than 40 research institutes as well as hundreds of life science enterprises ranging from small start-ups to branches of international pharmaceutical companies are active in CENTROPE. A number of institutions, e.g. in the field of molecular biology, have attained world-class status , while expanding life science clusters – especially in South Moravia, Lower Austria and Vienna – are continuously nurtured.

CENTROPE's *ICT sector* consists of about 5,000 ICT companies with more than 10 employees, amounting to about 350,000 specialists excluding numerous smaller enterprises. Nearly 60 universities and R&D institutions run ICT-relevant departments employing over 36,000 researchers. These numbers are relevant potential[52] for the success and further expansion of ICT businesses in the Region and beyond.

Innovative co-operation and excellent infrastructure are keywords of the *engineering industries* in CENTROPE. From mechanical engineering to electronics, from ecological technology to power engineering – they all benefit from the know-how of numerous competence and research centres, e.g. TechBase in Vienna and cluster initiatives like the mechatronics cluster in Lower Austria founded in 2011. Last, but not least, the International Engineering Fair (MSV) in Brno is one of the renowned top platforms of the engineering sector in Europe.

The Region is a major site for *green technologies* and green jobs, delivering outstanding know-how, e.g. via the European Centre for Renewable Energy (EEE) in Güssing/Burgenland, while the Green Building Cluster of Lower Austria tries to pool the most innovative companies from all sectors of sustainable building and living, including all types of construction materials and substances.

Innovation support and technology transfer projects within the CENTROPE Region

An example of cooperation between business and science is the **cross-border project centrope_tt**, where an international expert network in the CENTROPE Region collaborated on developing measures and tools for cross-border innovation and technology transfer in this region in order to improve the competitiveness of CENTROPE SME´s. The project with a budget of € 2 million for the period 2009 – 2012 was implemented within the CENTRAL EUROPE programme. The objectives were to create more transparent and faster access to R&D activities within the region, thus strengthening the competitiveness of CENTROPE SME´s as well as their cooperation with R&D institutions and HEIs on specific research tasks relevant to the market. Ecoplus, the Business Agency of Lower Austria coordinated the cooperation of 15 project partners from 4 countries in four working areas: (1) implementation of cross-border innovation voucher scheme in the Region, (2) development and implementation of a qualification course for the position of cross-border manager of technology and innovation transfer in the Region, (3) development and implementation of an online database of R&D institutions and enterprises in the Region, (4) promotion of the project and creation of an international expert network in CENTROPE.

All project tasks were fulfilled.[53] The **centrope_tt vouchers** were instruments for funding cross-border research cooperation projects (in the amount of € 5,000) implemented in the pilot sample of 50 CENTROPE SME´s thus stimulating their cross-border cooperation in research and innovation.

However, since SME´s often do not dispose of resources for time-consuming and complicated subsidy applications, inquiries, searching for contacts, etc., the project team

[52] http://www.centrope.com/en/regional-activities/citt-centrope-information-technology-transfer
[53] http://www.centrope-tt.info/

developed, implemented and tested an on-line qualification course for cross-border managers of technology and innovation transfer in the CENTROPE Region certified by the ECQA - **centrope_tt academy**. The course provided technology experts with a comprehensive understanding of the R&D and innovation funding schemes and institutions in the CENTROPE countries and the first participants went through an intercultural communication training as well.

To promote efficient networking of various stakeholders in the region, the project team developed and implemented the **centrope_tt map** as an online database listing of over 2,200 R&D institutes and enterprises within the CENTROPE Region located at www.centrope-tt.info. Searching by region and discipline enables both company executives and scientists of research institutions to obtain quick and targeted information on R&D providers in the bordering regions. It supports the easy and optimal use of the potential for interregional cooperation including innovation vouchers to be optimally exploited.

The additional result of collaboration in the project was the creation of the international technology transfer community, interlinked via the social media network XING (**centrope_tt community**), for posting information on relevant topics in technology transfer and innovations and search for expert advice.

The international potential of the Region in ICT has led four teams from Austria, the Czech Republic, Hungary and Slovakia to a project called **CENTROPE Information Technology Transfer (CITT)** co-financed within the 7th Framework Programme of the European Commission. The project was initiated by Vienna's IT Cluster "Vienna IT Enterprises" (VITE). The goal of CITT has been to investigate CENTROPE's potential for more ICT related cooperation between business and research, and based upon this, develop concepts for a cross-border ICT cluster network in the region. According to the project consortium, the core of a successful *CENTROPE ICT-cluster* are export oriented businesses, which are selling their products and services outside of region while supporting the local job market, local retailers and service businesses. A model of further business development may be seen in the automotive cluster in Slovakia or Györ/Hungary.

Other projects on international collaboration in technology transfer and innovations

Further collaboration impulses were given by means of bilateral Operation Programmes on crosss-border collaboration of Slovakia with the Czech Republic, Hungary, Austria and Poland in the period 2007 to 2013 funded from ERDF or some other programmes (Zajko, 2014). Collaboration in technology transfer and innovations was performed mainly through the following measures of Operational Programmes (OP):

- Slovakia - Hungary, priority axis 1: Economy and society (measures 1.1 Support of cross-border business cooperation, 1.2 Cooperation in science, research and innovation);
- Slovakia - Austria, priority axis 1: Learning region and economic competitiveness knowledge (measure 1.1 Cross-border SME cooperation and research, techmology and development cooperation);
- Slovakia - the Czech Republic, priority axis 1: Support of socio-cultural and economic development of cross-border region and collaboration (priority topic Scientific and technological development, innovations and enterprise).

Brief overview of the objectives and outputs of the selected key programmes is given below:

Project „Education.Innovations.Partnership“ was realised within the OP in collaboration between the Slovak and Czech Republics (2007 to 2013, 3 Czech and 2 Slovak partner regions):

Objectives: support of innovation potential of cross-border region through joint activities, strenthening relations between institutions and organisations there in order to create stable collaboration networks and contributing to the inception of framework for entrepreneurship and innovation support.

Outputs: technological and cooperation brokerage events of the partner regions, creation of a technological centre at Trencin University, support of young entrepreneurs by the Science and Technology Park Zilina.

Project ClusterCOOP (2011 to 2013, 7 partner countries):

Objectives: creation and improvement of conditions for efficient and long term collaboration in the Central and Eastern European countries by measures and solutions (legislative and institutional) on efficient support of interregional and transnational collaboration of clusters, implementation proposal of several financial schemes on more efficient innovation solutions.

Outputs: on international collaboration: overview on development potencial of new industrial branches in several regions of partner countries, as well as political tools for inception of these branches through cluster collaboration; distribution of information among clusters on possibilities of international collaboration via contact points and virtual interactive platform.

Project Cluster Excelence Network for Training and Mobility (2012 to 2013, 6 partner countries):

Objectives: quality increase of cluster management grouped in networks in the participating countries by training experts in cluster benchmarking, in cluster management and administration, and the elaboration of the European textile industry study by the Czech (Czechinvest), Hungarian (MAG) and Slovak (SIEA) partners;

Outputs: organisation of study stays of selected cluster managers in the participating countries; benchmarking of 60 clusters by the methodology of the European Cluster Initative and the possibility of their accession to the „Club of European Cluster Managers". They helped improve the management of the clusters in Slovakia.

Project Central Europe Research And Development Area (2009 to 2011, 13 partners from 3 countries):

Objectives: creation of international partnership of institutions in the field of R&D and innovations, mapping of regional R&D capacities for the needs of companies and training of experts from companies and R&D institutions.

Outputs: analysis of innovation environment of partner regions, catalogue of 178 R&D institutions in the regions, trainings in management of R&D and innovation projects.

The Eurostars Programme is a European Joint Programme dedicated to the R&D performing SMEs, and co-funded by the European Communities and 41 EUREKA member countries.[54] **For the period 2014 to 2020, continuation of the project is planned as Eurostars 2 under similar conditions:**

Objectives: stimulation of the SMEs to lead international collaborative research and innovation projects by easing access to support and funding. It is fine-tuned to focus on the needs of SMEs, and specifically targets the development of new products, processes and services and the access to transnational and international markets.

Outputs: up till now 3 collaborative projects with Slovak participation using a total funding of € 0.65 mill have taken place.

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[54] Eureka was founded in 1985 as intergovernmental organization for pan-European research and development funding and coordination. Since July 2013 it has 41 members including all 28 EU member states. Slovakia has been the EUREKA member since 2001 and started participating in the Eurostars projects in 2008 via the Slovak APVV agency. http://www.eurekanetwork.org/

The Centrope Regional Development Report 2011 (Frank, Huber, Rőmisch, 2012) made the following conclusions on the further development of the Region:

- CENTROPE cross-border interactions are still underdeveloped, be it patent and cross-border R&D co-operation, migration and commuting, cross border student mobility or cross-border enterprise networks.
- In this respect a number of initiatives on different topics such as support of cross-border student exchange and collaborative cross-border R&D projects, developing cross-border business enterprises, improving the conditions for cross-border labour mobility, are needed and a wide set of instruments reaching from general awareness building to concrete financial support should be envisioned.
- Some recent studies on individual CENTROPE countries and regions have shown that in international comparisons the export intensity of knowledge intensive service industries is rather low in CENTROPE.
- It is important to intensify the cooperation in international research programmes within CENTROPE, increase co-financing opportunities from European sources and mobility of graduate and postgraduate students as well as young scientists especially in technical disciplines in the region.
- More urban regions in CENTROPE have a strong specialisation on more knowledge intensive service industries. Services have provided an important impetus to both - gross value added and employment growth in CENTROPE in recent years as well as having proven to be more resilient to macroeconomic crisis.

2. Knowledge and technology transfer: implementation and management

The collaboration between businesses and HEIs should bring mutual benefits inspite of necessity to understandand overcome/mitigate the most common barriers to collaboration because of the very different organizational cultures of these environments. HEIs and enterprises may collaborate in various forms, inspiring examples in his context provide some top universities.

2.1 Types of knowledge and technology transfer

Cooperation between HEI departments and industry can take different forms and each requires specific management:

- **Consulting** is cooperation at micro-level. It often starts between a scientist and a business. It is a good way to build trust for further cooperation. Providing consultancy services is an integral part of the scientists' work (e.g. in the UK and Sweden), but there must be limitations so that it does not compromise their work performance in key areas, e.g. teaching.

  University of Oxford supports the provision of consultancy services through its subsidiary company Oxford University Consulting (OUC), which also provides indemnity insurance to scientists. University policy allows scientists to provide consultancy on a private basis in which case the indemnity insurance is not provided by OUC. The policy also highlights the responsibility to examine potential conflicts of interest and the terms of the contracts to which the subject of the consultation relates. OUC covers the provision of services from legal, economic and tax aspects, and promotes the know-how of scientists registered in its database. The university policy restricts external consultations for individual scientists to 30 days per year and stipulates that OUC is entitled to 15 % of the income received from a client on any project[55].

- **Technical support for industrial companies.** This includes:
  - Tools and techniques for programming, modelling and simulation, including theoretical prognosis;
  - Provision of technical equipment, devices and lab instruments;

[55] Based on the information included in the IP Policy of University of Oxford issued in 2009.

— Tacit knowledge[56];
— Solving technical problems for companies.

- Companies sponsoring areas of research, results of which could be useful for them and they do not have the know-how or the capacity to do it themselves. (e.g. lack of knowledge about basic research in the respective scientific field, it's not their primary area of interest). Sponsored research projects are also important to universities, because scientists may participate in R&D assignments with an opportunity for commercialisation, and to be at the forefront of applied research. In some cases contract research allows the HEI to acquire equipment, scholarships for graduate students and funding for support staff.

  To improve the effectiveness of processes associated with the management of sponsored research, HEIs adjust their IP Protection & Commercialisation Policy to include:[57]

  — approval process for commercialisation;
  — practice of identifying IP rights created during sponsored projects;
  — rules for licensing IP created in the course of sponsored projects;
  — an agreement on what aspects of the sponsored project must remain confidential;
  — a process for preventing conflict of interest and a procedure to follow in case it does emerge.

- **Joint research projects between HEIs and companies**, which serve to solve technical or technological problems (both parties exchange their know-how, human and other resources) and provide training for company representatives also tends to be included in such projects. A high amount of trust is usually needed for this form of collaboration and therefore companies are not likely to try it at the beginning of the relationship with a HEI. The government often initiates co-operation on applied research projects through funding programmes aimed at enhancing the competitiveness of businesses. This type of cooperation has similar advantages as in the case of sponsored research. University IP Policy must, as in all the other types of collaboration, consider IP rights, determine procedures for the implementation of such research projects, ensure confidentiality as agreed among parties and avoid potential conflicts of interest or other risks.

  Research within a consortium of partners has similar characteristics; the only difference is that the consortium involves more organisations. Working within a

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[56] Unwritten, unspoken, knowledge held by any human being, based on his/her experiences, insights, intuition, observations and internalized information. Tacit knowledge is acquired largely through association with other people, and requires joint or shared activities to be imparted from on to another.

[57] Intellectual Property Policies and Procedures for Universities and Research Institutions, 2009 (document prepared by University of Oxford for WIPO).

consortium brings advantages for businesses in that it offers access to research results before it can be obtained by competitors. HEI usually provides the base for the whole research and it has the ability to attract businesses with common research interest. In some cases, companies provide the initial idea which the HEI subsequently develops.

- **Technology transfer from HEI to industry.** This form usually requires a substantial amount of funds to finance the development of technologies into tangible, commercially interesting products. On the part of HEIs it requires the establishment of a professional TTO, which provides the necessary services: IP valuation and protection, negotiation of contract terms, commercialisation, marketing and training for researchers. There are two main ways of commercialising IP depending on whether it is required to create a new entity to extract the value the respective IP: 1) it is not required - these cases represent a direct donation, license or sale of IP, 2) it is required – it is necessary to set up a spin-off or a joint venture company.

    1) HEI can **donate** IP rights to someone who wants to use them and make publicly funded research available to society free of charge. This alternative is disadvantageous if the product/technology requires that other organisations have to use the IP (this may be subject to a fee), or if the buyer does not have sufficient means to complete the development of the product/technology or if the final product can be easily copied.

       When selling a license (exclusive or non-exclusive), the owner of IP rights enables the purchaser to use the product / technology for a certain period of time and for a certain fee (one-off, annual, as a profit share, compensation for patent fees, etc.) through a contract. Conditions for license agreements cannot be included in HEI IP policy; they must be set and agreed on a case by case basis.

       Cross-licensing agreement allows two or more parties to benefit from each other's IP in which they jointly own patent claims. A recent example of such cooperation is the agreement between Microsoft and Apple, which also covers patents relating to the design iOS devices. According to the Patent Affairs Manager for Apple there is an "anti-cloning" measure in force which prevents both companies from mutual copying. Another example is when Apple decided that Samsung infringed its patent rights in connection with the Galaxy Smartphone and offered Samsung a patent license with a discount for a cross-licensing agreement for selected Samsung licenses[58].

[58] Source: Information Week http://www.informationweek.com/apple-offered-patent-cross-license-to-sa/240005344

2) **A new company (spin-off)** is usually established if the IP is created as a joint effort e.g. as part of contract research, and stakeholders want to commercialise it. In these cases, IP rights tend to be transferred to a new company through an exclusive license. In other words, spin-off companies are new independent businesses established with the help of a parent company (HEI or a research institute) which provides the spin-off with a product or IP rights to a new product, technology, service, process, etc. In return, the parent organisation will obtain an equity share in the spin-off. It is very important for the parent organisation to have an IP protection and commercialisation policy in place which creates favourable conditions for spin-offs and defines clear rules for their establishment and support.

   In addition to IP Policy, HEIs normally have a policy for creating and supporting spin-off companies. The Spin-off policy defines the conditions under which it is possible to apply and obtain permission from the HEI to set up a spin-off company, including the rights and responsibilities of employees involved with spin-offs (e.g. rule against taking executive positions in the spin-off).

   Surveys show that policies on sharing profits from commercialisation among inventors and policies which determine the option for research organisations to gain returns from a license, influence the level of interest in setting up spin-offs (Gras et al., 2007). Additionally, sufficient government funding for R&D (especially chemistry, life sciences, and information technologies), technological capacity and entrepreneurial organisational culture at the HEI or a research institute, quality and reputation of researchers, experienced TTO, all positively influence the creation of spin-offs.

   University of Oxford manages the creation of spin-off businesses through its TTO (university subsidiary company called ISIS Enterprise), which provides consultancy, checks for conflicts of interest and submits an application accompanied by a business plan to the TTO Director, university bursar and the assessment committee. The University expects the same share of the assets of the new company as the participating scientists, but each case is evaluated separately. The TTO helps businesses find new professional managers, provides professional advice (legal, economic, tax etc.), and where needed it assists with raising funds for the development of new technology or a product[59].

[59] Source: Guidelines to researchers, Starting a Spin-out Company, Isis Innovation (Technology Transfer from the University of Oxford, 2009.

- **Complete outsourcing of R&D to HEIs.** Companies use outsourcing providing they have built a high level of trust with a university and this usually requires the university to set up a spin-off company. The Swedish parliament for example granted universities the right to set up holding companies which could purchase goods and services, implement projects and sell shares in R&D oriented companies. Holding companies also have the right to provide bespoke educational programmes and trainings (Göranson, Brundenius, 2011).

2.2 Technology Transfer Office and the process of commercialisation

2.2.1 Technology Transfer Office (TTO)

HEI business activities are normally performed by specialised units (TTOs), which offer a range of services for researchers, start-ups and established companies. The TTO is either part of the university (department, e.g. within the Rector's Office or as part of the university administration), or it operates as a separate legal entity (subsidiary of the University). Both forms have their advantages and disadvantages, but a separate trading company managed on a commercial basis is in a better position when it comes to communicating with external partners. Comparative analysis of German HEIs (Kratzer, Haase, Lautenschläger, 2010) which focused on their performance in KTT showed that TTOs outside the remit of the Rector's Office achieve much better results. They also tend to be impartial and objectively resolve conflicts arising in the commercialisation process. Additionally, universities sometimes create their own patent offices, incubators, etc.

TTO´s role is also to manage the process of IP commercialisation which can be quite complex also due to the number of different groups of stakeholders who may be involved. The World Intellectual Property Organisation (WIPO) recognises the following twelve:

- HEI;
- researchers/inventors;
- other researchers who helped (e.g. from the department);
- assistants;
- students;
- researchers on secondment;
- visiting researchers;
- sponsors;
- TTO employees;
- patent agency;
- government;
- public.

Each of these groups may contribute to the commercialisation process at some stage and create interest and expectations related to the results. Interests and expectations can differ and may get into conflict, therefore it is necessary to record them and confirm with all parties their share of the final value of IP rights at the beginning of the process. The University IP and Commercialisation Policy serves to establish good practice and prevent conflicts. The policy should also reflect the overall HEI strategy and objectives related to education, research and dissemination of knowledge.

The experience from foreign universities tells that the establishment of TTOs is a long-term project which may require three to five years of hard work and significant initial financial investment. One of the TTO's at a Czech universities secured in 2012 approx. € 11,000 per year for the following 3 years (€ 7,000 fom EU funded projects and 4,000 from the university).

Services for researchers include, inter alia, support for R&D of new technologies, products and services, and analysis of commercialisation options (Feldman, Stewart, 2006). TTOs assist entrepreneurial scientists to obtain the necessary financial resources to commercialise their inventions, incl. business contacts and they promote new technologies. They may facilitate laboratory testing and training to increase productivity, production of prototypes, and organise seminars, conferences and social gatherings for the purpose of establishing business relations. TTOs usually cooperate with other organisations such as patent offices, science and technology parks, technology incubators and venture capital providers.

Services for HEI employees include (Brighton, et al., 2012):

- searching for relevant market segments to assess demand for a product, technology etc.;
- monitoring of various databases with technological enquiries;
- estimating the commercial potential of a product, technology etc.;
- drawing up a marketing plan, preparing marketing collateral to promote IP;
- searching for industrial partners - licensees;
- searching for industrial partners for joint R&D projects;
- initiating preliminary talks with selected partners;
- placing protected IP in relevant databases and registers;
- utilising TTO contacts to advise on commercial exploitability of inventions (e.g. testing prototypes, testing operations, etc.);
- advising/participating in negotiations with partners from industry regarding contractual terms and conditions);
- sending targeted information to scientists regarding technological queries from businesses on various public portals, etc.;
- advising on financing options for further development of a product or technology;
- monitoring of projects and programmes which could help finance KTT at HEI (e.g. expert services, grants for financing IP protection, sponsoring opportunities, business angels' offers etc..);
- providing legal advice, monitoring compliance with contractual terms and conditions, drafting agreements incl. the preparation of standard document templates;

- advising on spin-off creations.

Services for industry partners include:

- offering technologies and products for licensing;
- organising presentations of R&D outcomes with commercial potential;
- distributing newsletters with new technological inventions and offers;
- portfolio of consultancy services;
- providing access to a range of laboratories, workshops and specialised equipment for various activities, including experimental work, testing prototypes, data analysis or training purposes;
- facilitating business meetings with selected university experts/scientists;
- organising social meetings for the community of industry partners, external consultants, financial institutions, etc.;

TTOs often participate in regional advisory boards, working groups with representatives from different sectors, and other national and international associations supporting knowledge and technology transfer, innovation and sharing of best practice.

Provision of professional consultancy services can bring HEIs a solid income; e.g. according to the 2010 annual report the University of Cambridge gained more than € 2.8 million from consultancy. Over € 2.6 million out of that was paid to university consultants and their departments. In 2010 the university entered into 165 consultancy agreements and filed 124 patent applications. The total annual income of the University of Cambridge from consultancy, licensing and transactions with equity shares in spin-off companies reached nearly € 10 million and about € 7.5 million was returned back to the university and its scientists.

In addition to facilitating finance from external sources (e.g. networks/ syndicates of business angels and venture capital providers and firms that can exploit the respective invention), universities tend to have their own funds to support the creation of innovative start-ups or their development. The University of Cambridge provides selected projects about € 12,000 to determine the value of IP it owns and to prepare a marketing strategy. The university has set up a fund which in 2010 had approximately € 68,000 for applied research projects, prototype development, market assessment, etc. provided that the process would lead to licensing a university IP. A university's early-stage investment fund of up to about € 285,000 is used to support the creation of new spin-off companies.

Those who are applying for financial aid must also demonstrate their understanding of the economics of the project and their entrepreneurial skills. Applicants must, inter alia, outline what profits and benefits (not just financial) the university investment would bring, what products could be developed on the basis of the development of the technology, what specific market needs would be met and/or what market failure would the project address. TTOs help future entrepreneurs from their university obtain the necessary know-how and enable them to seek support from experienced mentors.

The TTO usually manages university IP and safeguards compliance with the university IP and commercialisation policy. TTO's role is to assess and recommend the most effective form of IP protection and ensure that terms and conditions for using university IP are met. The TTO also resolves conflicts which sometimes occur despite the initial risk analysis and systems embedded in all associated procedures. TTO employees work with other departments of the university and use independent professional advice from the technology transfer advisory board (normally includes representatives from senior management of the university, senior scientists, and stakeholders from industry). Its members are representatives of the University and external experts. The technology transfer advisory board should:

- support the TTO in decisions on whether to protect IP created by HEI scientists;
- oversee that the right form of protection is selected, to ensure the university invests in IP with a commercial potential (e.g. spin-off applications must be backed up by sound business plans);
- ensure consistency and transparency in TTO's work.

Working in a TTO requires a wide range of knowledge and experience, and the ability to effectively communicate with researchers and business representatives. TTO representative must understand a given industrial sector and technology trends in order to make informed decisions on IP protection. A major part of TTOs work constitutes dissemination of information and linking inventors with potential investors and manufacturers. Effective project management, IP administration and the promotion of services and R&D outputs usually requires more staff, especially at universities that are not well known for their cutting-edge research and a portfolio of patents or other forms of IP which routinely generate a lot of interest (Siegel et al., 2004). Such HEIs must be a lot more active in marketing their IP.

The introduction of systematic processes, central IP administration system, legal support and sophisticated marketing are paramount for successful IP protection and commercialisation (Brighton, 2012). These tasks typically fall within the TTO's operations as well as other services for HEI scientists. HEI IP policy sets clear rules for communication and processes related to commercialisation management: from the initial communication with inventors to licensing or the establishment of spin-off companies. The policy is a key document, rooted it national legislation and takes into account other relevant HEI regulations. It provides a uniform guide for the implementation of protection and subsequent commercial evaluation of R&D results. It determines rights and obligations of HEI employees and students in relation to the creation, publication, protection, recording and commercialisation of the respective IP. However, the policy can fulfil its purpose only when it has the full support of the HEI management and scientists have embraced it.

The TTO also usually helps to create and establish a policy on scholarly publication and dissemination of research findings. It draws the attention to time delay required for publication when the research findings are to be protected. Most universities implement the policy to reserve the right to withhold publication for a period of time (4-6 months). The policy may also limit other activities (e.g. conference presentations) if they could lead to a loss of rights to patent etc. License agreements and the creation of spin-offs should form separate parts of the university IP. Granting exclusive licenses has to be carefully considered, because it can prevent the university continuing in the given research. The position of university staff engaged in a spin-off has to be clearly defined by the policy short and long term.

One part of the IP policy should focus on contract research and the information which has to be obtained from all stakeholders so that their interests are clear from the start and revenue sharing can be agreed in relation to license agreements or the creation of spin-off companies. To promote technology transfer European Commission developed recommendations and practical guidance on IP management and knowledge and technology transfer to businesses (European Commission, 2004 and 2008).

HEI IP policy applies to staff and students, as well as people who have worked at the HEI on the basis of short-term contracts and imposes ownership setting obligations in relation to the given IP and introduces compliance with confidentiality directives. The policy usually includes instances when the project is externally funded from public or private sources, or both and when students are involved. Experience of British universities[60] confirms that the easiest approach is to allocate revenues from commercialisation is to treat students the same way as employees. It is difficult to cover all eventualities, but it is recommended that the employment contracts are linked to all HEI policies and that students also sign they were made familiar with them. HEIs must bear in mind though that some researchers and students (e.g. Ph.D.s) need to publish their works.

The policy clearly defines how students can use their IP and what support they can receive from their university (including for starting up a company)). Well prepared policies balance the interests of students who pay for their studies, but also enable them to contribute to economic and societal development. It is common for HEIs which engage in business activities to embed IP protection and its commercial exploitation in curricula and training in order to grow interest in innovative entrepreneurship (e.g. top UK HEIs, as well as Czech universities, incl. the Czech Technical University in Prague).

When creating policies and guidelines, universities have to carefully consider the possibility of conflict, therefore inventors are obliged to fill in questionnaires, where they declare their contribution/share on the invention, funding sources, any publication of the respective invention and names of those who participated in the development process. If the TTO decides to invest in IP protection it has to perform legal due diligence

[60] Intellectual Asset Management for Universities, Intellectual Property Office, 2011

and likewise it has to address cases where investors' interests may damage the university's reputation or when a researcher with shares in a spin-off company also has responsibility for contractual relations with private companies.

The adoption of a university IP policy is preceded by consultations and a general agreement is sought on the split of net revenues from various forms of commercialisation. If the academic community does not accept the proposed rules, it will not be inclined to comply with them. Obtaining trust is critical for successful cooperation between the TTO and scientists, and it usually takes a long-term effort on the part of the TTO. History of successfully implemented KTT projects, clear and unambiguous rules, competent advisory and fair reward system are the key factors to motivate scientists to work with the TTO and use its services.

2.2.2 Commercialisation process

The commercialisation process is a set of steps and procedures that the HEI selects according to the type of IP and the preferred commercialisation route. Effective commercialisation, like any activity, requires standardisation of all processes and their continuous optimisation. Standardisation has to be introduced into all aspects of TTO's work, within the HEI and towards external customers, suppliers and partners.

TTOs use standard documents and processes; they prepare guides and presentations for scientists and companies, standard application forms, and approval processes. Scientists receive the necessary information when they first express interest in disclosing their invention, e.g. in case of patenting they receive the following documents:[61]

- Invention disclosure form;
- General TTO services guide;
- Guide on various forms of commercialisation;
- IP policy and a revenue reward scheme;
- Tips on avoiding problems with patent applications;
- Patent agent guide on how patenting works, what can/cannot be patented.

TTOs develop processes for recording information about clients and projects, and often use specialised document management software and client relationship management software for managing contacts with clients, partners and suppliers. All TTO's activities are planned and separate plans are usually prepared for marketing management and communications (internal, external). Figure 10 shows a sequence of processes the TTO project managers manage and monitor.

[61] Information provided by Isis Enterprise, subsidiary of the University of Oxford to the authors.

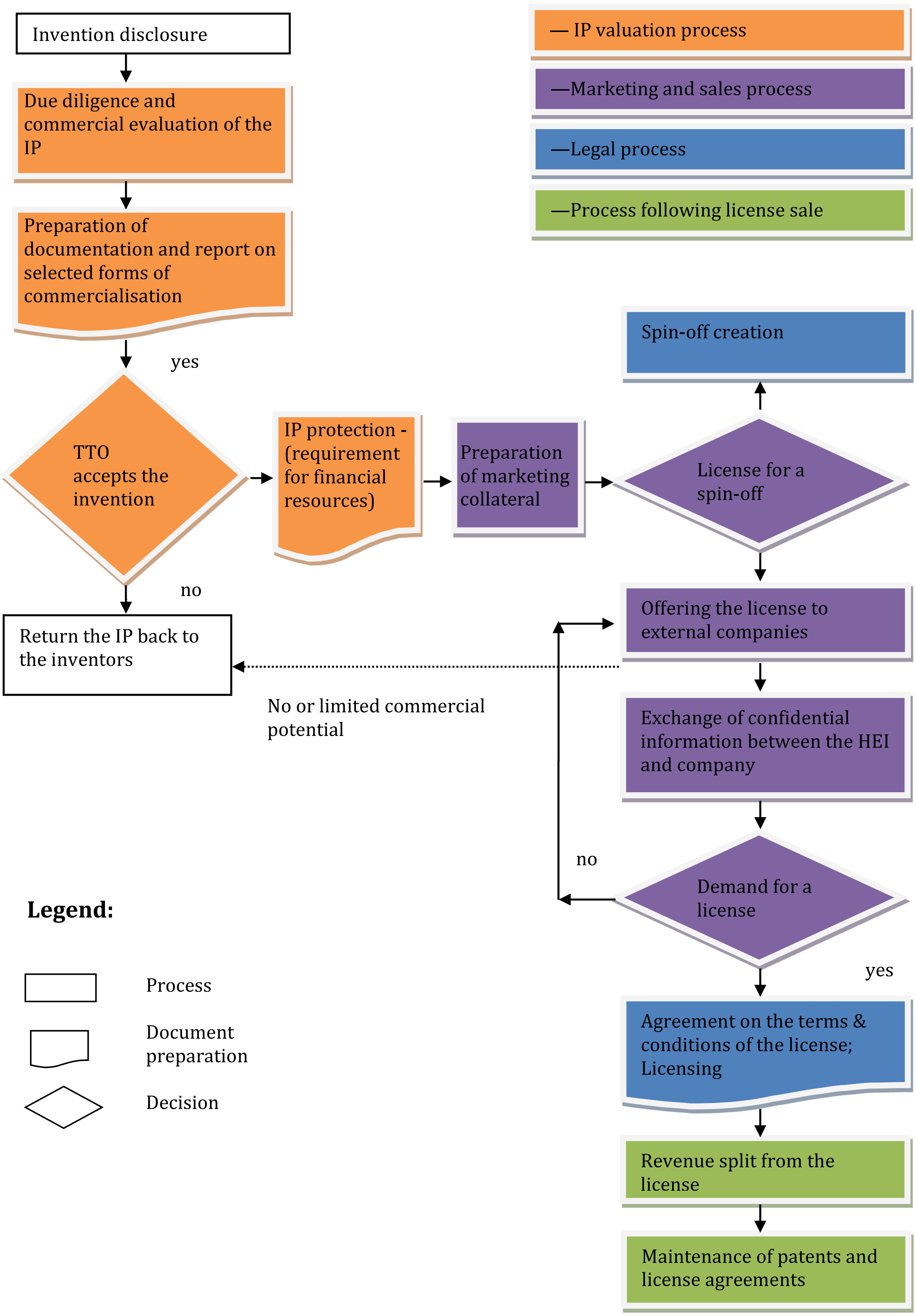


Figure 10: Commercialisation process of intellectual property

Association of TTO managers at universities in the U.S. (AUTM[62]) conducted a survey with one hundred stakeholders (e.g. HEI researchers, researchers working in industrial enterprises, TTO managers, entrepreneurs) at five research-oriented universities in the U.S. and established that the IP protection and commercialisation policy can potentially increase or impede knowledge and technology transfer from HEIs to industry (Siegel, Waldman, Link, 2003). It concluded it was extremely important for the TTO to possess good business and marketing skills and experience and for the policy to include a motivational reward system for researchers.

Each TTO project manager manages multiple commercialisation projects simultaneously (the University of Oxford has got approximately 40 projects in different stages[63]), and therefore it is necessary to follow standard procedures and build a good relationship with all stakeholders. Processes are set as to minimise risks and prevent conflicts. To secure all aspects of contractual relations with third parties, project managers work with legal advisers, advise researchers on their obligations and assist with administrative duties. Subsequently, they help researchers to find new funding sources to meet their research objectives. Project managers coordinate commercialisation projects from the planning stage through to their end or completion, thus enabling researchers to focus on their own work. In the course of their work they utilise the following services and tools:

- International patent databases;
- Patent search services (internal at the HEI or external);
- IP evaluation services – to establish its commercial value;
- Services of HEI departments overseeing contracts for financing research from various external sources – they usually assist with IP due diligence;
- Services of specialised legal advisers;
- Software tools to manage client and supplier relations (CRM);
- Document management systems.

In addition to managing day-to-day operations of the TTO, it is also important for the HEI management to invest time in regular meetings on strategic development planning of activities.

Effective KTT project management requires, according to Isis Enterprise at the University of Oxford, a sufficient number of project managers with a Ph.D. and experience of working in the industry. Project managers must be able to communicate with HEI researchers, business and other experts alike, e.g. patent agents, members of the TTO Advisory Board, external professional advisors (IP valuation, legal matters).

[62] Association of University Technology Managers, www.autm.net
[63] Based on the information obtained during a visit at Isis Enterprise, the University of Oxford TTO

2.2.3 Gaining researchers' interest in applied research and commercialisation

There are number of studies dealing with attracting and increasing the interest of HEI researchers in collaboration with businesses as its low level constitutes one of the major barriers to commercialisation. This subchapter provides a brief overview of several recent surveys of scientists' views on collaboration with industry which were performed with a view to increase their interest in this area of activity.

Although it is not possible to say that the interests of scientists and business converge, experience has demonstrated the benefits of cooperation between the two spheres (D'Este, Perkmann, 2010). Benefits from cooperation include obtaining additional grants for students, laboratory equipment and opportunities for further research. Moreover, the industrial application of an invention can motivate scientists to additional research. The main motivation for scientists is their own research area and if their research interests match the interests of a company, the likelihood of cooperation is significantly higher. Finding a solution to a problem usually motivates scientists more than a financial reward, although in the life sciences area the income from licenses can be very motivating and generate high interest (D'Este, Perkmann, 2010).

A wide survey[64] of British university scientists in engineering and physics studies carried out in 2004 (D'Este, Perkmann, 2010) which examined their motivation and frequency of various forms of collaboration showed that the largest percentage of scientists collaborated at least once, and most often it was on contract research basis, to solve a specific problem and on consulting activities. Patenting and participating in spin-off companies are less common. Those who had experience with patenting and worked in spin-off companies were motivated by financial reward, but in terms of further research the majority received no benefit. Consultancy services on the other hand not only led to a financial reward, but also to research contracts and stronger relationships with businesses. The most important outcome of the survey was the knowledge that the initiators of collaboration were businesses seeking new solutions to their problems or they wanted to improve the quality of their product or process. HEI researchers expressed interest in searching for such solutions.

The survey also aimed to identify barriers in collaboration with industry and these were shown to be: missing IP policy/guidelines for university-industry collaboration, adverse conditions and rules imposed by the university or funding body, different research interest of scientists in oppose to businesses' requirements, about possible conflict over royalties from patent licenses or other IP rights and short-term research interest of industry partners.

A study of ten universities in the counties of Thuringia and Saxony in the former German Democratic Republic (East Germany) (Gimm, Jaenicke, 2010), which analysed

[64] 1,528 completed questionnaires were received during the research,i.e. a return rate of over 35%.

the impact of innovation policies enacted in 2002 to improve cooperation between industry and universities and to increase the number of patent applications, highlighted the importance of a professional infrastructure at universities. As part of the Innovation policies, the government funded new innovation infrastructure, TTO establishment, licensing of IP developed at HEIs and building of networks and relations with the industrial sector. The government allocated a larger budget for the development of these counties - funds were allocated from the Regional Development Fund (ERDF) and government budget to promote R&D, education, innovation and to increase competitiveness. Additional resources from the European Social Fund (ESF) were allocated to develop networks and improve innovation culture. Public patent agencies were established on a national level and their objective was to relieve TTOs from extensive administration and expenses related to patent registration and maintenance.

Conclusions from the study highlighted low effectiveness of patent agencies and TTOs. The most important specific proposals made by HEI researchers to improve TTO support services included (Gimm, Jaenicke, 2010):

- Introduce better targeted marketing, not just patent administration;
- Increase profit share for researchers – they regarded the existing 30 % share of gross revenue from licensing as a weak incentive;
- Improve legal advisory capabilities of TTOs, particularly in negotiations on conditions of contractual work and conditions in licensing agreements;
- Facilitate access to venture capital or other financial sources as new spin-offs do not have money to overcome the period of negotiations on conditions with investors;
- Intensify weak contacts with networks of partners in relevant organisations and companies to improve access to finance;
- Markedly improve the ability to identify gaps in research and anticipate future products and technologies.

Scientists largely appreciated progressive government support for exploiting a patent as a mean to business development, even though they generally considered private enterprise as risky and would not choose it as a career. Analysis of different variables that influence interest in commercialisation (Siegel et al., 2000) offered an interesting result - by far the most important factor was the experience of researchers of working outside the university, followed by achieving the highest level of university education and the quality of support provided by the TTO. Age and gender of researchers also plays an important role - younger scientists and men are more interested in interacting with businesses.

Dissatisfaction with TTO services leads to inventors bypassing the TTO either by using an external IP advisor/patent agent or by choosing to collaborate on a contract basis without patenting or even leaving academia altogether (Siegel et al., 2000). It is therefore important not only to develop an entrepreneurial culture at faculties, but also to motivate scientists to inform the TTO about their new discoveries and share the income from commercialisation. Research shows that differences in the number of inventions disclosed to TTO are not related to different research capacities at HEIs or different prestige of science. It is important to stimulate interest in TTO services and to persuade scientists to perceive their usefulness not only for the HEI, but also for themselves. Many scientists feel that patents improve their visibility in the research community because they point to innovativeness and usefulness of their work.

Development of entrepreneurial culture at HEIs requires the following activities:

- Implementing successful commercialisation projects;
- Promoting successful case studies;
- Mutual support among researchers;
- Improving the position of scientists who achieved notable commercialisation outcomes.

A survey of scientists at four Swedish universities (Bergman, 2010) indicated that 80 % of those who successfully commercialised their research results said their TTO had not provided them with a clear overview of services or support. The scientists also reported that there was plenty of research with a commercialisation potential which went unnoticed. Various surveys of scientists in Europe, the United States and Canada have pointed to different preferences and values of researchers, e.g. German university professors were generally the least motivated to work with businesses, despite government policies and incentives within the university (Bercovitz, Feldmann, 2006). Studies conveyed at American universities (Bercovitz, Feldmann, 2006) found there were the following prerequisites for researchers to get involved in KTT:

a) Series of trainings performed at the HEI to clarify conditions and criteria for commercialisation;
b) Quality of support provided by the HEI management at various levels (department, faculty, rector’s office);
c) "Group effect" - people are influenced by the behaviour and experiences of other colleagues (HEI with a history of successful commercialisation and supportive management is more likely motivate its scientists).

2.3 International collaboration of technology transfer offices in Europe

Thanks to national innovation policies TTOs tend to cooperate at national levels and many have been incorporated into international associations in order to acquire access to the latest information, know-how on TT management and tools to promote IP of their institution. Association of Technology Transfer Managers (ASTP), for example, it unites TTOs in Europe and provides its members services related to education, networking and sharing of information and experience. Associations like ASTP engage in activities which include:

- Sharing of information and best practice;
- Creating and sharing TT management tools;
- Establishing common policies and guidelines;
- Communicating important outcomes and findings to the European Commission in order to influence future decision making;
- Supporting individual TTOs;
- Advising on improving communication between academia and industry.

In 2010 ASTP launched a new programme which allows professional project managers at TTOs to obtain accreditation recognised at European level. The Alliance of Technology Transfer Professionals[65] (ATTP) implements the programme and provides certified courses created exclusively for TTOs at universities or public research institutes.

ASTP works closely with AUTM (Association of Technology Managers) in the USA, the Swedish organisation for innovation and technology transfer SNITTS and a non-profit organisation to promote innovation and commercialisation of universities in the UK called Praxis Unico. In 2013 ASTP merged with ProTon Europe creating a single organisation ASTP-Proton. The merger allowed the integration of efforts to improve support for knowledge and technology transfer professionals and created favourable membership terms for both networks.

Membership in organisations such as ASTP-Proton has a great advantage for a new TTO as members receive support from experienced advisors and peers, and access to invaluable information and tools/methodologies/standards to streamline various aspects of work.

2.3.1 Evaluation of technology transfer offices in Europe

A survey of TTO success in Europe has been measured for approx. 10 years and is based on the collection and evaluation of seven key indicators (European Commission, 2009):

1. Number of inventions
2. Number of patent applications
3. Number of patents granted
4. Number of start-ups
5. Number of license agreements
6. Income from licenses
7. Number of research contracts.

ASTP-Proton conduct their surveys throughout Europe and they include other indicators – they monitor the number and type of TTO employees, budget for IP protection, the number of active patents, licenses granted and the amount of income from them, the number of new spin-off businesses, the number of active spin-off businesses and trends in all monitored fields.

[65] ATTP, for more information visit http://www.attp.info/

ASTP survey of 2008 published in 2009[66] evaluated TTOs in 37 countries (81 % in Europe) at 140 institutions, 111 of which were universities. ASTP also surveyed non-members, but the response rate from member TTOs was much higher. The most important outcomes of the survey were:

- A TTO employed on average 9 FTEs;
- Average TTO was in operation for approx. 9 years, more than 50 % of TTOs were established after the year 2000;
- 75 % of surveyed institutions own IP created by their researchers, for the rest of the cases the inventor owned it;
- On average, in 2007 16.1 % of research at member institutions was financed by private companies.

Figure 11 shows an overview of the services provided by member TTOs (dark blue) and non-members (light blue). Figure 12 shows an overview of achieved results by the top 10 % of TTOs – outcomes of performance in the field of technology transfer at TTOs at member universities (dark blue), TTOs at other member institutions (light blue) and TTOs at non-member universities (red).

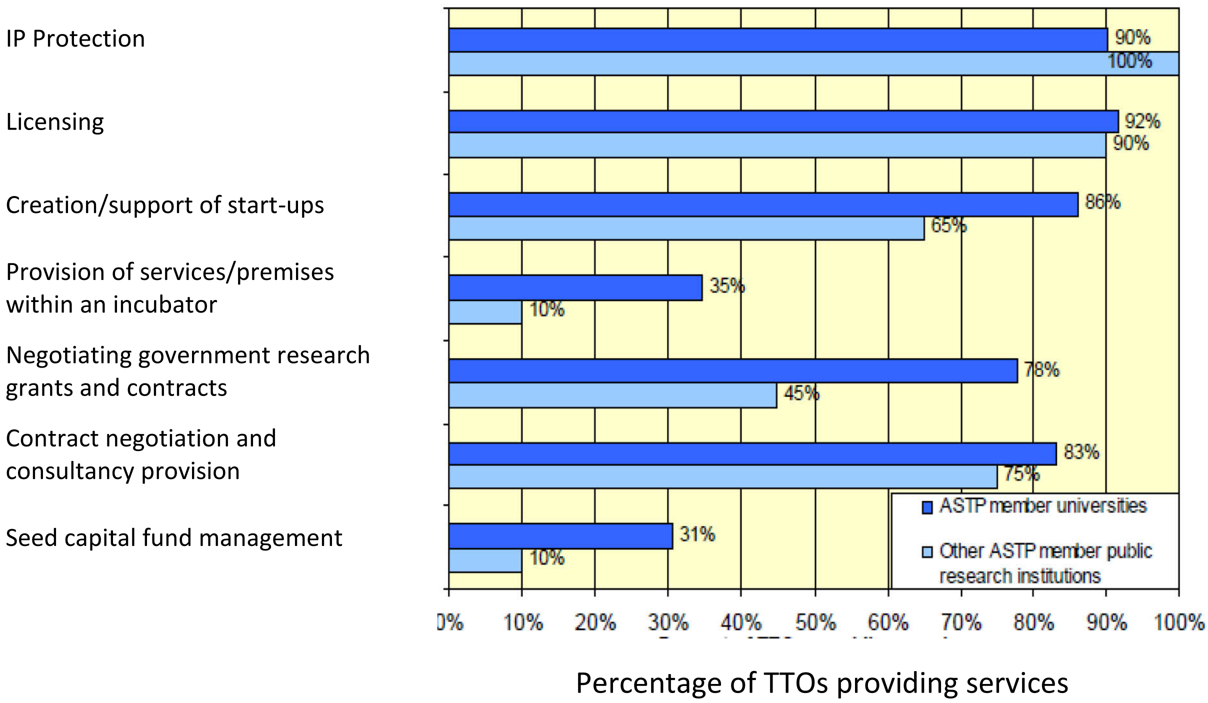


Figure 11: Percentage of services provided by TTOs which were ASTP members

(Source: ASTP, 2008: Summary Report for Respondents: The ASTP Survey for Fiscal Year 2008)

[66] Research evaluation report was obtained from ASTP based on the membership in the association.

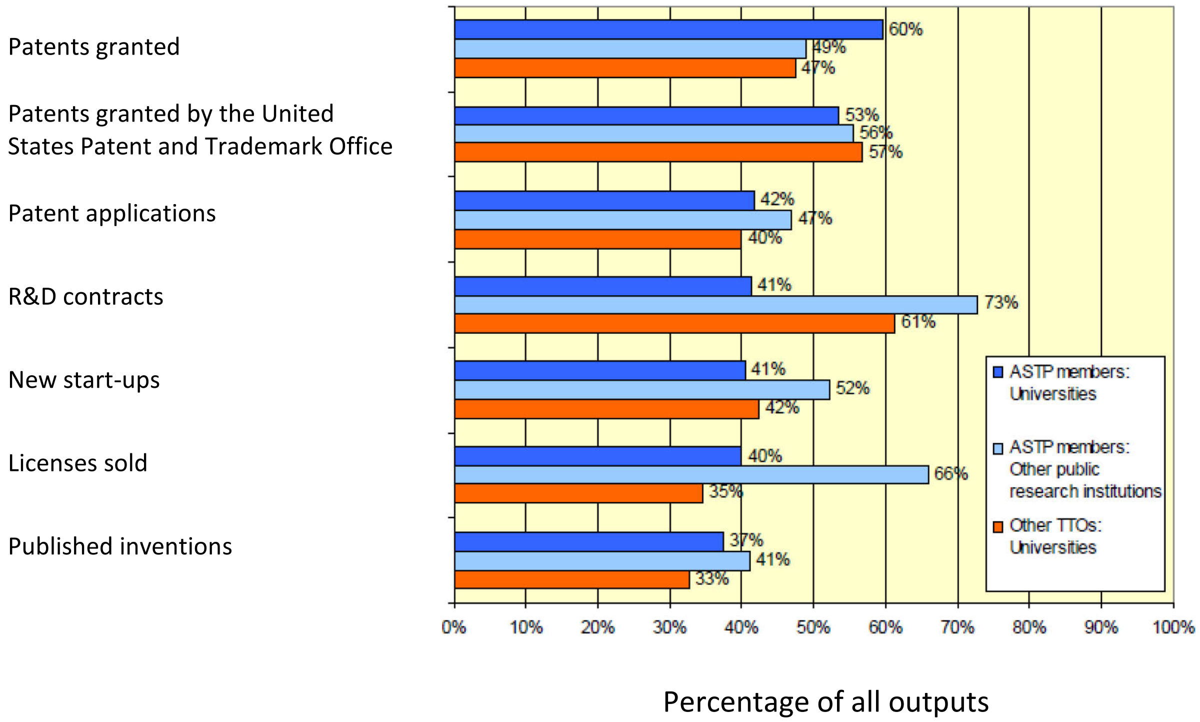


Figure 12: Percentage of technology transfer outputs from top 10 % of all surveyed TTOs

(Source: ASTP, 2008: Summary Report for Respondents: The ASTP Survey for Fiscal Year 2007)

Universities recorded 1.5 times more patent applications, 2 times more licensing agreements and 2.4 times more patents granted per 1,000 researchers than other research institutions which reflects the fact that research is not their primary mission.

Table 6 represents outcomes of the 2009 ProTon Europe survey.[67]

[67] Information provided by Marta Catarino, member of the Proton Europe management board in October 2012.

Table 6: Survey of TTOs in Europe

	2006		2007		2008		2009	
	All TTOs (325)	Only TTOs with non-zero values	All TTOs (323)	Only TTOs with non-zero values	All TTOs (305)	Only TTOs with non-zero values	All TTOs (321)	Only TTOs with non-zero values
TTO Characteristics								
Average staff per TTO (FTEs)	8.3	**8.4**	8.4	**8.4**	9.7	**9.7**	7.7	**7.7**
Average TTO budget ('000 €)	437.8	**449.0**	514.8	**514.8**	543.4	**564.5**	409.0	**409.0**
IP Management								
Average No. of invention disclosures per TTO	18.3	**27.0**	20.2	**28.6**	19.9	**28.4**	18.7	**27.7**
Average No of priority patent applications per TTO	8.7	**13.2**	10.7	**15.1**	10.0	**14.8**	10.6	**15.4**
Average patent portfolio as of December 31st	40.9	**65.3**	52.6	**78.4**	67	**101.0**	71.8	**104.5**
Average patent protection costs ('000 €)	166.6	**311.3**	129.6	**212.8**	139.7	**242.6**	161.3	**253.3**
Licensing								
Average No of licenses executed per TTO	11.2	**20.2**	12.6	**22.0**	12.4	**21.7**	16.3	**30.1**
Average licensing revenue per TTO ('000 €)	266.8	**471.6**	212.5	**360.7**	246.9	**395.4**	259.5	**493.5**
Spin-off companies								
Average No of spin/offs created per TTO	1.6	**3.3**	1.8	**3.3**	1.6	**2.9**	1.5	**2.7**
Average No of active spin/offs per TTO	---	**---**	8.2	**11.9**	8.1	**12.4**	8.2	**11**

ProTonEurope used to perform a survey of European TTOs once every two years. In 2009 (Table 6) survey TTOs participated from the UK (50 % of the sample), Italy, Spain, France, Ireland and Denmark. The most important results of the survey were comparable to ASTP survey results and they were the following:

- In 2009 the average TTO employed 7.7 FTEs, 2 % reduction from the previous year;
- The average TTO had been operating for 9.6 years, 60 % of TTOs were established after the year 2000.

These outcomes were very similar for surveys of both organisations. Other results showed that the average TTO had (2009):

- a budget of € 409 K;
- 18.7 undisclosed inventions;
- 10.6 patent applications;
- 71.8 patents in their portfolio;
- researchers on secondment;
- 6.3 sold licenses;
- € 259.5 K license income;
- 1.5 new spin-off companies;
- 8.2 existing spin-off companies;
- public.

In some countries, e.g. Denmark and Austria, information from such surveys was used when deciding on new financial instruments and in shaping national policies in the field of innovation. In some countries the survey was interlinked and harmonised with surveys performed by national organisations. ProTonEurope not only followed commercialisation activities, but also the interests of scientists doing research in the area of KTT.

ASTP survey was aimed at professionals in the field of IP commercialisation and compared obtained results. TTO managers used this information for further strategic planning, in discussions with R&D project managers, and for influencing public policies.

Information about knowledge and technology transfer in the twelve new EU Member States was poor and no Slovak institution had participated in the survey[68]. It is therefore not possible to compare Slovakia with other countries on the basis of these surveys.

[68] Metrics for Knowledge Transfer from Public Research Organisations in Europe, European Commission 2009.

2.4 University spin-offs

2.4.1 Theoretical issues of the spin-offs

Spin-off definition issues

There are various possible types of mechanisms for KTT, ranging from licensing, contract research, spin-offs, mobility of scientists, and technology roadmaps to publications of research results in the public domain. The conventional route to KTT from university to market has generally lead along two routes: 1) licensing the rights to use technological discoveries controlled by university owned intellectual property, e.g. patents and 2) contract research. In recent years, university spin-off companies have become an increasingly popular way of exploiting potentially valuable research and knowledge.

Sometimes are the terms spin-off and spin-out used as interchangable. However, there is no general agreement from all authors on this. They distinguish between (a) the spin-off as a company started by employees who leave their parent organisation, but maintain loose ties with this parent organisation, and (b) spin-out as a company that does not have a direct link to a parent organisation, and the decision of forming a new company is taken by employee(s) (Koster, 2004). Spin-outs do use resources created in other firms, and the seed phase of these firms is not directly supported by the parent company. Unike spin-outs, spin-offs and corporate spin-offs are built on existing resources, and during the seed phase they are supported by a parent company. Individual start-ups are predominantly based on resources of individual entrepreneurs.

The differences in parental support and resource sharing between a spin-off, spin-out and startup are reflected in the Figure 13.

Spin–off appears to be a more appropriate term in describing companies supported by universities. University spin-offs (USO) have become a global phenomenon over the past twenty to thirty years. They may be considered as a subcategory of research-based spin-offs playing an important role in moving early-stage technologies developed in universities to the market. Although the OECD countries were very interested in research commercialisation few of them countries regularly monitored and recorded the formation of spin-offs based on public sector research. Therefore when summarising the results of a 1999 OECD survey of government information sources on spin-offs, Callan (2001) characterised a research spin-off as a company that falls into at least one of the four following categories:

1) company that has an equity investment from a national library or university;
2) company that licenses technology from a public research institute or university;
3) company that considers a university or public sector employee to have been a founder;
4) company that has been established directly by a public research institution.

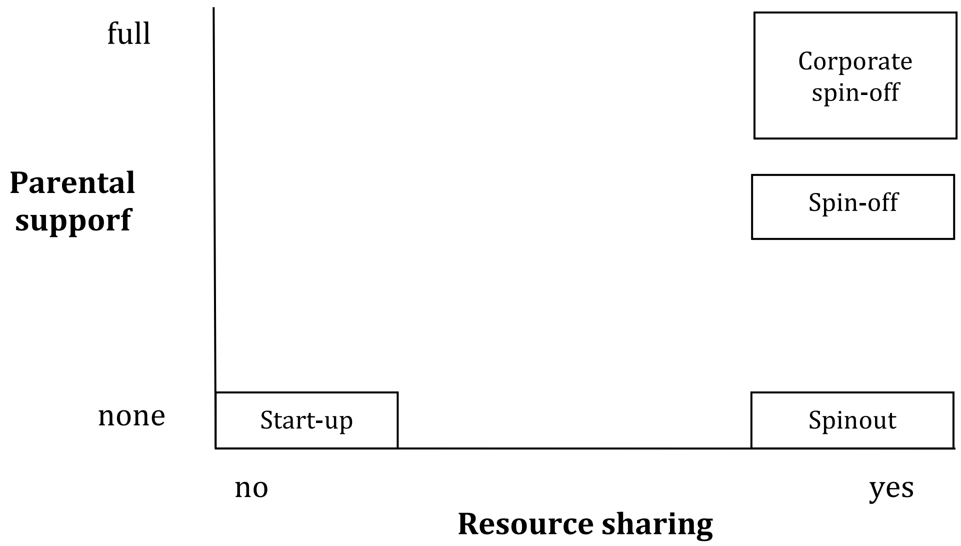


Figure 13: Types of newly established firms

(Source: Koster, 2004, p.5)

Note: A corporate spin-off is usually a result of restructuring in the parent company.

Earlier definitions of USOs were broader, e.g. (Rappaert et al., 1999) „USOs are firms whose products or services developed out of technology-based ideas or scientific technical know-how generated in a university setting by a faculty member, staff or student who founded (or cofounded with others) the firm. The individual(s) may either leave the university to start a company or start the company while still inside the university."

(Pirnay et al., 2003, p. 356) formulated the traditional definition of university spin-off as *"new firms created to exploit commercially some knowledge, technology or research results developed within a university"* has been widely employed since then. *„The entrepreneur(s), accordingly, may be a university staff member, a university graduate, as well as an entrepreneur from outside that commercialises university knowledge, e.g. based on a license".*

Recent authors prefer narrower definitions of the USO focussing on protection of intellectual property, e.g. (Shane, 2004) defined a university spin-off as *"a new company founded to exploit a piece of intellectual property created in an academic institution".* Mostly, the parent company or organisation provides to spin-off support covering: investing equity in the new firm, being the first customer of the spin-off and helping to create cash flow, providing incubation space (office, furniture and ITC equipment, etc.) or providing legal, finance, technology, etc. Both of the definitions stated above are in line with the spin –off characteristictics stated in earlier in the 2.1 (p. 56-57) and reflect the position of the authors on this topic.

Spin-off process

Rasmussen models the process of a university spin-off (Figure 14) simply as the process where a research-based idea or opportunity, one person or a team of entrepreneurs, and the relevant context create the necessary properties for a new organisation to emerge (Rasmussen, 2006).

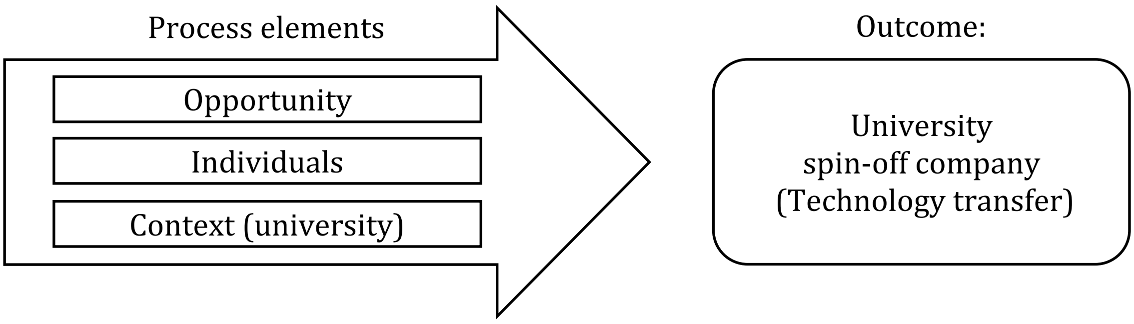


Figure 14: The entrepreneurial process of university spin-off creation

(Source: Rasmussen, 2006).

According to (Ndonzuau et al., 2002) the process of a spin-off development from the standpoint of both public and academic authorities consists of four stages and is very similar to the 'stage-gate' process (Cooper, 1993) described for the new product introduction process. *"Each of these stages has a specific function in the global spin-off process. The first stage generates and assesses ideas with regard to possible commercialisation; the second stage considers these ideas and translates the most promising of them into final entrepreneurial concepts; the third stage realises the best concepts by launching new spin-off firms; and the fourth stage consolidates and strengthens the economic value created by these new firms"* (Ndonzuau et al., 2002, p. 282). A note of caution must be made with respect to the model's suggested assumption of linearity (Figure 15). The four stages are not wholly independent of each other.

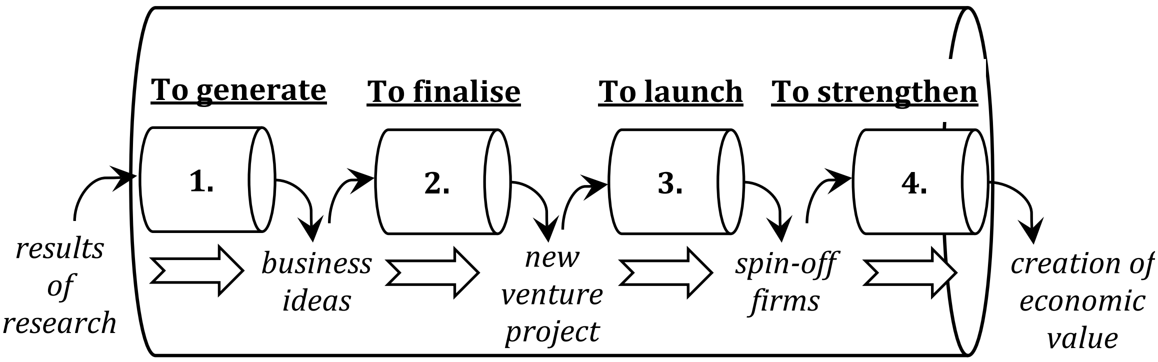


Figure 15: The global process of valorisation of spin-off

(Source: Ndonzuau et al., 2002, pp 281-289)

The programme IDEAS with the Universidad Politecnica de Valencia (UVP) promoted a process which could launch spin-off and start-up companies out of a university activity using the metaphor of a newly conceived and born human. In this model, the spin-off generation process (Figure 16) may be seen as a chaotic process driven by the interaction of three elements: **the entrepreneurs (E), the opportunity (O) and the resources (R)**. These three elements at the first awareness or 'embryo' stage need to be combined by the entrepreneur's mind to create the fertile seeds of new ideas. These seeds are accumulated in a pre-incubator phase to concrete concepts, configuring the Cells of Opportunities (CoO). The "healthiest of them" with best balance among the availability of entrepreneurs, opportunities and resources are born in a distinctive form, which, however, needs an incubation period to form all the characteristics necessary to succeed in a globalised environment.

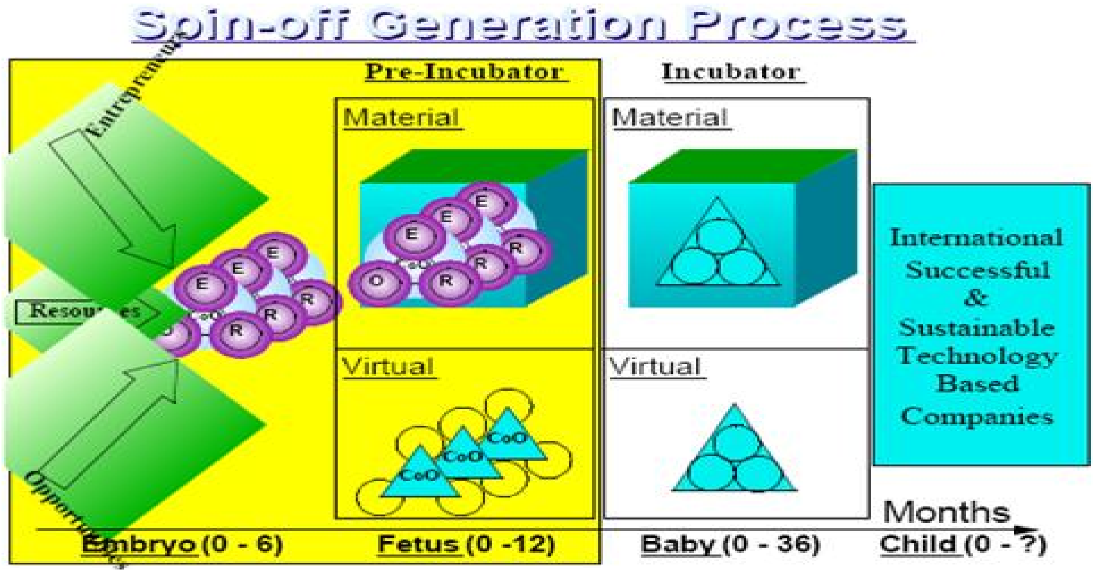


Figure 16: Sequence of the spin-off generation process at UPV

(Source: USINE project, http://www.usine.uni-bonn.de)

In the transformation of knowledge into economic value via product commercialisation four basic stages may be identified as the "Core Entrepreneurial Action":

1) Exploring ideas of products and services and the mechanisms and criteria used for selecting them to be developed;
2) Implementing the business concept of the idea, i.e. the stage where a firm is created with its processes and functions, defining and distributing the required human and economic resources considered necessary for the creation of cash-flow for the company survival and growth;
3) Finding the financial resources to develop the business concept;
4) Running a company, consolidation and strengthening of entrepreneurial culture necessary to achieve the goals of company strategy.

The basic entrepreneurial process alone may proceed well; however, the result will face a higher or lower risk of success if certain environmental elements and supportive structures are not present. The Operational Environment required involves market needs, human capital, appropriate government policies and appropriate regulatory framework. The Supportive Structures of the early stages involve: (a) financial institutions helpful in keeping positive cash flow throughout the early stages, and (b) bridging organisations to incubate the early days of the new spin-off in a relatively favourable environment. These different elements must work together in order to support the spin-off progress to a maturity phase.

All these phases and factors play a significant role in the process of a spin-off development, creating a systemic framework called the "Spin-off chain" (Figure 17).

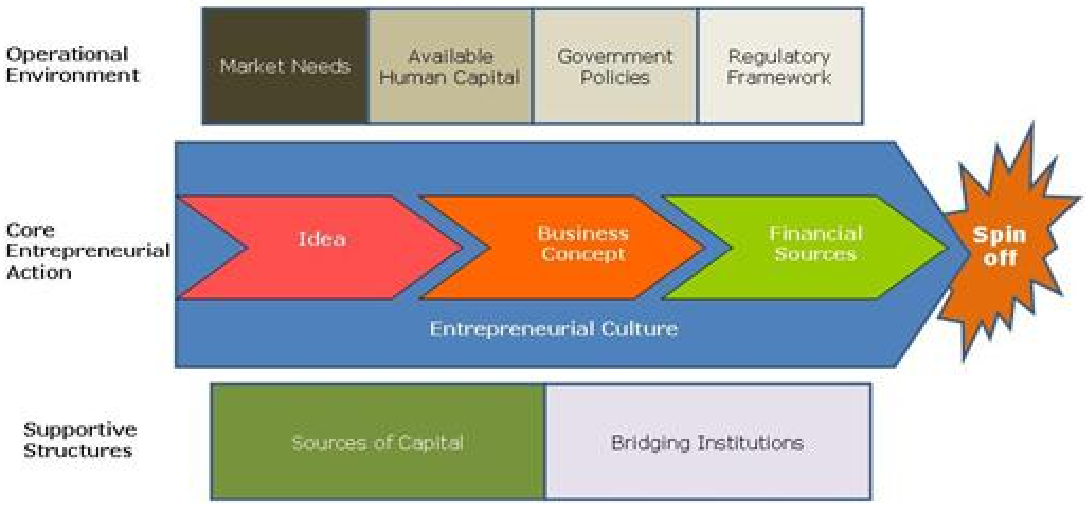


Figure 17: The "Spin-off chain"

(Source: Elpida, S. et a.l, 2010)

Shane in his fundamental book on university spin-offs (Shane, 2004) provided in-depth analysis of the four major factors that jointly influence spin-off activity:

1) the university and societal environment,
2) the technology developed at universities,
3) the industries in which spin-offs operate,
4) the team involved.

2.4.2 Typology of university spin-offs

There have been suggested various typologies of university spinoffs (Carayannis et al., 1998), (Pirnay et al., 2003), (Nicolau and Birley, 2003), (Mustar et al., 2006), (Bathelt, Kogler and Munro, 2010), (Epure et al., 2012) and (Salvador, Benghozi, 2013). In the context of our spin-off definition stated above some selected typologies expanding it are discussed in more detail below.

Nicolau and Birley (2003) classified USO by the affiliation of the inventor to the university in three categories:

1) orthodox spin-offs – where the inventor/academic left the university to start the new company;
2) hybrid spin-offs – where the inventor/academic remained at the university holding a part-time position in the new company;
3) technology spin-offs – where the inventor has no involvement in the creation of the new company.

Bathelt, Kogler and Munro (2010) suggested typology of university spin-off/start-up firms based on four variables: (1) the type of university sponsorship, (2) university involvement in firm formation, (3) the character of knowledge applied, and (4) co-localisation of the founders as shown in Table 7 and Table 8. It was confirmed by survey results as well.

Table 7: Typology of spin-offs and startups according to university sponsorship and involvement in formation process (adjusted)

University sponsorship	University spin-offs (university research)	University spin-offs (university - industry joint ventures)	University start-ups (decentralized idea development)
Sponsored spin-offs	Intellectual property (IP) developed at the university through publicly funded research grants; as a part of standard university operations	Formal development agreement between university and industry; typically: preferential licensing rights for IP generated in the research for the sponsoring firm	Firms started by former graduates or undergraduates after finishing school; they might have developed a business idea from their joint classroom experience
Unsponsored spin-offs	Researcher developed an idea within the university; pay for the IP and then leave the university to develop it further; possibly without support of the university	Off-site, unsolicited innovation brought forward by someone in the research group and developed into a product; possibly an ancillary development not central to the study or research project that is subsequently developed	Completely self-developed firms; principals meet informally, off-site or outside academic facilities but have social ties with the university; typically the university is not aware of these processes

(Source: Bathelt et al., 2010, p. 523)

In terms of university sposorship spin-offs are differentiated according to how "close" their start-up process is to the university's core research competencies. *The sponsored spin-offs* are viewed as firms established with active university support and approval. However, only rarely this support involves direct money transfers. Instead, sponsorship typically relates to training and support in the management of the start-up phase. Sometimes, this includes granting preliminary office/research space, and the use of university facilities such as libraries and research laboratories at a lower than market rate. Support can also entail the university buying a new firm's products instead of established goods and services from existing firms.

Unsponsored spin-offs/startups result from emergent processes, rather than just intended spin-offs. An example of this category would be if a researcher, previously employed by a university, establishes a firm that is legally acceptable, but is not sponsored by the university. Alternatively, although possibly quite rarely, a firm might spin-off despite the university's objections. The latter could occur in a university-industry joint venture project in which the private partner establishes a firm that utilizes knowledge that was primarily developed in the university.

In terms of university involvement, three types of ventures may emerge:

- spin-offs resulting from university research that are based on intellectual property developed at the university,
- spin-offs resulting from university–industry joint ventures, IP licensing
- start-ups resulting from decentralised individual or collective ideas developed at the university, unrelated to the university's research projects.

Table 8: Typology of spin-offs and startups according to character of knowledge applied and co-localization of the founders (adjusted)

Character of knowledge applied	Founders co-localized	Founders not co-localized
Generic, broad knowledge	Broad knowledge largely based on the capabilities and focus of the local incubator university, limited innovation potential	Broad knowledge drawing from a wider set of experiences at different places; innovation benefits from broade access to generic knowledge pools
Specific knowledge, including tacit knowledge	Drawing on specific knowledge in the university´s competencies, including tacit knowledge pools (particularly in dynamic technology fields)	Drawing from different specific knowledge pools (different research projects/specializations, regional knowledge pools), large innovation potential

(Source: Bathelt et al., 2010, p. 524)

The criterion of co-location in the start-up period means whether the founders of a firm are associated with the same university (also in the case if there is only one founder), or with different universities in different regions (non-co-localized start-ups/spin-offs). In the co-localization scenario, firms will likely draw more heavily on regional resources in the start-up stage while, in the case of non-co-localization, when the founders are not from the same regional university/organization, firms may be able to develop and use wider interregional networks from the very beginning. The spin-off's success predominantly depends on the size of its contact network to a range of partners including customer and financial organizations. The second criterion makes the distinction between generic, broader, less specific knowledge which can, that may be transmitted in seminars or lectures and specific knowledge related to the competence base of the university that is closely tied to university research, including the tacit knowledge.

It showed several important trends:

(1) sponsored spin-offs are results of particular university research activities. They apply specific knowledge inputs in the development of their initial core technology; (2) unsponsored spin-offs that originated in decentralised idea developments outside the university setting strongly rely on broad generic knowledge in the development of innovative products. It was surprising that even the firms that received some kind of direct university support described the role of the university as relatively limited.

The survey also showed that once there were multiple firm founders, they were usually co-localised in the region, regardless of what type of knowledge was utilised. It would be difficult to make predictions on the growth potential of the individual university spin-off/start-up firms, since they vary significantly in age, level of specialisation, and the resulting prospective market size. However, the non-co-localised spin-off type, with a great potential to achieve wider market acceptance in the start-up stage were only exceptions in the sample population. Nevertheless, the vibrant merger and acquisition activities that have become apparent in this research indicated the capacity of many ventures to attract the interest of other regional, national, or international firms, that stimulated growth in the regional sector. Employment levels and growth performance related to the spin-off process have, however, remained modest in many firms. Therefore, it seems premature to overemphasise regional economic success of university-driven ventures.

In many surveys various entrepreneurs stated that, even if they had received support from the university TTO, they did not have any relationship with the parent university. They just needed assistance in applying for public funds. Others indicated that they were not exploiting technology developed within the university. Therefore the traditional spin-off definition by Pirnay et al. was revised to include the following three different groups of spin-offs (Epure et al., 2012):

1) Spin-offs with formal technology transfer agreements with the parent university, e.g. patents, know-how contracts, equity, or contract research. This group agrees to a greater degree with the definitions that can be found in literature.
2) Spin-offs that incorporate at least one person from the parent university within their current staff or founding team. They do not have formal technogy transfer agreements with the parent university. Hence, it agrees to a medium degree with the definitions in literature.
3) Pseudo spin-offs, this group does not incorporate members from the parent university, nor does it have any formal agreement with the parent university. Formally, firms in this category cannot be considered spin-offs, they may be called pseudo spin-offs since they do appear in the TT network database.

The results of the cluster analysis of Italian spin-offs by (Salvador, Benghozi, 2013) revealed the existence of two main kinds of research spin-offs: (1) „more open-oriented research spin-offs" and (2) "less open-oriented research spin-offs". The three factors identified by the factor analysis: "competencies", "company attitude" and "spin-off founders´ and university choices" confirmed and improved the cluster results. It confirmed the importance of the role played by the parent institute of a research spin-off, as perceived directly by company founders. More specifically, a key role is played by *choices* (reasons for company creation and the founder´s personal choices) and a second role is given by *competencies* (technological vs managerial and business ones). Choices and competencies both influence the company's *attitude* (product or service orientation with or without patents). These three factors taken together are the pillars of the cluster analysis grouping and should be taken into account for researching spin-off policy strategy.

In fact, a knowledge gap is observable more in research spin-offs not founded by university personnel. Possibly the spin-off firms supported by their parent institute can easier fill in the knowledge gap through aid from university structures as well as meetings, tutorship, consultancy services, networking with colleagues and not only through self-training. The lack of managerial and business competencies has consequences on the company's attitude - product or service orientation with or without patents, i.e. entrepreneurial competencies have a pivotal importance.

2.4.3 Some research conclusions on university spin-off programmes

The creation of spin-off firms from public sector research activities became one of the favoured IP management strategies of universities and public labs in the period 1980-2000. The number of spin-offs generated in an economy was understood as an indicator of the public sector´s ability to develop commercially relevant knowledge, of its entrepreneurial capacity, and of the depth of knowledge transfer between the public and private sectors. For these reasons, spin-offs were a very visible and politically attractive form of technology transfer. OECD countries have enthusiastically launched multiple programmes to spur greater entrepreneurialism within the public sector.

Callan (2001) based on his extensive survey (Table 9) concluded that contrary to wide-spread belief, that spin-offs are mainly product innovators, they act more as mediators between the research and industry communities. In his research he used the following working definition of a spin-off. It had the following four characteristics:

- any new firm which includes a public sector or university employee as a founder,
- any new firm which licenses technology from a university or public research institute;
- any new firm in which a university or national laboratory has made an equity investment;
- any new firm directly established by the public research institution.

Table 9: Comparison of spin-off formation across the OECD

	Institutions	Cummulative number	Period	Spin-offs per year	Period	Reference
Australia	All	138	1971-99	10	1991-99	Thorburn
Belgium	All	66	1979-99	4	1990-99	Clarisse and Degoof
Canada	Universities	746	1962-99	47	1990-98	Cooper
France	All	387	1984-98	14	1992-98	Mustar
Finland	Public labs	66	1985-99	4.5	1990-99	VTT data
Germany (a)	Public labs	462	1990-97	58	1990-97	ATHENE
Germany (b)	Universities	2,800	1990-95	467	1990-95	ATHENE
Norway	Public labs	122	1996-98	41	1996-98	Research Council of Norway
United Kingdom	Universities	171	1984-98	15	1990-97	PREST
AUTM[69]	Universities	1,995	1980-98	281	1994-97	AUTM

(Source: Callan, 2001; OECD)

Studies showed that almost universally, spin-off firms tend to be concentrated in the life sciences including biotechnology, pharmaceutical, medical and the agri-food sciences and information technologies. Many of them were small and slow-growing, with few products, but longer survival rates than the average start-up. Even in the U.S., Germany and Canada they have less than 50 employees, very often less than 20 employees. They have long gestation periods before moving into production, marketing and sales because of their technological orientation. Their economic impact was not sufficiently documented by all countries surveyed, however, U.S. and Canada submitted the best results on revenues and sales. Many research spin-offs were likely to be contract research or consulting boutiques that maintained close ties to their parent institution. The potential lessons for policy makers were:

- universities and research institutions may not be able to squeeze out as many spin-offs as one might have initially hoped, although the upper limit has not been reached in most countries;
- research spin-offs have an important place in the innovation process, but their promotion must be part of a wider policy package fostering an entrepreneurial business environment and encouraging networking among universities, industry and the public sector.

[69] AUTM includes universities and research hospitals. Cummulative numbers are for the U.S. alone, the per year figures are for the U.S. and Canadian institutions

Benchmarking of the spin-offs in OECD countries (Callan, 2001) brought the following results:

- nearly all OECD countries had experienced growth in the number of firms spun out from universities and public laboratories, the leader being U.S., Germany and Canada, however, the number of public spin-offs as compared to total new firm creations and corporate spin-offs is small in all countries considered;
- there is a broad range in spin-off performance across OECD countries,
- agreement on the definition of spin-offs which could be helpful in normalising the survey data submitted so that spin-off performances can be compared over time and across countries more easily;
- it is impossible to achieve spin-off performance targets due to variances in research institutions which make up the national research base of each country, variances in the industrial structure and entrepreneurship conditions of the countries and finally, the fact that spin-offs are only one form of technology transfer which may be more or less necessary in a specific country;
- evaluation of public spin-offs should be executed in a broader context of technology transfer and generation of new firms;
- as for the access to early stage financing of spin-offs many countries provide a wide variety of grants, loans, and venture capital seed funds targeted at high-tech new firms or, at public sector spin-offs alone; equity investments may not be an important source of capital since equity stakes are often given in exchange for lower royalty payments to the parent institution;
- public sector universities or research institutes are not the principal source of funds for spin-offs,however, other government funds are frequent sources of seed capital; despite governmental and institutional enthusiasm for new seed funds for spin-offs, it is unclear whether they reach firms at the right stage in their development, or even whether funding is truly a weak point in innovation systems;
- any cross-country comparisons on spin-offs should only be done with great caution.

As for government policies governments are encouraged first and foremost to continue improving the environment for entrepreneurship in their economies. Spin-offs are a small sub-population of new firms, and their relative importance should always be kept in perspective. Public spin-offs probably warrant special policy attention because of their mediator role played in the public-private interface. In addition, spin-offs bring important local benefits to their home institution in the form of reputation improvement.

The Belgian study of the early-growth phase of new technology-based firms presented by Clarysse, Heirman and Degroof (2001) aimed at explaining why European new technology-based firms fail to grow like their U.S. counterparts. They concluded that "structural deficiencies" such as the financial, fiscal or regulatory climate cannot explain this slow growth. Rather, the entrepreneurial climate of the firm's region and its experience and opportunities for knowledge acquisition are determinative. Regions that are not supportive of spin-off early-growth needs – before the first infusion of venture capital – have a lower incidence of high-growth ventures. Therefore the challenge for Europe is to create an environment that allows spin-offs to learn how to translate research into a product tailored to market demand and to develop an appropriate business model. Intermediary institutions and incubation centres would play a key role in it.

The OECD study on the status of spin-offs in Europe of 2001 (European Commission – DG, 2002) stated that there had been some 300 spin-out programmes taking various institutional forms, and operating at widely different levels of activity and financial support. The average programme supported 35 projects a year. Annual revenues averaged just over € 3 million making a range from € 22,000 per annum for a university TTO to € 24 million for a national programme. Average annual costs were about € 6 million, concluding with the general need for subsidies for spin-off promotions. It formulated four distinct models of development of spin-off/spin-out programmes in Europe which may have been followed with some adjustments up till now:

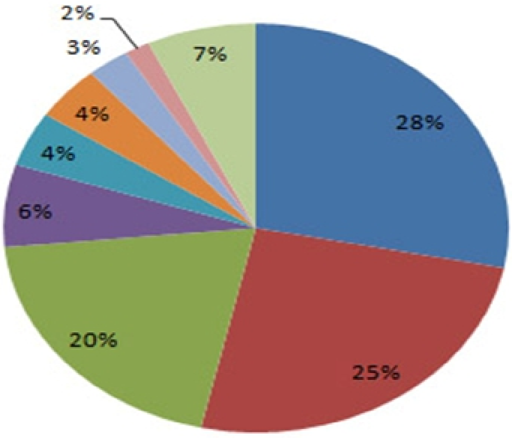
1) top-down model, where government funding is channelled to spin-offs through public agencies - it works well in establishing national programmes from a very low level (Slovakia, the Czech Republic, other „moderate and modest innovators by European Innovation Survey);
2) network model, where there are created and supported networks of privately funded university incubator, business support agency and investors (VC or business angels), it works well in rising local economies, e.g. Chalmers University in Sweden;
3) incremental approach model, where incubators and funds of local universities are gradually developed over time, e.g. Lausanne University in Switzerland; mostly followed by the European universities;
4) technopole model, involving the fundamental reorientation of universities to create an entrepreneurial culture in all aspects of university life, it needs strong support for innovation and change within the university, e.g. INNOVA Program of Technical University of Catalonia.

Countries with strong investment and business expertise networks tend to have more succesful spin-off/spin-out programmes. Universities with strong interaction with their local economies tend to have a higher percentage of successfull spin-off/spin-out projects.

Table 10: European academic spin-offs by industries and development status

Country	Total	%*	Active	Merger	Acquisition	IPO	Failure
Belgium	32	17%	23	1		2	6
Denmark	11	6%	10				1
Germany	22	12%	18		2		2
Italy	9	5%	8				1
Netherlands	31	17%	24	1	4		2
Norway	10	5%	7		2		1
Spain	11	6%	11				
Sweden	48	26%	43		3		2
UK	11	6%	7			2	2
Total	**185**		**151**	**2**	**11**	**4**	**17**
%*		**100%**	**82%**	**1%**	**6%**	**2%**	**9%**

Industry sector	Total	%*
1 Pharma / Biotech	52	28%
2 Electronics	47	25%
3 Software	37	20%
4 Materials	12	6%
5 Medical Devices	8	4%
6 Energy Cleantech	8	4%
7 Agriculture / Food	5	3%
8 Mechanics	3	2%
9 Others	13	7%
Total	**185**	**100%**



(Source: DeCleyn, 2011)

The influential study of 185 European USOs (De Cleyn, 2011) in nine European countries across nine industries during period of their lifecycle (Table 10) showed interesting results:

- 73 % of the USO´s were in the sectors Pharma/Biotech, Electronics and Sowtware;
- the USO life cycle paths in individual countries show interesting facts: a) varying failure rates: above the average in Belgium and below the average in other considerd countries, very few of the USO´s achieved IPO(2 %) and only few were either acquired or merged with other companies (7 %);
- European USOs are reported to be small-scale ventures (mostly one-man SMEs) with limited growth ambitions and clear visions. Their employment and turnover were not very high;
- the founding teams seem to perform better than individual spin-off founders; heterogeneous teams composed of a mixed background, contribute significantly and in a positive way to USO success probability;
- product development teams comprizing (potential) customers increase the survival likelihood of USOs substantially;

- USOs whose business plan were screened, challenged and altered by risk capital providers faced an increased failure risk;
- USOs using patents to protect their core technology do not necessarily enjoy higher survival probability;
- academic long-term support turns out to have a positive and significant impact on USO success probability.

The conclusions of the Grimaldi et al (2011) study on USO were: *"...that much recent policy attention has been at the systemic and university levels. USOs have been a particular focus, yet the evidence on their performance is decidedly mixed, especially in relation to corporate spin-offs by individuals with a university education. There has generally been* ***less focus upon the individual academic entrepreneur****, yet they likely have an important role in spin-off performance through being able to identify and exploit suitable opportunities. There is a need to develop policy at individual level to support both USO and company CSO"*.

Unlike the study of Grimaldi et al. (2011) the Wai Fong Boh et al. (2012) study on university commercialisation efforts in the USA emphasises that graduate and post-doctoral students are critical participants in university spin-offs and examines their roles, especially in the preliminary stages of spin-offs initiated by faculty and students (Boh et al., 2012). It confirms the key role of TTOs in evaluating invention disclosures, marketing inventions to potential licensees, filing patents, and licensing inventions to interested parties. However, it also finds that the overall university ecosystem and a broad range of practices, as well as the scope of university programmes and practices may have a significant impact on technology transfer. The study is based on detailed case studies at eight leading U.S. universities: Harvard University, Massachusetts Institute of Technology, Stanford University, University of Arizona, University of California, Berkeley, University of Maryland, University of North Carolina, and University of Utah. At each institution four to eight cases of technology commercialisation attempts by faculty and students were studied there. This research brought the following relevant findings and conclusions on technology transfer and spin-offs:

1) **Six stages for early technology commercialisation process at universities** were established:

    1. idea generation,
    2. commercialisation decision,
    3. prototype generation and establishment of commercial and technical viability,
    4. founding team formation,
    5. strategy and commercialisation process determination,
    6. fund raising to sustain activities, with the aim of convincing investors that the new technology has commercial and technical viability.

2) **Four primary pathways for university spin-off developments** were identified. They differ from one another by the varying roles played by faculty principle investigators (PIs), experienced entrepreneurs, Ph.D./post-doctoral students, and business school graduate students during the spin-off development process as stated below:

— pathway 1: Faculty PI and an experienced entrepreneur (23 % of cases);
— pathway 2: Faculty PI and Ph.D./post-doctoral students (41 % of cases);
— pathway 3: Faculty PI, Ph.D./post-doctoral students, and business school students (13 % of cases);
— pathway 4: Pure student effort, typically involving a Master's/Ph.D. student and business school student (23 % of cases).

3) **Independent of the TTO activities, the following university programmes and practices may enhance entrepreneurial efforts for commercialising university technologies, including spin-offs:**

1. project-based classes on technology commercialisation;
2. mentoring programmes offering guidance and advice to new entrepreneurs, accelerator/incubator programs for start-ups providing mentoring, funding, office space, enhanced credibility, and, in some cases, oversight and management;
3. business plan competitions as a platform for platform spin-off team formation and business plan development;
4. entrepreneurship education for students, critical for their inspiration to pursue entrepreneurship and for providing knowledge on successful spin-off development;
5. entrepreneurship education for faculty members.

Experts, business people, entrepreneurs, and other alumni volunteers play a vital role in many of the programs listed above and make important contributions to the university's entrepreneurial ecosystem.

4) **Three widely applicable guidelines for technology transfer and spin-off developments at universities:**

1. aligning the objectives of the university, TTO, faculty, and graduate students;
2. leverage all potential university resources; and
3. encouraging graduate students to see technology commercialisation as a career option.

While successful commercialisation of faculty research will always depend, to a certain extent, on the ideas generated in university laboratories and the personalities and talents of the researchers, universities can create an environment that fosters new business creations on university campuses.

According to the Spin-outs UK analysis of all companies emerging from UK universities and research institutes since 2000 by the Young Company Finance[70], the first three ranks in the number of spin-offs in the UK are occupied by:

1. University of Oxford (93 spin-offs);
2. Imperial College London (88 spin-offs);
3. University of Cambridge (77 spin-offs);
4. Edinburgh University (69 spin-offs).

For over 40 years, the University of Edinburgh has successfully translated its world-class research, academic expertise and research facilities into intellectual, social and economic benefits for business, industry and society, through its commercialisation arm, Edinburgh Research and Innovation (ERI)[71]. ERI delivers a comprehensive range of services to support entrepreneurial staff & students in establishing enterprises that have the potential to become major players in their sectors as they grow and employ more staff. Student entrepreneurs received dedicated support through ERI's award-winning information, advice and mentoring service LAUNCH.ed. In addition, the LAUNCH.ed Accelerator Pipeline initiative helps postgraduate students who intend to build high-growth businesses in Scotland.

An independent economic impact report in May 2012 concluded that ERI's commercialisation activities generate over £164 million GVA per annum for the UK economy (globally over £200 million), and support almost 3,000 jobs in the UK (over 3,500 worldwide). The same report also established that of the 262 new companies created by ERI since 1969, 81 % are still operating in some capacity. This firmly establishes Edinburgh Research and Innovation as a recognised UK leader in commercialising research and entrepreneurship, and strengthens the University's position as one of the top-performing enterprise universities in the UK. This helped ERI achieve a record in the efficient and effective stewardship of the IP generated by the world-class research undertaken at the University. In the years 2009 - 2013, ERI generated over £14.5 million in royalty income from 276 license agreements, with a growing portfolio of over 160 active licence agreements currently under management. It has developed an impressive number of links with business and industry each year, with almost 2,400 industry partnerships in the years 2008 -2013.

The USOs are faced with the following key callenges: [72]

Growth challenge:

- Most USO are not larger than 10 employees after six years of survival. (P. Mustar, 2007);

[70] http://www.heraldscotland.com/business/markets-economy/scotland-leads-the-way-over-university-spin-offs.21836127, 11 Aug. 2013
[71] http://www.spinoutsuk.co.uk/Downloads/Spinouts_UK_Quarterly_Journal_April_2014.pdf
[72] Growth challenge for university spin-offs and the project Spin-up. Presentation TU Delft.

- USO in Delft (Netherlands) have faced an average annual growth of 0.84 full time equivalent, roughly in the years 1998 to 2006. Idem Spin-Offs in Trondheim (Norway): 0.89 full time equivalent , (D.P. Soetanto, 2009);
- USO in Delft (Netherlands) have faced an average annual growth of 1.0 full time equivalent , in the years from the founding of the firm up to 2010 (Fadilah, 2012).

USO creation and operation may be viewed as a form of commercialisation of university IP via its TTO, form of academic entrepreneurship, or part of a university ecosystem especially with regard to the concept of an entrepreneurial university.

Main barriers to USO growth:

- legal framework (IPR and employment status of researchers);
- finance gap;
- knowledge gap.

The initial lower performance of USO is highly influenced by their founders who have more extensive formal education and less extensive managerial skills than the founders of other independent start-ups.

The knowledge gap of USO is the basic reason for the lack of growth. This gap concerns the lack of entrepreneurial knowledge and skills by the entrepreneur (Franklin et al, 2001).

An academic entrepreneurs' lack of managerial or generalistic skills may directly influence their behaviour and thus the performance of USO (Barocca, 2013). A lower performance of spin-off firms reflected in their turnover and profitability is often due to missing skills in management, finance, marketing, and above all in leadership. Top missing skills perceived as hampering the company growth are:

- gaining financial capital;
- internationalisation;
- sales;
- financial management;
- marketing management;
- leadership.

There are country differences in missing entrepreneurial skills, e.g. the Dutch and Finnish tend to be in short of sales skills and the Portuguese of internationalisation skills, while all countries except for the Dutch are missing skills in gaining financial capital in the first place.

2.5 Internationalisation of innovations

2.5.1 Theoretical background and hypothesis development

Innovations have been studied in different research fields, including social science, economic science, the science of history and administration science (Nieto, 2003). These research fields provide a variety of definitions of innovation. In the economic environment, innovation is understood as the "implementation of a new or significantly improved product (good or service), process, marketing method or a new method of business practice organisation, arrangement of workplace or creation of external relations" (OECD, 2005). In this paper the concept of innovation is considered in a narrower sense, namely as the development of a new product line based on original specially developed technology (Valdaytzev et al., 2011) and technological innovations.

Technological innovations are products, processes and technologies used for the production of goods or the provision of services (Mensch, 1979). At present, one of the most popular technological innovations is radio frequency identification technology (RFID), which is a radio channel data transmission method that allows users to uniquely identify previously marked objects using software to receive information on it (Daniel, 2007). This technology is especially relevant in such industries as logistics, manufacturing, trade and transport, and has recently been launched into civil industries, too. Furthermore, the application range is expanding steadily, like the needs of potential RFID technology users. Geographical distribution of this technology is taking place at a fairly rapid pace, and one can say that RFID is a global technology since firms from several countries participate in its creation, promotion and utilisation.

Diffusion research is considered to be the theoretical foundation for investigating the technological innovation development process. The principle of this approach is based on Rogers' (2003) diffusion of innovation model and the technology acceptance model (TAM) of Davis (Venkatesh and Davis, 1996). However, this study only refers to the former one, as it can be integrated and combined with the internationalisation theory for innovative firms. According to Rogers (2003), the diffusion of innovations is understood as an innovation distribution process using certain communication channels among the members of a social system.

Launching innovations is not a short-term decision, because requires a long process of analysing various factors. According to Rogers' model, innovation passes through five stages from the moment of its initial announcement to its introduction: knowledge, persuasion, decision, implementation and confirmation (Rogers, 2003), each of which can be considered from the consumer view, as well as from the seller view of the innovative technology (Pezoldt et al., 2012). The speed at which each user passes through these five stages is influenced by factors dependent on the participants involved in the diffusion process (Rogers, 2003). Research on the diffusion of different innovations has shown that the diffusion process depends on specific innovation (e.g. Venkatesh et al., 2003), user (e.g. Pezoldt and Schliewe, 2012) and environmental (e.g. Bagozzi, 2007; Wolfram et al., 2008) characteristics. As a result, firms which produce and distribute technological innovations globalise extremely quickly during their development stage due to informational, technological, financial and product exchange. Therefore, the following hypothesis is derived:

Hypothesis 1: Firms engaged in the production and distribution of technological innovations at the development stage are more involved in the internationalisation process.

There are a great number of studies in literature dealing with the internationalisation of large firms. However, they do not pay proper attention to the specifics of SMEs' development (Gankema et al., 2000), arguing that the access of such firms to foreign markets is more a threat than an opportunity (Lindmark, 1996).

Yet, SMEs play a crucial role in the innovative products market, acting as a bridge between science and industry. The increasing number of SMEs in recent decades (Ruzzier et al., 2006) has led to the formation of separate internationalisation theories for innovative firms (Bilkey and Tesar, 1977; Cavusgil, 1980; Czinkota, 1982; Reid, 1981). According to these theories, a firm goes through a series of stages during its development process, from "uninterested in export" to "engaged in export" (Andersen, 1993). Differences between the studies lie in the number and description of stages. For example, Bilkey and Tesar (1977) and Cavusgil (1980) analysed the internationalisation process, starting with the sales implementation phase in a domestic market, whereas the results of Czinkota's (1982) and Reid's (1981) research show firms' interest in export activity in the early stages. Transit from one development stage to another depends on the acceptance or rejection of a number of internal and external factors, which in turn resembles the structure of Rogers' diffusion of innovation model (Bell, 1995).

In addition, another similarity between the internationalisation and diffusion theory is that a large number of organisations are involved in both the mechanism of diffusion and the internationalisation of technological innovations (as shown in Figure 18), including component suppliers (firms producing electronic components), developers (firms involved in the creation of new technological solutions), integrators (firms engaged in the innovative delivery of finished equipment), standardisation bodies (organisations that issue documental confirmation), consumers, and many other institutions (Wolfram et al., 2008).

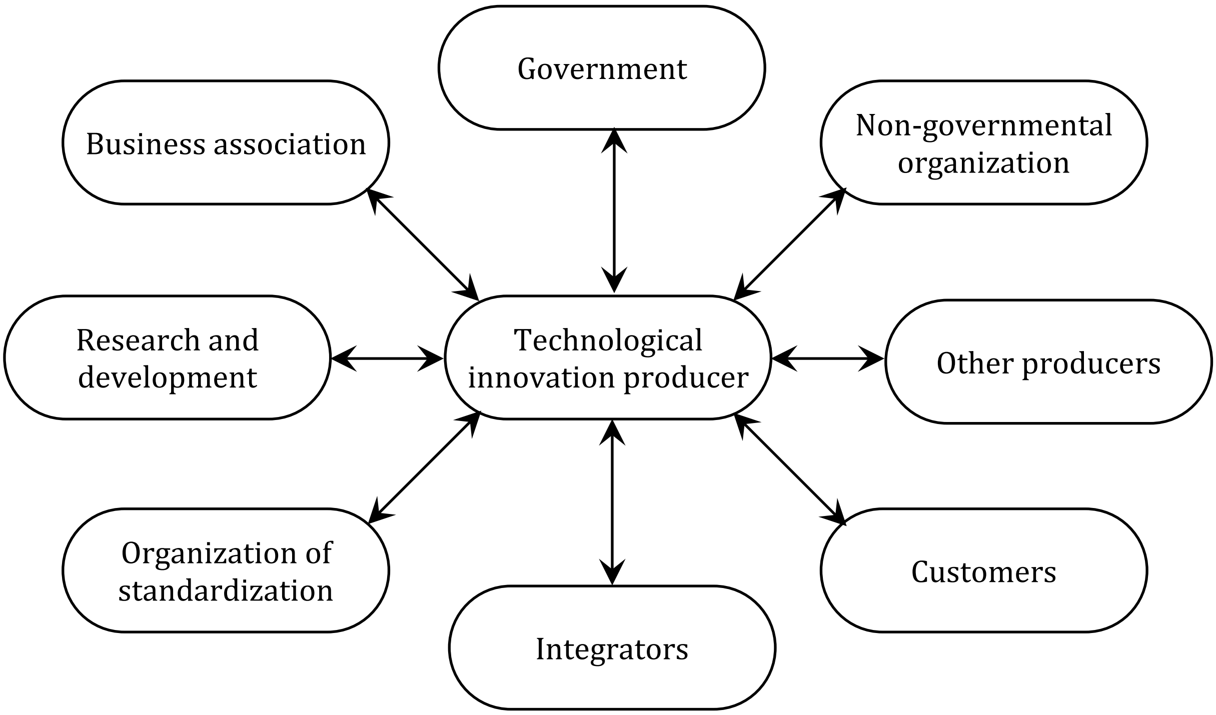


Figure 18: Interaction scheme of the subjects interested in RFID technology distribution

(Source: Wolfram et al., 2008)

During their activities, they exchange goods, funds and information, thus facilitating the process of innovation development. This interaction between market participants leads to the formation of networks, which, according to theorists and practitioners of modern management, is the reason for the accelerated development of innovative firms (Coviello, Munro, 1995; Oviatt, McDougal, 1994). Therefore, the following hypothesis is derived:

Hypothesis 2: Interaction between network members leads to acceleration in the technological innovation development process.

According to Wasserman and Faust (1994), a network is a structure formed by a number of participants (such as individuals or organisations) and the linkages between them. The various networks in a country may well extend far beyond that country's border, and have strong implications for the internationalization of the firm. In terms of networks, internationalisation means that a firm will develop business relationships within other countries' networks (Johanson/Mattsson, 1993). This can be achieved in three ways: (1) through the establishment of relationships in country networks that are new to the firm – extension; (2) through the development of relationships in those networks – penetration; and (3) through interconnecting networks in different countries – integration (Johanson/Vahlne, 1977). The above-mentioned stages of internationalisation are typical for technological innovations due to the complexity of entering a foreign market for single SMEs, and also due to the specificity of supplied solutions, which often comprise the whole interaction system. For SMEs, network contacts do not only influence the foreign market selection (Andersen/Buvik, 2002), but also the dynamics of entry (Meyer/Skak, 2002), the time of internationalisation (Oviatt/McDougal, 1994) and marketing-related activities (Coviello/Munro, 1995). Therefore, the following hypothesis is derived:

Hypothesis 3: The unification of innovative market participants into the network leads to the successful internationalisation of firms.

Depending on the developmental state of the cooperating firms, the spheres of their activities, their trust of each other and the interaction between them, this can take place in various directions: economic, legal, administrative, technological, social or informational (Cameron, 1995). Moreover, interaction can be both formal and informal. According to Laage-Hellman (1989), personal relationships and networks are especially important in turbulent, high-technology industries. Choosing the right partner is one of the major issues for SMEs entering a foreign market. As a result, there is often a "coordination problem" in the actions of legally independent firms subjected to unification, which often leads to the necessity of a "system integrator" who can serve as an intermediary (Cherenkov/Uhanov, 2003). In the course of cross-border cooperation, this problem is one of the main reasons for the slow internationalisation process of firms. Therefore, the following hypothesis is derived:

Hypothesis 4: The direction and type of relationships within the network are key factors affecting the success of the internationalisation process of a firm engaged in the production and distribution of technological innovations.

2.5.2 Influence of the macro-environment on the internationalisation process

In the framework of political, economic, social and technological analysis (PEST-analysis), countries differ from each other by their level of economic development, political system, culture and technological experience (Wright, 2004). These macro-environmental factors influence the activities of innovative firms, not only within their own countries, but also abroad, creating a certain image among foreign partners.

At present, there is a noticeable lack of publications in scientific literature on the comparative characterisation of innovation process participants' network cooperation in countries with different levels of development. As a consequence, this analysis primarily aims at conducting a comparative PEST-analysis of Russian and German cultures.

Political and legal factors

According to the World Economic Forum, indicators of political stability in Russia are much lower than in Germany, especially with regards to the effectiveness of legislature. There are practically no laws in Russia that regulate innovative activities, which results in a low level of intellectual property development. In Germany, business is conducted according to the rules and regulations determined by German laws.

Furthermore, Germany is not a corrupt country, but is characterised by its transparency in conducting business. For Russian producers, such methods of conducting business are quite unusual and complex, because it requires supplying a product of high quality, as well as participating in real rather than fictitious contests to select the most suitable supplier.

Germany has a fairly high index of investment attractiveness: it ranks 13 among 191 countries, whereas Russia ranks still 116, which will undoubtedly affect the country's rate of innovation developments.

Economic factors

As shown in Table 11, the German economy is characterised by a high level of development. This is reinforced by the share of exports and imports, as well as the gross domestic product (GDP) level.

In addition, there is a significant difference in royalty payments between these two countries. In Germany, a large number of patents and licenses have spread abroad which cannot be said about Russia.

Table 11: Key economic indicators in Russia and Germany (2012)

Indicators	Russia	Germany
GDP volume (mill. USD)	2,014,775 (rank 8)	3,399,589 (rank 4)
GDP growth (%)	3.4	0.7
Inflation level (%)	6.5	2.1
Export (% of GDP)	26	43
Import (% of GDP)	16	45

(Source: World Bank Database, 2012)

In comparison with the German market, the Russian market exhibits only a low level of competition among innovative firms. The reason for this is the substantial state support for Russian innovative developments. This trend contributes to the delivery of innovative solutions under the control of the state sector only, which is reflected in the low availability of innovations to the masses.

Socio-cultural factors

This study compares Germany and Russia in terms of their culture, based on one of the most popular and comprehensive typologies developed by Hofstede (The Hofstede Centre, 2013a). According to Hofstede's dimensions, there are significant cultural differences between Russia and Germany that affect firms' operations in general and innovative firms' operations in particular. The parameters considered by Hofstede are as follows: individualism–collectivism (IDV – the extent to which the individual has ties to others within the community); power distance (PDI – the extent to which the least empowered individual accepts inequity in the distribution of power and considers it to be a normal state of affairs); the desire for uncertainty avoidance (UAI – the extent to which individuals feel threatened by uncertain and ambiguous situations, as well as the extent to which they try to avoid such situations); and masculinity–femininity (MAS – the extent to which dominant values are established for both men and women). They have a significant influence on forming a network between participants both inside the country and abroad.

Figure 19 shows that Russia has a high power–distance index; that is, its behaviour reflects and represents the status roles in all areas of business interactions, such as visits, negotiations or cooperations. Russian management should operate in a top-down manner and provide clear instructions for any task. Several decades ago, Russian firms were working according to determined standards, and it was strictly forbidden to depart from them. Conversely, German firms at that time were using actively defined technical regulations and standards, but it was not forbidden to introduce new techniques or procedures in order to improve the quality of manufactured products and related services. Today in Germany, direct and participative communication and meeting styles are common practice. These differences affect the speed of innovation distribution, as well as the formation process and the various kinds of interaction between network participants.

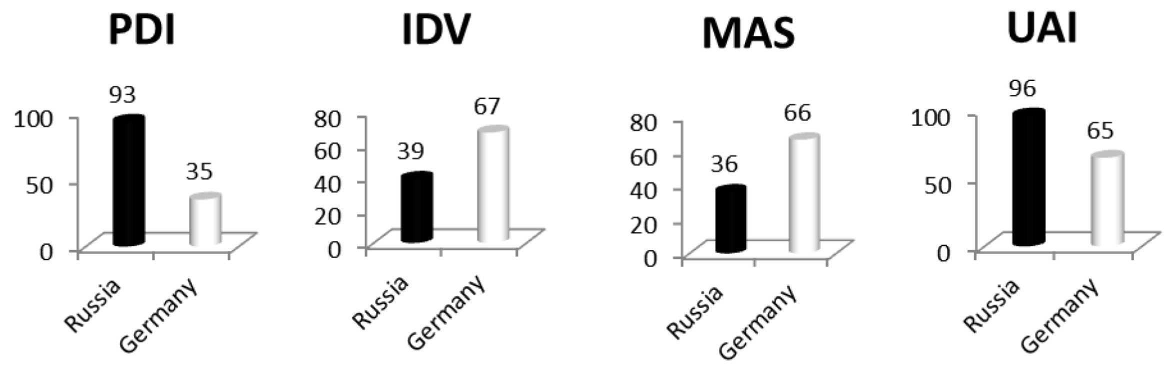


Figure 19: Comparison of Hofstede indicators between Russia and Germany

(Source: The Hofstede Centre, 2013b)

Russian business is characterised as conservative, i.e. working staff and top management usually have a solid job position and are reluctant to change. They are expected to be personable, authentic and trustful so that they are able to focus on tasks and build on careful relationships with recipients. That is why they search for independent solution strategies to overcome low levels of trust with other market participants, and to resolve the long-term preliminary negotiations before the joint implementation of decisions.

Following the ideal to be "honest, even if it hurts", and by giving their counterpart a fair chance to learn from mistakes, German communication is deemed among the most direct in the world. This approach allows German firms to be more open towards new ideas and interactions, resulting in rapprochement between business associates.

Russian mangers are afraid of uncertainty. Detailed planning and briefing is very common. Furthermore, Russians prefer to have context and background information. As long as they interact with people considered to be strangers, they appear to be very formal and distant. As a result, one should not expect Russian firms to easily accept cooperation offers or to purchase a product, especially in cases involving of innovations.

Managers of German firms can be attributed to the category of people whose confidence in a particular case depends on the information they have received. Details are very important, and they use them to produce clear solutions. At the same time, they do not tend to devise a thorough picture of their further actions, which allows them to be more flexible in the market. Therefore, the following hypothesis is derived:

Hypothesis 5: *The less conservative the culture of a country is, the easier it is to build and interact within the network.*

Technological factors

Both Russia and Germany have great potential for the development of innovations. Unfortunately, however, the Russian economy is spending twice less money on R&D than Germany despite having a similar number of working staff (1.25 % of GDP vs. 2.82 % of GDP, respectively). This testifies about the low level of wages of working staff and inadequate funding of activities. Also, the amount of published studies is a crucial issue. Russian scientists publish three times less scientific studies than their counterparts in Germany.

According to the results of PEST-analysis, Russia is inferior to Germany with regards to a number of indicators (as shown above); however, Russia has a fairly high potential for further development. Cultural differences between the two countries reveal that Russia is characterised as a more conservative business environment, thus preventing the mass marketing of innovations.

The practical verification of the theoretical assumptions proposed above is based on a survey of Russian and German RFID firms, as well as expert interviews with RFID market participants. The survey was taken among 91 German and 41 Russian firms in two stages from January to June 2013. The sample was formed on the basis of the following criteria: the presence of the firm's website and publications in print and electronic media; the number of completed projects; and the availability of key informants in each firm. Fifty-one German firms involved in RFID solutions development and 40 German firm integrators received the survey questionnaire. In Russia, the spread was somewhat different: 31 firm integrators and 11 manufacturing firms received the survey questionnaire. Questionnaires were sent over the Internet in both German and Russian. At the first stage, a total response was obtained from 35 % of the firms (37 % from the German firms, and 33 % from the Russian firms).

The aim of the first stage was to conduct a study about the RFID market situation in Germany and Russia. Suggested questions were aimed at obtaining information about the firms (e.g. sphere of activities, number of years in the RFID market, sales volume and cooperation with foreign partners), and to determine the market position (e.g. number of projects implemented per year, spheres of implementation, promotion problems, etc.). The second stage dealt with the description of network interaction between the main RFID market actors. A number of firms refused to participate in the second stage, referring to the fact that they did not work in a network and saw no benefits of such an interaction.

The purpose of the survey is to identify the position of the main RFID market participants, so as to determine the direction of their interaction and their types of relations, as well as the prospects of network relations development. Expert interviews were conducted during September 2012 and February 2013, among 24 Russian and 8 German firms related to the RFID market. In total, 32 senior managers were interviewed: 8 were from RFID firms; 7 were from the business community; 5 were from research institutes; 9 were from consumer firms; and 3 were from non-governmental organisations.

Respondents were selected on the basis of their awareness about the interactions of both external and internal interested participants, as well as interactions with customers and suppliers. Data were collected through personal interviews with key respondents; the average length of the interview was one hour.

All interviews were audiotaped and transcribed verbatim. The purpose of the interviews was to determine the degree of RFID development in both countries' markets, and to identify the prospects for further technology growth.

2.5.3 Survey findings and discussion

Process of diffusion and internationalisation of innovative enterprises

Hypothesis 1 states that firms engaged in the production and distribution of technological innovations at the stage of development are involved in the internationalisation process.

As a result of the literature review and the conducted study, it was found that the main participants in RFID technology development were component suppliers, manufacturers, integrators at various levels and consumers. Typically, consumers' interaction processes are transboundary in nature as a result of permanent informational, product and financial exchange.

The process of innovation diffusion in Germany takes place in two directions: the domestic and overseas markets. In Russia, however, only domestic supply or the equipment import is possible. This, in turn, leads to a non-saturation of the domestic market, but also results in a high level of competition between firms from outside the country.

According to the results of the conducted study, about 56 % of German manufacturers positioned themselves as firms operating within and outside the country after entering the market, supplying equipment to neighbouring countries in Europe and gradually expanding their geographical activities to markets in the former Soviet Union and Asia. In addition, 87 % of those surveyed German firms have confirmed that they are constantly exchanging information with foreign counterparts, which allows them to be up-to-date with global trends.

67 % of Russian producers indicated their interest in exchanging information with foreign partners in order to become acquainted with new trends, to copy technologies and then transfer them to the Russian market. Only large Russian firms can afford to position themselves in overseas markets (9 %), while others work with firms from countries in the Commonwealth of Independent States (CIS) (23 %). All integrators presented in the Russian market confirm that, since starting their business, they have mainly been involved in internationalisation processes through the purchasing of foreign equipment.

Thus, we can confirm the fact that innovative firms are involved in the internationalisation process from the first stage of their development. Thus, Hypothesis 1 can be confirmed. The difference between Russia and Germany refers to external factors that characterise a country's degree of innovative development. That is, Germany has a high degree of innovative development, and thus a high degree of RFID export technology, whereas so far Russia only imports foreign products.

Interaction of network members

According to Hypothesis 2, network members' interaction leads to the acceleration of technological innovation development processes. Interactions occurring between the main actors in the RFID market are affected by a number of institutions, such as government agencies, business communities, standardisation bodies, various associations and institutions, which also function as a diffusion network (as shown in Figure 18).

Russian RFID manufacturers often interact with representatives of business communities, especially with suppliers of components, integrators, other RFID manufacturers and consumers; contacts with other members in the network are not so well established. Interaction with public authorities is established in order to implement public contracts, while standardisation bodies provide legitimacy through their use of equipment developed in the Russian Federation.

In Germany, networking differs, as close relationships are not just established with the aforementioned organisations, but also with academic institutions involved in scientific research, as well as with non-governmental organisations represented by various industry associations that exploit new technologies. Hence, the network of German company contacts is ramified and allows for a higher level of network cooperation, where the functions of innovation diffusion are clearly divided among network participants. In Russia, however, this trend is just beginning to develop, and RFID market participants are still trying to find common interests in order to establish interactions with one another.

Interestingly, about 15 % of the German RFID firms and 35 % of the Russian RFID firms interviewed believe that they are not members of a network, and that the considered direction of cooperation is unlikely to bring any additional benefits for the development of their firms. This fact either indicates that these firms are not striving to develop their business or that they are not aware of the current market situation where an economic entity cannot exist in isolation.

Thus, the German RFID firms are capable of establishing direct links with foreign consumers due to their more developed network and a greater regard for quality equipment. On the contrary, the Russian RFID producers are still at the initial stage of the internationalisation process, and only just demonstrating interest entering foreign markets.

According to experts, more extensive networks of cooperation between Russian firms in the RFID market would undoubtedly contribute to more possibilities for market players, and thus strengthen their position in the international market. Hence, the more extensive the network contacts existing within a country, the greater the probability of its successful development in the domestic market, and also the greater chance of entry into foreign markets. Therefore, Hypothesis 2 is supported. However, aside from this, one should not forget about the product itself, whose competitiveness plays a significant role too.

Success of the internationalisation process

Hypothesis 3 states that the unification of innovative market participants into a network will lead to the successful internationalisation of firms. However, some firms assume that interaction within successful internationalisation should be formal in the field of financial goods exchange. That is why our fourth hypothesis states that the direction and type of relationships within the network are key factors affecting the success of the internationalisation process for firms engaged in the production and distribution of technological innovations. The main areas of cooperation for both German and Russian RFID manufacturers are:

- purchasing or transferring new scientific knowledge as a result of technology innovation and its continuous development;
- testing equipment and obtaining documentation to ensure the rights for its introduction;
- purchasing or supplying components and finished products;
- joint development of new solutions;
- marketing activities for launching a product on the market;
- project financing.

Thus, the most common areas are economic, technological, professional and informative types of connections, which further develop the technology.

The firm's degree of involvement in a particular process depends on the position it occupies in the market (manufacturer or integrator), as well as on its level of development and level of contact network. The difference between Russia and Germany lies in their respective network's orienting point. For example, German manufacturers quite commonly exchange not only components and finished goods, but also cooperate in the field of marketing, including the exchange of market information, participation in joint projects and organising joint seminars and conferences. The joint efforts in bringing innovations to the market allow companies to address larger audiences, what facilitates an increased potential for consumer awareness. This is important, as a lack of basic technological knowledge and its benefits is one of the main problems of RFID market promotion.

Marketing cooperation between producers in the Russian market has been poorly developed until now. The reason for this is a "closed" information policy between competitors and their unwillingness to conduct joint projects.

Both formal and informal types of cooperation have become widely spread within these areas of the RFID technology market. Formal communications both in Russia and in Germany may be characterised by interactions with academic institutions and government agencies. Moreover, the majority of German firms build formal links with standardization bodies, whereas Russian producers interact with these types of organisations on a less formal basis. In terms of business societies, the opinions of integrators and consumers are divided among Russian and German manufacturers: they are both looking for ways to interact with the above-mentioned participants. For German firms, it is common to have both formal and informal connections with a party. In Russia, only one type of connection is usually created. Both Russian and German respondents said they would like to interact with other RFID manufacturers, even with those from other countries.

Areas of cooperation among German firms are wide, and this allows them to successfully enter overseas markets, using pooled resources from an entire network. Thus, Hypothesis 3 is supported.

The relationship types of Russian and German firms are also similar. Hence, it can be concluded that the formality of relationships between parties does not affect the success of a firm's internationalisation. Therefore, Hypothesis 4 is not supported. The success of internationalisation depends not only on the direction and type of network interaction, but on the external factors in which technological innovation producers exist.

Influence of cultural differences on successful internalisation processes

Hypothesis 5 was derived so as to examine the influence of external factors; it stated that firms from countries with less conservative cultures find it easier to build and interact within networks. Different approaches to networking are rooted in various cultural components; they are dependent on the centralisation and bureaucratisation levels of the market, as well as differences in the political, economic and technological environment. As the results show, the more the macro-environment is adapted to free interaction among firms (legal protection, informational and technological base), the faster and more successful firms interact with one another. In addition, firms from countries that adhere more closely to the free market economy find it easier to establish communication with each other, and are less likely to look for other methods of interaction, since all links within the network will be set up to improve the current state. As a result, German firms are more open to collaboration with other market participants than Russian firms. Furthermore, German firms select partners more carefully and prefer collaboration with them on a formal basis. These described characteristics of Russia and Germany underline the importance of cultural differences in the process of network cooperation and its impact on the internationalisation process. However, for further research, deeper analyses of social factors and cultural differences are required.

There are a number of problems in Russia preventing the successful development of networking. Russian firms tend to conceal information and, as a consequence, distrust each other. Furthermore, there is an increased unwillingness to improve well-established processes, which results in a lower acceptance of innovations.

The gradual involvement of innovative Russian firms on the world market has led to a growth of newly formed networks. However, interaction often occurs at mid-management level, rather than at top management level. This has led to the development of informal networks that often have no specific purpose as the high power–distance levels restrict managers from making important decisions. As a result, experts from both countries believe that there is a strong demand for the establishment of "system integrators" in the Russian market. These integrators may link representatives from different countries, supervise their interaction and assume associated risks that are not related to the direct activities of cooperating firms. The presence of such integrators will enhance the information awareness of firms and consumers, as well as accelerate the development of innovative process in Russia.

These early results provide an overview of the current firm attitudes towards networking problems with both domestic and external partners. According to a number of RFID market participants, networks represent the future. However, for their further development it is necessary to create conditions that will increase the level of information security, as well as the trust between communicating parties.

2.5.4 Conclusions and implications

Data from 132 respondents from Russian and German innovative firms were examined in order to investigate cultural differences, and to overcome problems commonly associated with common method bias. The results provide evidence that network collaborations are crucial in the diffusion and internationalisation process of technological innovations. Furthermore, the empirical results demonstrate that network collaborations have a significant and positive effect on business performance. These findings support recent suggestions that there is a relationship between cultural differences, the level of network collaboration and the success of the internationalisation process.

The study also demonstrates that in order to achieve successful internationalisation results, firms need to broaden their network cooperation in their home country and try to find new partners abroad. Unfortunately, Russian producers are presently only able to buy foreign parts or equipment if they intend to create technological innovations or sell them in the domestic market; however, many firms are beginning to consider the possibilities of entering foreign markets. German firms, in contrast, use established network contacts, actively introduce their technological solutions abroad and make use of knowledge competence of local "system integrators".

Such a significant difference follows from the different levels of political, economic and technological development, especially with regards to the cultural component. The less conservative the culture of a country is, the easier it is for firms to establish network relationships with each other and to work together to access foreign markets. Further studies on this subject should reveal valuable sources of long-term interactions between innovative firms and fundamentally change their behaviour in the market.

3. Current state and future direction of knowledge & technology transfer in Slovakia

Our research was aimed at higher education and research institutions focused on technical and natural sciences which have the greatest potential to transfer knowledge and technologies to industry. The research consisted of examining the following (Brighton, 2014):

- opinions and interests of researchers in relation to knowledge and technology transfer based at Slovak higher education and research institutions (through an on-line electronic survey platform) – Survey No. 1;
- opinions and interests of leaders of selected Slovak universities in relation to the development of knowledge and technology transfer in their organisations – Survey No. 2.

3.1 Academic engagement with a technology transfer office

In March 2013 the following groups were approached to fill in a survey questionnaire entitled *Survey of opinions of researchers and scientists in academia on industry collaboration and working with a TTO*:

- all researchers and lecturers (approx. 1100) at the Slovak University of Technology (STU) - distributed centrally via e-mail;
- researchers and lecturers at the Technical University in Košice (TUKE) – the survey questionnaire was placed on the University TTO website (the No. of those who accessed it is unknown);
- deans at Žilina University in Žilina who were also asked to distribute the survey questionnaire to researchers (each dean was approached twice). The deans disregarded the requests and hence the researchers from Žilina University did not take part in the survey;
- 30 researchers at seven technology oriented institutes at the Slovak Academy of Sciences - distributed by the TTO manager via e-mail;
- 20 researchers at the school of natural sciences and school of mathematics and physics at the Comenius University in Bratislava - distributed by one of the associated professors at both schools via e-mail.

The survey questionnaire was placed on the surveymonkey.com platform (the world's leading provider of web-based survey solutions), which enables simple navigation. The survey questionnaire was available to access till 31st May 2013. Respondents had the option to remain anonymous. The questionnaire included 31 questions (excluding introductory questions to obtain basic information), out of which 8 were open questions and 5 incorporated a blank window for the respondents to expand on their answers.

146 responses were received, which constituted a 12.7 % response rate (researchers from TUKE were disregarded as it was not possible to quantify the number addressed by the survey). Most responses were received from the Slovak University of Technology (114, 78 %), 12 (8 %) were from the Slovak Academy of Sciences, 9 (6 %) from the Technical University in Košice and 8 (5.5 %) from Comenius University. A further three respondents learnt about the survey from peers and decided to participate – one from the University of Žilina, one from the University of Cyril and Methodius in Trnava and one from Pavol Jozef Šafárik University in Prešov. The response rate is considered adequate for this type of survey. Taking into account that most respondents were from the Slovak University of Technology, their responses were evaluated separately where appropriate or beneficial (Figure 20).

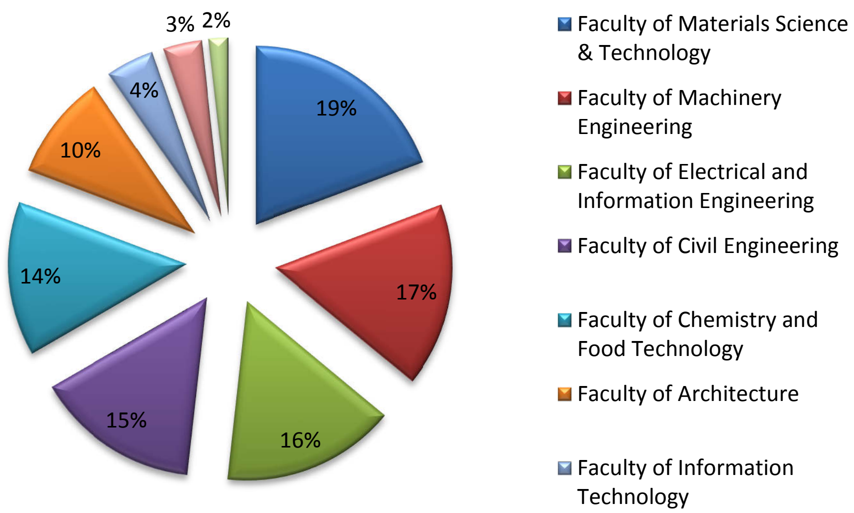


Figure 20: Participation of researchers/lecturers from the STU in the survey

In total, 105 men (72 %) and 41 women (28 %) participated in the survey. In the age category under 30 years there were 40 respondents (27.4 %), in the age category 31-45 years 52 respondents (35.6 %) and in the age category over 46 years there were 54 (37 %) respondents.

145 respondents stated their position in their organisation (categorised in 6 main positions) - 50 (35 %) researchers, 44 (35 %) junior Ph.D. Researcher/Lecturer, 32 (22 %) associate professor, 10 (7 %) Ph.D. student, 6 (4 %) professor and 3 (2 %) director (Figure 21).

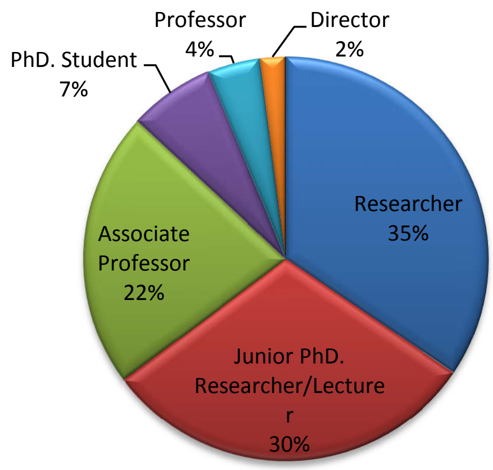


Figure 21: Participation according to the participants' position

Awareness of researchers and lecturers of the existence of aTTO

100 (68.5 %) respondents knew that universities and research institutions often have TTOs which focus on commercialisation of know-how and research results. They said they learnt about the TTO from the sources listed in Figure 22.

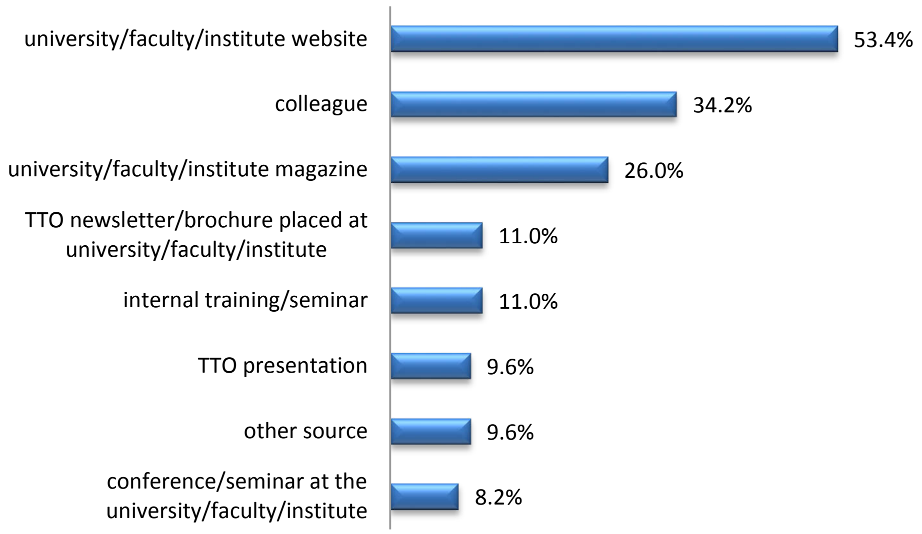


Figure 22: Source of information on TTO for researchers

73 respondents answered a multiple-choice answer question: "What services does your university/institute provide?" Out of those who were aware of their TTO, approx. 60 % did not know or were unsure of the type of services it provided. 53.4 % of respondents said they did not know about the type of services provided by their TTO and the majority of those who selected „other", later stated they did not actually know what type of services were provided. 26(35.6 %) respondents said their organisation provided IP protection related services, 21 (29 %) said it facilitated the provision of

consultancy services to industry by researchers, 11 (15 %) stated it assisted with applied research project applications and 10 (14 %) said it assisted with acquiring contract research projects.

Researchers' own experience with IP protection

135 respondents answered the question about having own experience with IP protection. 99 (73 %) said they had no experience and 36(27 %) said they did.

39 men and 8 women said they had experience with IP protection. The highest number of researchers (23) with IP protection experience was in the age category "over 46" (15.7 % of all respondents). The age group "under 30" (9 respondents, 6 % of all respondents) had the least experience.

34 researchers from the Slovak University of Technology (30 % from all respondents from this university) said they had experience with IP protection, out of which 15 (13 % from all respondents from this university) were over the age of 46, thereof 28 were men and 6 were women.

Table 12 shows experience of researchers with IP protection by their gender and age. 35 (24 %) respondents answered a multiple-choice answer question „What specific experience with IP protection do you have ?". 6 researchers had experience with various types of IP, e.g. patent, utility model, design, Figure 23 shows the number and percentage of researchers with own experience in protecting various types of IP. Those who selected „Other" mostly referred to copyright related to publications and student work, only two referred to unique technical solutions developed for industry and sold as part of a contract for works.

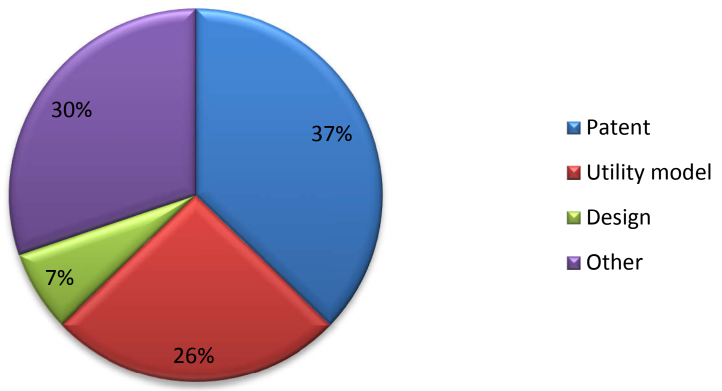


Figure 23: Researchers with own experience in IP protection

Table 12: Experience of researchers with IP protection according to their age and gender

Age/Sex	No. of researchers with own experience with IP protection		Out of those researchers from the Slovak University of Technology	Subtotal
Under 30 years	40		28	
Male	32		24	
Have experience		9		7
Does not have experience		23		17
Female	8		4	
Does not have experience		8		4
31 - 45 years	52		44	
Male	37		31	
Have experience		12		10
Does not have experience		25		21
Female	15		13	
Have experience		3		2
Does not have experience		12		11
Over 46 years	54		42	
Male	36		25	
Have experience		18		11
Does not have experience		18		14
Female	18		17	
Have experience		5		4
Does not have experience		13		13
Total	**146**		**114**	

Interest of researchers in IP training

58 researchers (40 %) confirmed that their organisation offered them IP training. Only 15 (26 %) researchers attended IP protection training out of which 14 (93 %) were men. Half of them were aged 46 and over. 43 (36 %) respondents who did not attend training stated they would attend in the future, 77 % of this group were men and almost half of them were aged 31-45 years. 65 % of those who were not offered IP protection training stated they would have attended had it been offered. 58 % of them were men (Table 13).

Table 13: Information and interest in training on IP protection according to gender and age

Has your institution offered you IP protection training and have you attended?	under 30	31 - 45	over 46	Total
Male	**32**	**37**	**36**	**105**
Yes and I attended it	4	3	7	14
Yes, but I haven't attended it, I would attend it in the future	9	15	9	33
No and I would not have attended even if it had been offered	5	6	9	20
No, but I would have attended had it been offered	10	10	8	28
I am not sure	4	3	3	10
Female	**8**	**15**	**18**	**41**
Yes and I attended it		1		1
Yes, but I haven't attended it, but I would attend it in the future	2	1	7	10
No and I would not attended even if it had been offered	1	2	3	6
No, but I would have attended had it been offered	5	10	5	20
I am not sure		1	3	4

All the other respondents showed no interest in IP training. 15 respondents (10 % of all respondents) answered the question: *"Have you used the information provided at IP protection training, do you think you may use it in connection with the protection of your own IP?"* as represented in Figure 24.

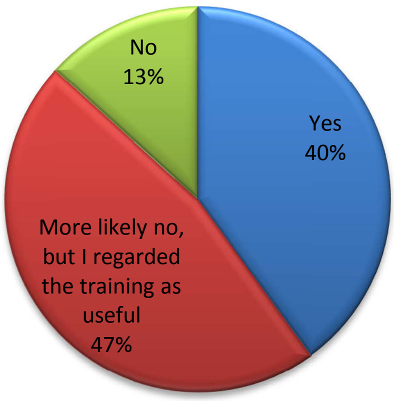


Figure 24: Utilisation of IP protection training for own IP protection

It was clear from the number of responses to this question as well as from the responses themselves that the researchers did not have that much interest in matters related to IP protection and commercialisation.

Support of IP commercialisation by the university/research institute management

130 (89 %) respondents answered the question whether their institution's management supports IP commercialisation. Only 21 % of them said the management did support commercialisation, 35 % said the management did not support it and 44 % stated the management supported IP commercialisation only partially.

77 respondents specified the way their institution's management supported IP commercialisation. 29 (37.7 %) of them stated they were not really sure how was IP commercialisation supported in their organisation. Some respondents added they did not know of anything specific and suggested the institution's management only talked about support, but did not actually provide it. 11 (14 %) respondents said the management organised the provision of some information through the organisation's website, presentations and trainings. 9 (11.6 %) said the management initiated meetings with companies, supported cooperation with companies via contracts for works and provided overall support to entrepreneurial activities. 8 (10 %) said the management supported patent applications (or other forms of IP protection) either financially and/or by providing all associated services. 4 respondents stated spin-off companies were supported (also through a university incubator) and 4 gave as an example the establishment of a TTO. Other examples were vague. It was evident from the responses that the management support of collaboration with industry and IP commercialisation was not sufficient. As one of the respondents pointed out: *"There is a lot of talk on the subject, but the support is not provided continuously, it is mostly based on the availability of various projects financed by EU Structural funds"*.

Researchers' interest in collaborating with industry

98 (67 %) respondents from all the survey participants expressed interest in collaborating with industry, thereof 78 (80 %) were men. Among researchers most interested in academia-industry collaboration (both genders), there was however a small difference in numbers in all age categories. 30 (20.5 %) respondents stated they had no interest in collaboration, thereof 18 (60 %) were men. The remaining survey participants (12 %) said they might be interested in the future. The overview of participants' responses according to their age and gender is shown in Table 14.

Table 14: Researchers' interest in collaborating with industry according to their age and gender

	Male		Female		Total	
Up to 30 years	**32**	**30.5 %**	**8**	**19.5 %**	**40**	**35.6 %**
Yes	21	20.0 %	4	9.7 %	25	26.0 %
No	7	6.7 %	1	2.4 %	8	6.2 %
Not presently, but perhaps in the future	4	3.8 %	3	7.3 %	7	3.4 %
31 - 45 years	**37**	**37.1 %**	**15**	**36.6 %**	**52**	**27.4 %**
Yes	30	28.6 %	8	19.5 %	38	17.1 %
No	5	4.7 %	4	9.7 %	9	5.5 %
Not presently, but perhaps in the future	2	1.9 %	3	7.3 %	5	4.8 %
Over 46 years	**36**	**34.3 %**	**18**	**43.9 %**	**54**	**37.0 %**
Yes	27	25.7 %	8	19.5 %	35	24.0 %
No	6	5.7 %	7	17.1 %	13	8.9 %
Not presently, but perhaps in the future	3	2.8 %	3	7.3 %	6	4.1 %
Total	**105**		**41**		**146**	

10 respondents from universities added a note that had been collaborating with industry for a long time. They also highlighted these activities presented a tremendous burden due to the extent of their responsibilities and obligations at university. Some added they would not be able to secure a master's graduate thesis without collaborating with industry due to a lack of public funding for research required for a master's graduate thesis. Collaboration with industry was listed as one of the ways of keeping in touch with the latest technology innovations.

Men aged 31- 45 years have the highest level of interest in academia-industry collaboration and the interest of researchers aged 46 and over is just 3 % lower. Women aged 31-45 years and over 46 years had the same interest, but women aged below 30 years had 10 % lower interest. The number of men who were not interested in collaboration with industry was the same in all age categories. As far as women were concerned, those aged 46 and over were the least interested in collaboration with industry.

Those who stated they had no interest in collaborating with industry were asked an open question why they were not interested. There were mainly three reasons given: 1) the preference of basic research, 2) not having thought about it and 3) opinion that Slovak companies had very low absorptive capacity for R&D innovations.

The aim of the questionnaire was also to establish what motivated researchers to collaborating with industry most. 111 respondents (76 %) answered the question using the Lickert scale (Table 15).

Table 15: Motivation of researchers to collaborate with industry

Answer options	The most	Medium	Less	Does not motivate	N/A	Weighted Average
Opportunity to solve a problem/work on interesting assignment related to applied research	81	26	3	0	1	1.29
Opportunity to engage students in applied research projects	45	40	17	5	4	1.83
Additional income for myself	39	42	21	6	3	1.94
Additional income for my department	37	39	20	13	2	2.08
Personal prestige	34	35	19	12	11	2.09

We calculated the average rating to all individual response options applying the following formula:

$$[\, n1^*(1) + n2^*(2) + n3^*(3) + n4^*(4) \,] \,/\, n$$

n1, n2, n3, n4 – number of respondents who chose that particular answer and ranking

n – Total number of respondents who selected the particular answer

Ranking "The most" has weighting 1, "Medium" has weighting 2, "Less" has weighting 3, "Does not motivate" has weighting 4 and answer "N/A" has weighting 0. Numbers in round brackets are weighted values assigned to columns (1-4).

Answers to this question showed (Figure 25) that researchers were mostly motivated by gaining higher personal prestige and additional income for their department. They were slightly less motivated by additional income for themselves and the opportunity to engage students in applied research projects. They were the least motivated by an opportunity to solve problems or work on assignments from industry.

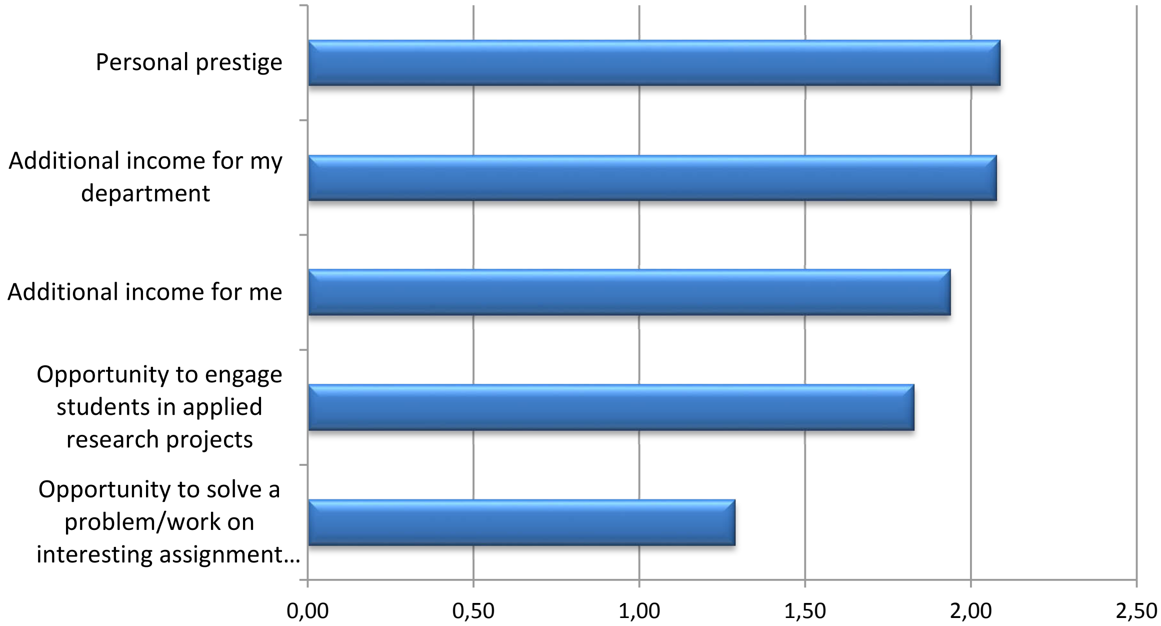


Figure 25: Motivation of researchers to collaborate with industry (average weighting of answers)

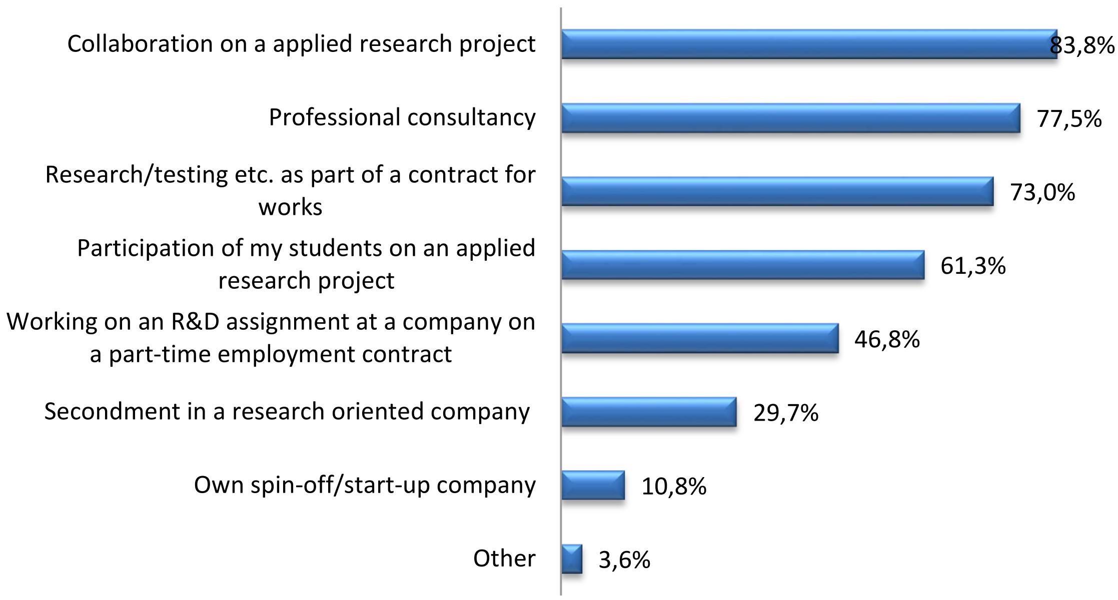


Figure 26: Type of collaboration researchers would offer to industry partners

Type of collaboration researchers would offer to industry partners

111 respondents (76 %) answered a multiple-choice answer question: „*What type of collaboration would you offer to industry partners?*" 93 (83.8 %) respondents stated they would collaborate on an applied research project. 86 (77.5 %) offered consultancy services, 81 (73 %) offered research/testing, etc. as part of a contract for works and 68 (61.3 %) proposed they could engage their students in applied research project. Respondents expressed less interest in working on R&D assignments for a company on a part-time employment contract (52, 46.8 %) or in secondment to a research department in a company (33, 29.7 %). 12 (10.8 %) respondents said they would collaborate with industry through their own spin-off company (Figure 26).

Working with a TTO

115 (78.8 %) respondents answered a question whether they used the services of their TTO and 86 % of them said they had not. Those who said they had used the services gave examples presented in Figure 27. Category "Other" included consultations which were unrelated to TTO's primary line of work.

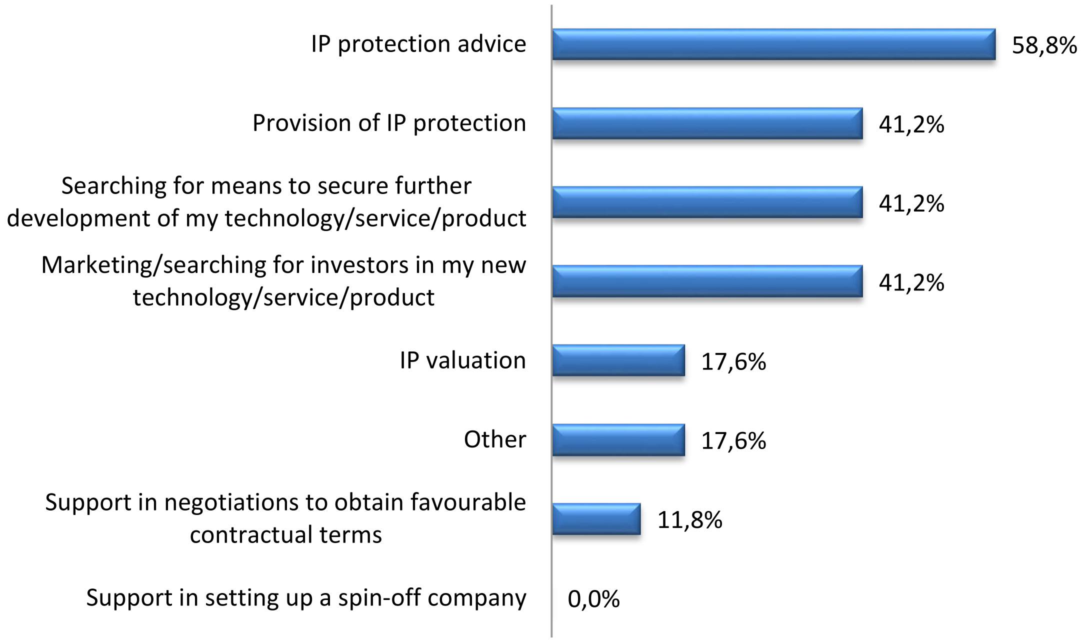


Figure 27: Types of TTO services researchers used

Only 10 (6.8 %) respondents answered a multiple-choice answer question regarding specific projects implemented through a TTO and named some examples. These included assistance with patent or utility model applications, drafting a collaboration agreement with companies as part of applied research projects (incl. testing products) financed by the Slovak Research and Development Agency (government agency) and EU Structural Funds, setting up cooperation with Automotive Cluster Slovakia and facilitating the provision of consultancy services.

A majority of respondents (80 %) were satisfied with TTO's services, no one gave a negative statement regarding the quality and scale of services provided by their TTO. Out of 17 respondents to this question 3 gave a neutral answer, 3 respondents were very satisfied and 11 were satisfied.

Respondents offered the following proposals on improving and expanding TTO services:

- Achieve a mutual agreement about what services should be offered at all levels (rector's office, faculties, institutes, etc.);
- Assist with winning applied research projects;
- Assist with administrative work which often significantly burdens the responsible researcher – project manager and his deputy;
- Provide financial assistance; help to co-finance international applied research projects;
- With the assistance of the TTO change the general attitude of all of those who deal with innovations to consider patenting before they publish (provide consultancy and training, raise awareness about the importance of IP protection);
- Increase the capacity (incl. the number of professional employees) and funding of TTOs;
- Improve the dynamics of work at the TTO (type of activities, development of new contacts, etc.), speed and efficiency of work;
- Motivate the TTO's employees (give them personal rewards);
- Invite more specialists from industry to present/teach at practical seminars at universities;
- Increase awareness about the TTO – the majority of researchers have no knowledge of it;
- Support patenting of innovations which can be commercially utilised and obtain funds to implement commercialisation (many patents do not leave the drawers due to lack of finance);
- Improve the appraisal criteria for those who work in applied research.

99 respondents (67.8 %) stated reasons why they had not worked with their TTO (Figure 28). The majority of respondents (73.7 %) either did not know about the TTO or its services were not aligned to their needs. Only 4 % said they had no interest in TTO services and would not have it in the future. Reasons marked as "Other"included lack of awareness of TTO's offer and insufficient marketing of TTO's activities (50 % of cases). Other 50 % of respondents said they had no need for TTO's services at the time.

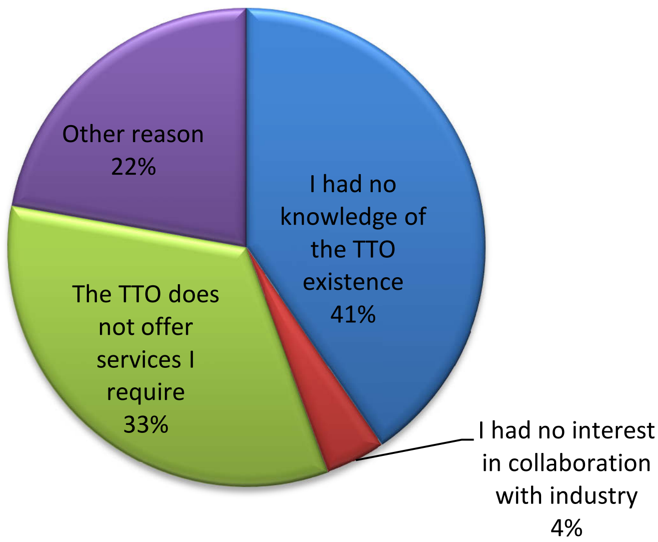


Figure 28: Reasons of no collaboration of researchers with their TTO

TTO services

93 (63.7 %) respondents answered a multiple-choice answer question *"Under what conditions would you use TTO's services?"* Their responses are shown in Figure 29.

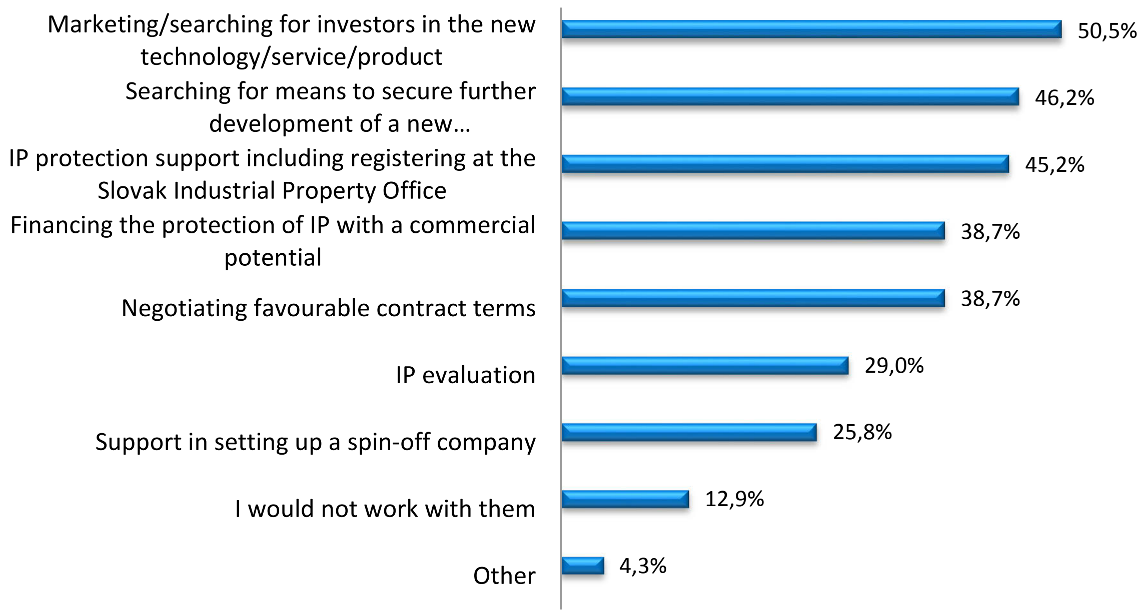


Figure 29: Overview of services the researchers indicated the TTO should offer

Researchers expressed the most interest in services associated with marketing the results of their research and searching for investors (50.5 %). The lowest level of interest was in support with setting up a spin-off company (25.8 %). Those classed as "Other" included proposals that the TTO should actively seek demand of Slovak companies requiring innovations and interested in collaborating with academia. Some researchers were interested in a public portal where specific industry demand would be presented and updated on a regular basis.

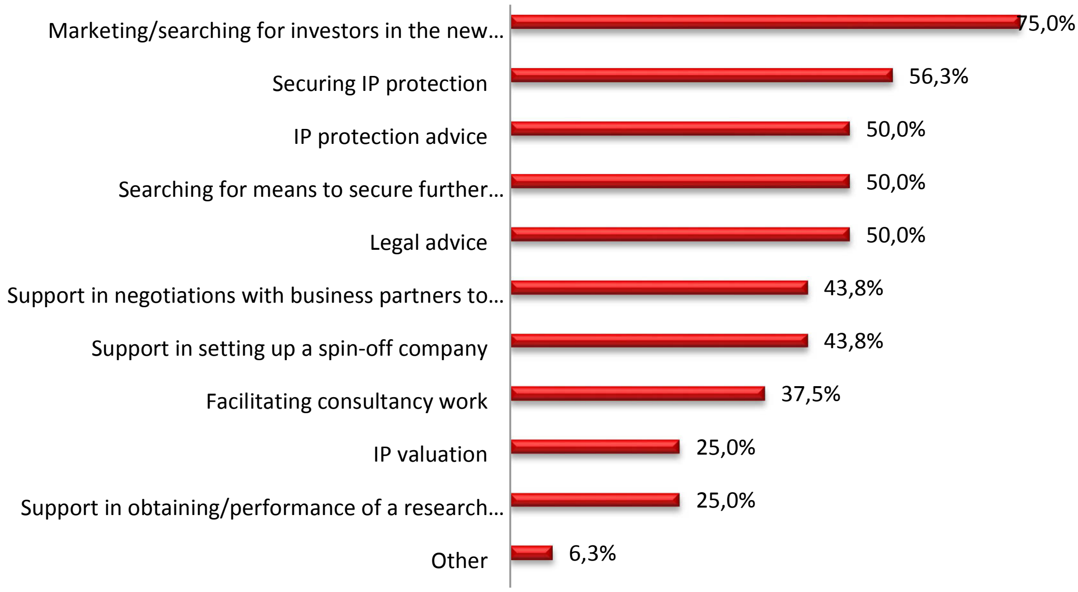


Figure 30: Ranking of key TTO services as expected by the researchers

Figure 30 shows services the researchers regard as key to be provided by any TTO. 96 (65.8 %) respondents answered a multiple-choice answer question and 75 % of them viewed services associated with marketing the results of their research and searching for investors as the most important. 56.3 % of respondents thought securing IP protection was key. 50 % of respondents regarded the provision of IP protection related advice, searching for means to secure further development of their technology/service/product and legal advice as key. Respondents regarded IP valuation services as the least important as well as assistance with winning and/or implementing research contracts (25 %).

Cooperation with external services providers

109 (74.6 %) respondents answered the question whether they had used external services related to IP protection and commercialisation. 91 (83.5 %) said they had never used such services. All of those who had used them (18, 16.5 % of those who answered this multiple-choice answer question) named the services listed in Figure 31.

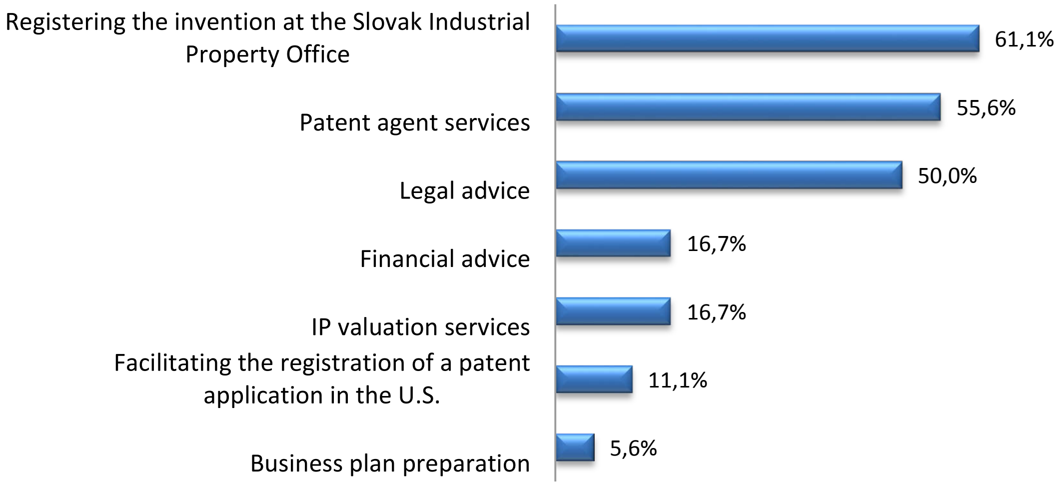


Figure 31: External services used by the researchers

IP protection and commercialisation policy

113 researchers (77.4 %) answered the question whether IP protection and a commercialisation policy was adopted at their institution. 95 (84 %) of them said they did not know whether it was adopted, 14 (12.4 %) said it was adopted and 4 (3.5 %) stated it was not adopted (Figure 32).

Figure 32: Awareness of researchers about the adoption of IP protection and commercialisation policy at their institution

Those who said they were aware of the IP policy being adopted were further asked whether it included a reward scheme stimulating academia-industry collaboration. 57 % of this group stated they did not know whether such scheme was included and 7 % said it was not included. 36 % of this group of respondents said the IP policy had included such a scheme. Survey responses show that most researchers who were aware of the policy did not know of its contents.

The importance of academia-industry collaboration for educational purposes

113 respondents (77.4 %)answered the question whether they considered academia-industry collaboration important for educational purposes. 97.3 % of these respondents said they did, the remaining answers were neutral (Figure 33). Those who gave a neutral answer (2.7 %) added that collaboration with industry was essential only in relation to certain subjects and that 1st and 2nd year students at technical faculties or institutes should focus on subjects like maths, physics, programming and algorithmisation, which do not require collaboration with businesses. The survey showed most researchers considered academia-industry collaboration as very important for educational purposes.

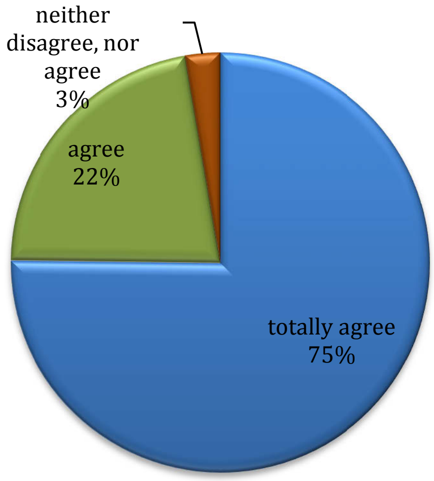


Figure 33: Importance of academia-industry collaboration for educational purposes

In the next part of the survey researchers were asked (open question) to express their opinion on the types of collaboration they considered useful for students. 109 respondents stated their proposals which could be summarised in the following three groups:

1. Students should work on projects which improve existing business processes in companies, the effectiveness of a manufacturing process, etc. Students should participate in applied research assignments from industry; they should not work on artificially created tasks.
2. Students should get to see practical issues (including methods and work on R&D projects, perform testing and analyses of new products and processes) taking place in well-equipped firms, also solve practical problems as part of their university course, e.g. internships in companies (including changing roles), on-site excursions, as part of their graduate thesis, etc. They should get to understand the present and future needs of companies and the vast difference between theoretical training at Slovak universities and business practice.

3. Students should gain experience with the process of obtaining funding as any additional finances would help to improve the quality of teaching in the department and so help to support the next generation of students.

Final notes and observations of respondents

In the final part of the survey 37 (25.3 %) respondents summarised their opinions on the whole subject of academia-industry collaboration and these could be categorised in the following points:

To improve conditions internally it is necessary to:

- Spark interest and create awareness in researchers about the importance of IP protection. IP protection issues require more attention and researchers need to receive a much wider spectrum of information. IP protection should become an integral part of R&D activities, which is the way it works at HEIs and research institutions in other more advanced economies.
- Increase flexibility, speed of response and reduce bureaucratic procedures at HEIs and research institutions when trying to establish the third mission activities. Respondents highlighted the excessive length of time administrative processes related to business contracts.
- Amend rules at HEIs on splitting income earned from contracts related to knowledge and technology transfer so that the project manager (main researcher) could benefit from it. Present conditions for contract work, including various contributions, which are not motivating for researchers and this can overprice the contract for a client company.
- Improve communication with industry. It is necessary to actively reach out to companies with absorptive capacity and a potential to collaborate and approach their senior management.
- Create space for flexible cooperation of individual departments within the Slovak University of Technology and other universities, particularly for projects where wider and more intense teamwork is desirable.
- Increase marketing and promotion of R&D results and successful research teams. There are a few scientists who have many years of personal experience with manufacturing processes in leading companies like Slovnaft (the largest Slovak oil refinery, member of the MOL group), Volkswagen, etc. Their experience should be exploited to achieve successful cooperation with other business entities and these activities should be encouraged by HEIs and research institutions.
- Eliminate the confusion when establishing TTOs at HEIs (e.g. at the Slovak University of Technology there is a TTO within the Rector's office and also at one of the faculties. It is not clear whether they provide complementary services or compete in some way. This also applies to the creation of spin-off companies, the Rector's office supports them, but at lower levels it is not quite so).

- Improve TTO's systems and procedures and its internal and external communication. The TTO is not very motivated in its approach to some issues (incl. client requirements), it lacks interest in clients' matters and effort to better engage with people.

To improve conditions externally it is necessary to:

- Change the ranking of universities which currently reflects only academic outputs, knowledge and technology transfer to industry are not being evaluated. This concerns particularly engineering study fields - researchers and scientists are ranked primarily for scientific outputs (e.g. scientific papers which may not have any practical application), not for successful applied research outputs, which significantly demotivates those HEI researchers who may want to collaborate with businesses.
- Increase government funding for science and academia-industry cooperation. The government funding has so far been insignificant which has led to a poor effort on the side of researchers and hence poor commercialisation results overall.
- Improve communication with business and the marketing of R&D results. Respondents also suggested it was necessary to change the prejudices businesses have in relation to academia, e.g. lack of quality work, academic institutions should offer services for free.

3.2 Support of knowledge & technology transfer by the institution's management

A Survey of university leaders opinions on the future development of industry collaboration personally addressed university leaders at top Slovak universities with engineering and natural science courses in March 2013. Potential participants were contacted personally and then emailed with a structured questionnaire. Some were contacted three times in order to obtain answers and the maximum amount of information. The aim was to find out the further direction of development in the area of IP protection and commercialisation. Regrettably, only three university executives agreed to participate in the survey. The Institute of Technology at the Slovak Academy of Sciences, which provides services on IP protection and commercialisation to all the Slovak Academy of Sciences institutes, did not have a director at the time of the survey, therefore it did not participate. Comenius University did not provide information due to the exchange of Vice-rectors for Development whose remit was KTT. The survey participants were the Slovak University of Technology (Vice-rector for Industry Collaboration), the Technical University of Košice (Deputy of the Vice-rector for Development & Construction) and the University of Žilina (Vice-rector for Science & Research). The survey was completed in July 2013 due to respondents' work commitments.

TTO management and development in the period of next 2 years

At the Slovak University of Technology the strategic management of KTT fell under the remit of the Vice-rector for Industry Collaboration. The day-to-day management of the TTO was the responsibility of the Know-how Centre Director who could directly influence TTO's results (TTO was a department within the Know-how Centre). At the Technical University of Košice the Rector had the statutory responsibility for TTO's outcomes and the daily operations were managed by the TTO. At the University of Žilina there were several offices at different faculties dealing with KTT.[73]

The management of the Slovak University of Technology planned to adopt an already prepared IP Protection and Commercialisation Policy which incorporated the TTO services for researchers and students[74]. The Know-how Centre's task was to actively search for the right candidates from industry who would be interested in applied research projects and/or inventions they could utilise for their business.[75]

The Technical University of Košice planned through its TTO to promote all forms of R&D collaboration with industry and provide advice on IP protection. Other services were to be developed during an EU funded project to build a science park at the Technical University of Košice (2013-2015). All of the universities participating in the survey had assisted their researchers with IP protection, using the services and funding offered by the National Infrastructure Project for technology transfer.

In terms of KTT, the Slovak University of Technology intended to focus primarily on the chemical industry (petrochemicals, plastics) and food technologies, but it also wanted to develop cooperation in the fields of machine and electrical engineering. The University of Žilina planned to focus on transport, machinery engineering, electrical engineering, construction, information and communication technologies and crisis management. The management of the Technical University of Košice wanted to support industry collaboration in all fields related to the focus of its faculties.

All university leaders indicated they wanted to focus on providing consultancy, contract research, licensing and support the creation of spin-off companies. The Technical University of Košice wanted to create shared workplaces with industry and provide specific education and training for industry partners. The Vice-rector at the Slovak University of Technology stated collaboration through research project contracts had been well developed, but said valuable IP was either not created or the academic project managers surrendered their claim to it when signing contracts with business partners. The aim at the Slovak University of Technology was to increase its IP portfolio and increase its income from licensing.

[73] A central university TTO was set up at the University of Žilina in the second half of 2013as part of an EU funded project to build a university science park.

[74] The IP Policy was finally adopted in September 2013.

[75] The Know-how Centre as such did not have any employees in 2014. The TTO had 1.5 FTEs in 2014 who developed the office operations and marketing, and assisted researchers with IP protection.

The Slovak University of Technology planned to finance the TTO and its activities mainly from EU Structural Funds projects (50 %) and national projects (40 %). The remaining 10 % was to be provided by the university. The Technical University of Košice and University of Žilina also intended to finance their TTOs predominantly from EU Structural Funds (60 %). The Technical University of Košice planned to obtain further funds from businesses and private sponsors (20 %), from international research projects (5-10 %) and the remaining funds from the university budget (to fund IP protection). The University of Žilina aimed to obtain additional funds from national projects (20 %) and use its own budget (20 %).

The University of Žilina estimated that the turnover from TTO's activities would reach € 1.6 million in 2013. Other universities did not expect significant turnover from TTO's work given the early stage of operation and considering that TTO employees would have to meet administrative obligations related to the management of projects financed by EU Structural Funds.

Raising interest in applied research and commercialisation among researchers and students

Several faculties at the Slovak University of Technology had an incentive programme undersigned by a dean which offered financial rewards to researchers for patent and utility models awarded to the university/faculty. The faculty of Machinery Engineering paid € 300 to an employee for a patent it wanted to retain (on average 3-4 such awards were paid annually).

In the first half of 2013 the Know-how Centre at the Slovak University of Technology organised a series of training seminars for staff and students on IP protection in cooperation with the Slovak Industrial Property Office and the Slovak Centre of Scientific and Technical Information. Seminars were held at individual faculties, but the interest was very low.

At the Technical University of Košice each faculty had set its own incentive system which the university management did not want to disclose for this survey. IP training for staff and students has been organised regularly since 2008.

The University of Žilina offered researchers as a reward participation at conferences and funding for projects. The university management did not want to disclose the reward scheme and IP training had not been offered.

At the time of the survey IP Protection & the Commercialisation Policy was already adopted at the Technical University of Košice, the approval process was underway at the Slovak University of Technology and at the University of Žilina it was not in place or planned to be adopted before the end of 2013. A reward scheme for license sale for researchers related to invention disclosure was incorporated in the IP Policy at the University of Košice and in the IP Policy to be adopted at the Slovak University of

Technology. It was aligned with the Slovak Patent Act and the final reward was to be calculated as a proportion of net profit based on the overall sale value.

As a result of certain measures, e.g. IP disclosure forms, provision of IP advice and training, the TTO at the Slovak University of Technology registered an increased number of queries from researchers (the number was nor recorded) and was preparing two patent applications at the time of the survey. The TTO at the Technical University of Košice did not record the number of queries from researchers either, but in 2012 they registered 9 utility model applications and 5 patent applications. The University of Žilina mentioned an increased number of utility model and patent applications, but did not give specific figures.

Major barriers of academia-industry collaboration

Management at the Slovak University of Technology considered researchers' reluctance to co-operate with the TTO and low awareness of the importance of IP protection. Management at the Technical University of Košice saw the problem in disinclination of researchers to co-operation among themselves and with the TTO, diversity of interests and considerable autonomy faculties, and also in the lack of integration of activities within the university. Additionally, they criticised the Higher Education Act as it did not support integrated and effective industry collaboration. The management at the University of Žilina also criticised the Higher Education Act as a barrier, but not the Slovak University of Technology. The management at the Slovak University of Technology did not consider this barrier as insurmountable. The management at the University of Žilina and the Slovak University of Technology did not regard any of the listed barriers as insurmountable, but the management at the Technical University of Košice regarded the Higher Education Act and the autonomy of faculties as insurmountable obstacles.

Recommendations of university leaders

Recommendations to improve KTT could be summed up in the following areas:

For universities:

- increase the awareness of legislation related to IP protection in researchers and students;
- promote the benefits (within the university) of using TTO's services and motivate researchers to disclose their inventions to TTO;
- introduce clear systems and procedures for IP protection and commercialisation (through IP Policy) in order to increase interest in collaboration on innovative projects with industry partners (do not apply for patents just to pursue personal goals).

For government and respective ministries:

- effectively stimulate R&D activities in businesses, e.g. tax breaks for companies investing in R&D, innovation vouchers etc.;
- introduce flexible legislation to encourage the creation of joint R&D organisations between private companies and public institutions;
- strengthen applied research at HEIs and research institutes (provide finance and stimulate collaborative projects), including innovation projects focused on sustainable economic growth;
- amend evaluation schemes for researchers, so that in their career progress they could also be rewarded for their successful applied research results, e.g. patents, utility models, international contracts, etc.;
- provide finance for IP protection at HEIs and research institutes.

Planned developments in the area of academia-industry collaboration

All university leaders wanted to support easily implemented forms of KTT and included the following (ordered according to their priority for concerned universities):

- contract research, testing and taking measurements;
- consultancy;
- students at all levels to collaborate with businesses on graduation thesis ;
- licensing;
- support spin-offs and start-ups.

As part of development plans the Slovak University of Technology addressed leading companies with an offer to collaborate on their R&D tasks and to create joint teams to solve their technical problems or improve technological processes. The Technical University of Košice and University of Žilina planned to concentrate on the development of their new science parks and business incubators as a base for innovation partnerships.

All universities also participated in a national project entitled "HEIs as growth engines of the knowledge society", which enabled students to apply for internships in companies and enabled universities to take advantage of offers to collaborate.

3.3 Summary and conclusion

KTT in Slovakia has been developing for the last approximately 6 years as a result of various EU funded projects at HEIs, the Slovak Academy of Sciences and the Slovak Centre of Scientific and Technical Information (National TT Infrastructure Project). KTT projects at universities and the Slovak Academy of Sciences have not been supported continuously due to gaps in project funding and the unwillingness of institutions to finance the development of their TTO from their own sources. Furthermore, public universities and research institutes have been underfunded by the government; they have lacked interest in systematically developing a portfolio of commercial activities. Private companies in Slovakia have limited interest and absorptive capacity for innovations and there has been a long-term issue with limited access to start-up and venture capital. Results and achievements cannot be therefore compared to those at universities in other more developed economies like the UK, Germany, Austria or the U.S.

The government has to systematically invest in basic and applied research, development academia-industry collaboration and IP commercialisation. There has been a long term absence of appropriate national joint research programmes in specific areas which would appeal to businesses. The government should also finance mechanisms supporting innovation in businesses, stimulate interest in businesses to working with HEIs and research institutions. Analysis of the British innovation charity NESTA (National Endowment for Science, Technology and the Arts, 2009) showed that half of the growth of the British economy between 2002 and 2008 could be attributed to 6 % of the most innovative companies that had twice as higher job growth than those that did not innovate and almost double the growth rate of revenues. However, even these experienced companies referred to barriers when in co-operation with universities.

KTT can only be successful provided that universities and research institutes create and sustain conditions for its continuous development, in other words, they create an entrepreneurial architecture. This requires the interest and support of the institution's management. A survey of TTO managers at various European universities (Brighton, Zajko, 2013) has clearly shown that institutions with strong management support in promoting the establishment of a TTO, IP policy in place and a flow of funds to secure the operation and development of the TTO achieved their goals and successfully developed their TTO.

Outcomes from survey No.1 as well as the experience from top universities (e.g. the University of Oxford) showed that researchers have generally low interest in working with businesses. Their interest can be raised provided such collaboration would bring benefits for themselves and the faculty, and help with teaching. Some researchers already co-operated with industry, but to use a central TTO they would have to see tangible benefits such as competent and experienced TTO staff who would provide legal advice (IP rights, contractual terms, licensing, etc.), valuation of the commercial potential of a created IP, marketing, facilitating contacts with businesses, assist with the whole IP commercialisation process and secure the necessary funds.

According to survey No.1, approx. half of the respondents from Slovak HEIs and research institutes were not aware whether their organisation had a TTO or not. 60 % of those who knew about it did not know nor were unsure what services it provided. According to survey No.2 all participating universities planned to improve the quality of TTO services (the University of Žilina was only in the process of setting up their TTO whilst the survey was being conducted) by using EU project funds to build a science park in their region (the project incorporated the development of services providing IP protection and commercialisation).

Only 20.5 % of survey No.1 respondents stated they had no interest in collaboration with businesses, others expressed interest either to pursue it presently or in the future. The most interest in industry collaboration had men in the age group 31-45 years, and it was only 3 % lower for those aged above 46 years. Although the interest of women in all age groups was significantly lower than that of men, it has to be noted that only 28 % of women researchers took part in the survey. One of the most extensive empirical studies of the cooperation of universities and enterprises in Europe, "The State of the European University-Business Cooperation" (European Commission, 2011) found that male researchers were much more (than female) engaged in R&D projects, commercialisation of R&D results, entrepreneurial activities and the mobility of students. It also found that senior researchers usually co-operated with businesses more than young ones. Additionally, the survey established that researchers who co-operated more had the following characteristics: a) have more than ten years of experience working at a HEI, b) have more than two years of experience working in a private company, c) work in a technical field and d) work at a technical university.

Services offered by a TTO are the same for researchers of both sexes (also at high ranked universities); they have to be designed to meet the needs of all researchers. TTOs ought to regularly seek feedback on the services they provide, evaluate them as well the effectiveness of the IP policy and associated processes and procedures.

Researchers at the Slovak University of Technology, respondents of survey No.1 were offered IP protection training just once (they accounted for 75 % of respondents to this question) and given that it was not sufficiently advertised (confirmed by the TTO manager), only 9.1 % of them attended it. 75 % of all researchers from the Slovak University of Technology and 69 % of all respondents to this question however, expressed a positive attitude towards the training by stating: "IP training was offered to me, I did not attend it, but I would in the future" or "Training was not offered to me, but if it was, I would have attended it". From survey No. 2 we found that regular IP related training took place only at the Technical University of Košice. Executives from all universities participating in survey No. 2 said they intended to facilitate IP protection training regularly and promote it well to the research community.

As well as businesses which want to improve their competitiveness and hence their innovation performance, HEIs also wishing to successfully develop a third mission have to introduce new processes and structures and gradually build their entrepreneurial architecture (section 1.4). To achieve high innovation performance, organisations must first develop organisational culture, attitudes and practices supporting and stimulating innovation. Only in such favourable conditions, is it possible to develop innovation capacity in R&D so that the organisation can efficiently produce innovative results and improve its innovation performance.

Given the long-term unmanaged and fragmented systems of academia-industry collaboration practice at Slovak HEIs and research institutes, as well as procedures exerted by faculties and the strong powers of individual faculties, the introduction, acceptance and subsequent compliance with the university-wide IP policy becomes an enormous challenge.

It is also important to note that neither of the Slovak HEIs participating in the survey had a TTO which could be compared (in terms of know-how, capacity, financial resources, marketing, networking, etc.) with those at established European universities (including Comenius University which did not participate in survey No.2).

Since HEIs and research institutes have a limited budget for KTT, they would benefit from developing only one central TTO (except institutions with faculties or departments which are geographically distant from each other, e.g. in another city may present an exception). This way, it is more likely to develop a good quality facility. TTOs can use the services of other partner organisations such as the National TT Infrastructure Project. Representatives from partner organisations, however, should not act as substitutes for regular TTO staff on a long-term basis. Researchers prefer to communicate with representatives from their own institution.

If we look at the results of the survey of efficiency in 67 TTOs at 40 universities and 27 other HEIs in Germany (Kratzer, Haase, Lautenschläger, 2010) we find that the critical success factors are: a) adoption of a university-wide IP policy, b) focus particularly on the provision of information, development of R&D collaborations, contract research, licensing and the creation of spin-off enterprises, c) the number of TTO experts and their heterogeneity, d) financial incentives for TTO project managers, e) ability to make decisions independently, at a TTO level (not transferring then onto a statutory representative). The survey concluded that HEIs disposing of lower levels of funding and a smaller number of TTO experts, but with well-developed networks and industry relations had shown strong potential to commercialise it's IP. A positive impact on the TTO performance also had collaboration with several external professional advisors, e.g. patent agents, national KTT centre.

Academia-business collaboration faces significant challenges, including the fact that these organisations operate on different motivational systems. Universities are focused on education and the creation of new knowledge, while private enterprises aim to obtain valuable knowledge and know-how that would give them a competitive advantage (Dasgupta, David, 1994). In recent years universities have been more entrepreneurial, co-operated with businesses and strove to protect and benefit from valuable IP more than in the past. Considering the high level of importance given to academia-business collaboration by governments of many European countries, the lack of research into barriers and ways for their elimination becomes a serious obstacle for designing effective innovation policies.

3.3.1 Barriers to knowledge and technology transfer and factors that diminish them

Some of the most significant barriers include researchers' apprehension to engage in applied and experimental research, and lack of understanding about IP protection and commercialisation. Up until recently interest in this type of research was fairly low due to government policy supporting predominantly fundamental research and due to existing appraisal scheme which does not adequately recognise outputs from applied research (preferred are publications and teaching outcomes). Research of various TTO's mainly in Central and Eastern Europe (Brighton, 2014) showed that researchers had initially lack of faith in the quality of TTO services and competence of TTO employees. Most HEI's participating in the survey also did not offer adequate financial reward for patents and other industrial property.

Based on the survey, observation and experience in academic insitutions in Slovakia we can summarise the barriers inhibiting academia-business collaboration as follows:

Barriers within the business environment

- legislative rules complicating involvement in entrepreneurial activities for public universities and research institutes, operations of business clusters and inconsistency in the implementation of measures of the Slovak Innovation Strategy between 2007 and 2013;
- lack of effective instruments to entice businesses in innovation (e.g. tax benefits, national and international innovation voucher schemes, access to venture capital etc.). The Slovak Ministry of Economy prepared in 2013 legislative changes to operate a scheme supporting innovative products, processes and services in private companies through innovation vouchers. The Ministry allocated a budget of € 250,000[76] for vouchers with a value of € 3,500 for SMEs and € 10,000 for large enterprises. Tax incentives to promote innovation are planned in the new innovation strategy S3 (see section 1.5 above);
- lack of support for enterprise development and missing innovation systems on a regional level (e.g. government support for regional development agencies in the area of business enterprise and innovation development – county and city councils should have specialised departments aimed at promoting entrepreneurship and innovation within their geographical area and push for the creation of technology and innovation centres as appropriate);
- insufficient support of new schemes (proven to work in other European countries) stimulating co-operation between universities and SMEs, e.g. successful examples from the UK:

[76] As declared by the representative from the Industry & Innovation Section at the Slovak Ministry of Economy at the Innovation Forum meeting on 25.9.2013 in Bratislava at the Slovak Centre of Scientific Information.

- Knowledge Transfer Networks comprise 15 networks sponsored by the UK government, involving industry and universities focused on certain industrial sectors. The network support staff provides information on funding, they organise meetings and influence relevant government policies;
- competition programme which stimulated co-operation on scientific research projects between academia and industry in key areas of science and technology provided will generate new products, processes or services;
- Knowledge Transfer Partnerships are proven successful method enabling companies to obtain new knowledge, skills and technologies from HEIs in order to improve their competitiveness on the market. The Programme allows the company to employ an expert from a HEI (incl. postgraduate students) to work on specific projects for a period of time and provides a significant financial contribution towards the costs;
- SME grants for all stages of innovation range from market research to prototype development in collaboration with academia.

Barriers at universities

- deficient quality of research;
- insufficient interest and dedication of university management to establish professional KTT systems through a TTO (linked to the next barrier);
- absence of a qualified TTO with adequate capacity to lead commercialisation projects at a professional level;
- missing IP Policy defining clear procedures and rules for handling university IP;
- existing reward system does not motivate researchers to disclose their inventions or to co-operate with businesses through the university TTO;
- existing appraisal scheme for researchers does not adequately recognise outputs from applied research (preferred are publications and teaching outcomes);
- lack of equipment or the inability to use lab equipment for commercial purposes;
- different value systems in private companies and universities: University researchers are driven to develop their academic careers and build a professional reputation by publishing academic papers. In the private sector the process of knowledge creation is dominated by an effort to acquire economic value from the knowledge to gain a competitive advantage. While university researchers want to disclose new knowledge as soon as possible to gain a lead, businesses want to keep or acquire know-how or trade secrets for themselves;
- lack of flexibility and timeliness in communicating and solving problems for businesses - businesses are often at odds with university researchers regarding research topics, timing and form of publishing research results. Universities often work on projects over a longer time period and there may be issues in differences related to organisational culture and communication language;
- lack of funds for IP protection and for external advisors on IP valuation, acquisition of industry partners and investors, legal support, etc.;

- lack of information on innovation markets with innovation, potential partners, co-operation opportunities and lack of effort to identify the needs of businesses, their demand for externally developed technologies or products. This is most likely due to insufficient experience and missing skills within the TTO;
- lack of funds for marketing and license sale;
- lack of proof of concept funds;
- lack of funds to support technology spin-off companies.

Barriers that prevent businesses from collaborating with universities

- low interest in developing own innovations due to lack of equity or the unavailability of venture capital. Costs of co-operation may seem a barrier for a company, particularly during negotiations of contract terms relating to the acquisition of patents etc. A further barrier is the lack of seed capital for preparing products, technologies or services ready for the market;[77]
- lack of absorption capacity of firms – company employees may not have the intellectual ability to understand and co-operate with university scientists and be able to translate their knowledge to meet business requirements. The company managers have to see collaboration with universities as an opportunity to deepen their knowledge and experience or to get specific problems resolved. The company must also have internal infrastructure and resources to adopt new processes/technologies etc.;
- no tradition or previous experience of cooperation with academia which poses a risk for the company. In contrast to knowledge creation on campus, "private" knowledge is largely enclosed within the enterprise. If published, it is only to a limited extent through patents which provide a temporary monopoly (Dasgupta, David, 1994). Despite the existence of successful examples of open innovation, the primary motivation of businesses is to create new knowledge for profit, and openness to external entities are only used as a strategic mechanism to gain competitive advantage (Chesbrough, 2006);
- no awareness of universities' offer in terms of applied research;
- lack of faith in universities caused by perceived problems in communication (universities have not been set up to solve technical challenges industry faces, they have a different organisational culture to the private sector);
- mismatch between the expectations of businesses, TTO and researchers – in case the company is interested in co-operating with a university on a specific issue which requires a formal contract, various departments from both, the university and the company may get involved in the process. It is however important that all parties share the same expectations and are interested in the project. Some innovative companies in the UK which participated in a survey (Abreu et al.,

[77] This issue was presented by the Business Innovation Centre (Bratislava) managers and the Secretary of State from the Slovak Ministry of Education at the annual Technology Transfer Conference (NITT SK) on 8.10.2013 in Bratislava.

2008) expressed concern that TTOs complicated matters in contract negotiations and IP valuations. This resulted in an unwanted delay for companies and university researchers concerned (universities tend to overvalue their IP). This problem can be attributed to a mismatch between the expectations of TTO employees on the one hand and motivation of researchers on the other (David Metcalfe, 2008). The experience of TTOs at leading universities (e.g. the University of Oxford and Cambridge) is that if contract terms and conditions are discussed and agreed at an early stage of co-operation, minimum problems arise later.

Key barriers to KTT

The following barriers to KTT may be regarded to be the most significant:

1. deficient quality of research;
2. low interest in applied, experimental research and IP commercialisation;
3. insufficient interest and dedication of university management to establish professional KTT systems through a TTO (linked to the next barrier);
4. no tradition or previous experience of cooperation with academia;
5. lack of effective instruments and funding to entice SMEs in innovation and motivate universities to collaborate with industry and commercialisation;
6. lack of support for enterprise development and missing innovation systems on a regional level.

3.3.2 Factors suppressing the barriers

Better KTT management at HEIs

Positive and realistic attitude of HEI management towards collaboration with industry partners is essential for developing strong relationship with industry. HEI leaders cannot focus on short-term wins – fast returns on investments in the HEI TTO. They need to provide continuous long-term support, including financial to build a sound KTT model of collaboration with businesses.

Experience of collaboration

Practice shows that those researchers who successfully collaborated with businesses would utilise the experience and further engage in diverse partnerships. Also, it can be assumed that regular collaboration will bring on the introduction of the necessary systems and procedures which can help to reconcile opposing views on the research objectives (Gomes et al., 2005), dissemination of results and deadlines for the delivery of results (Hall et al., 2003) etc. Operational reviews of various partner alliances showed that the experience of co-operation was a critical factor in the success or failure of subsequent partnerships (Hertzfeld et al., 2006). Previous co-operation often results in the introduction of standard procedures which becomes the starting point of negotiations on the purchase of IP rights and other contractual relations.

Variety in the types of interactions between academia and industry

Although some interactions may not require a formal contractual relationship, they are crucial for improving the effectiveness of future long-term formal research agreements. Wider involvement of both parties contributes to the gradual build-up of the ability to reconcile conflicting interests arising from different motivational systems between academia and industry (D'Este, Patel, 2007). Thus, if a firm and university co-operate in various ways (different types of interactions), barriers may arise in relation to IP transactions, but at the same time the breadth of collaboration reduces the barriers associated with different priorities on both sides.

Trust

High level of trust helps reduce concerns that one of the partners will approach the collaborative project opportunistically (Bradby, Eccles, 1989). Trust gives partners the assurance that their co-workers would be honest, objective and consistent, and help them solve any problems that may arise.

Research of factors reducing the influence of barriers on co-operation

Survey of 3119 private organisations engaging in the cooperation with universities[78], addressed the person responsible for cooperation with universities (Bruneel et al., 2010) investigated the barriers of interaction with universities and the frequency of different types of interactions. The survey was based on the assumption that cooperation was often local and therefore it is decided locally rather than centrally (Criscuolo et al., 2005).

The survey results showed that larger firms had perceived more barriers relating to IP transactions and employees with a Ph.D. degree had been more prone to consider possible issues that could arise in interactions with universities. Practical experience the company had obtained from the implementation of a joint research project with a university reduced barriers related to long-term research collaboration with the university. Experience of working with universities, however, do not reduce the barriers that firms perceive in relation to possible conflicts with IP rights and existing administrative processes at universities. Experience thus only partially mitigates barriers to co-operation.

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[78] The survey was conducted in 1999-2006 and included organisations of various sizes from various sectors (incl. Professional services providers) in the United Kingdom which collaborated on research projects financed by the Engineering and Physical Sciences Research Council (the Council provides government grants for research and post gradual studies in engineering fields and natural sciences in the UK, particularly at universities.

The survey results also confirmed that cooperation with universities in several types of activities enables private companies to better adapt to the system of work and timeframes at universities. The willingness of companies to invest in several types of activities, according to research, allows building practices for long-term and mutually beneficial cooperation. Diverse co-operation however also includes discussions with various representatives from different university departments and most likely also with the TTO. The more actors with a low risk tolerance will be involved in the process the more likely the barriers associated with their diverse interests, mandates and priorities will arise.

Barriers related to IP transactions can be, according to the survey, more difficult to limit. It is important to add that these barriers are particularly sensitive to government policy and the way universities are governed in Slovakia. This trend is unlikely to improve, given the costs of multilateral co-operation and the time needed for its establishment. At the same time, informal collaboration systems are coming more under control (the role of TTOs). Efforts to win new collaboration contracts with businesses will therefore be accompanied by complications, particularly if central university rules are inflexible and unfavourable.

An important finding of this survey was that trust was one of the most effective mechanisms for mitigating barriers. This means that the traditional system of informal reciprocity and exchange of information should be an important part of the effort to build cooperation.

An extensive survey of 6,280 scientists and university representatives at more than 3,000 universities in 33 countries implemented by Science-to-Business Marketing Research Centre of the European Commission (European Commission, 2011) came to a conclusion that motivation and barriers were interconnected in researchers' minds and trust between the co-operating parties played an important role. Both, the researchers and the university representatives stated that lack of funding was the biggest barrier to collaboration. Neither group, however, considered opportunities of obtaining funding for cooperation with industry, which means that funding alone is not enough as an incentive to cooperate. Mutual trust and commitment to common goals were identified as the most salient motivation. This means that if there was no motivation based on relationships and anticipated benefits from co-operation, adequate funds would not secure the collaboration.

To eliminate barriers, the study based on the above survey (European Commission, 2011) recommends not only securing sufficient funds, but also to eliminate unnecessary red tape and provide researchers with support through the TTO. To improve motivation, the study recommends the inclusion of industry needs and requirements in research plans of individual departments (through training researchers and students in marketing and entrepreneurship) and give researchers cooperating with businesses appropriate reward and career advancement. According to the results of the study, Slovak universities had the lowest rate of co-operation with industry compared to universities from other participating countries.

4. Success in knowledge and technology development in Slovakia

Management of KTT in Slovakia should take into consideration the following recommendations based on findings from well established TTOs at universities like the University of Oxford and research of various TTO's mainly in Central and Eastern Europe (Brighton, 2014):

1. Establish consistency in the management of KTT and commercialisation of R&D outputs by creating an appropriate form of TTO, innovation and entrepreneurial culture and values across the institution (e.g. by introducing incentive schemes and developing entrepreneurial spirit of employees).
2. Be bold and exploit experience from public HEIs and research institutes in other countries, e.g. UK, Germany and Austria, which benefit from significantly higher levels of public R&D funding. The governments in these countries distribute support through various organisations and agencies and reward public universities and research institutes for R&D results which get used by private companies or other organisations. In addition, governments in these countries introduced several mechanisms to encourage co-operation between academia and industry for mutual benefit. Such steps also increase the social importance of KTT and competitive advantage of universities. Innovation ecosystems in these countries should inspire governments and regional actors in the former Eastern bloc countries, which suffer from an insufficiently developed innovative culture, to improve the conditions for efficient KTT.
3. HEI management to enable TTO staff continuously improve their knowledge and skills, otherwise it cannot expect the TTO to produce substantive outputs. The TTOs informed decisions are the driving force behind the development of KTT hence its competent staff is a key factor in the major decisions in the process of KTT and IP commercialisation.
4. Financially secure the sustainability and development of TTOs at HEIs. The experience and best practices from Europe and the U.S. undoubtedly prove that to create and maintain a well-functioning TTO, which can effectively address the needs of scientists and researchers and businesses, requires a long-term commitment by the HEI leaders.

4.1 Model of successful knowledge & technology transfer management at higher education institutions

In developing the model we focused on the aspects that underlie the academia-industry co-operation. Government support is crucial for both HEIs, as well as for companies that lag behind in innovation of their processes/products/services. It is clear from the amount and nature of barriers affecting KTT that they are inherent in the combination of the way knowledge is created at HEIs, differences between timetables and priorities of HEIs and private businesses and fundamental differences in the objectives of both parties.

The following recommendations can be applied to a TTO which operates as a department at a HEI or as a separate company (see section 2.2.1). They provide a framework for the analysis of different types of barriers occurring in the commercialisation process and a succession of steps to inhibit them (Brighton, 2014).

4.1.1 Organisational and financial aspects of successful technology transfer office

A successful TTO requires**:**

1. **Leadership of the HEI management in strategic planning of KTT**:
   - Adoption of clear rules defining the process of co-operation between TTO, researchers and companies – IP Policy, which will define the responsible persons (positions) and time periods for delivering various decisions by the TTO, information on registering inventions, property rights etc. and necessary adjustments to employment contracts. If the HEI wants to provide consultancy services to external entities through its researchers, a separate policy would ideally provide rules on such activity. Supporting the creation of spin-off enterprises should also follow guidelines defining associated conditions;
   - Allocating an adequate budget for TTO operations and development, also in the absence of EU funds;
   - Expand strategic partnerships and continuously lobby for better government support of R&D at public HEIs and programmes to advance academia-industry collaboration.
2. **Professional team** consisting of:
   - Experienced manager with devolved powers to manage TTO operations, (human resources, budget, authorise inventions to be protected, etc.). It is not possible to kick-start the TTO without an experienced leader who would be accepted by academics as well as private company representatives;
   - Lawyer(s) specialising in IP and commercial law;

— Project managers with knowledge and experience corresponding with the sciences taught or practised at the HEIs or research institute. Ideally, the project managers are Ph.D. graduates with excellent communication and business skills. Even if less experienced, they should possess potential to develop these skills over a short time period.

3. **TTO Advisory Board** – to advise in the process of appropriating funds for IP protection and commercialisation, on strategic development issues, on conflict and risk management, etc. (members of the board should be: vice-rector or an institute director responsible for the TTO and academia-industry collaboration, scientists and researchers from various faculties with commercialisation experience, experts from industry and other specialised institutions).

   Note: *HEI management has to set the Advisory Board election and membership rules. Members have to sign a nondisclosure agreement and provide their services based on a contract with the HEI. Reward for their services should be incorporated into a TTO's budget.*

4. **Adequate budget for KTT**

   TTO needs finances for:

— motivating salary for TTO staff;
— office operation costs;
— external advisor and access to patent databases;
— IP protection;
— marketing a business development;
— continuous development for TTO staff, memberships in national and international networking organisations, e.g. ASTP-Proton, LES;
— seed fund for spin-offs (provided the HEI's strategy is to support spin-offs). TTO at the University of Cambridge provides access to angel and early stage capital through the Cambridge Enterprise Seed Funds and Cambridge Enterprise Venture Partners, and offers business planning, mentoring and other related programmes. These funds are a special instrument to support university spin-off companies and in Slovakia it could be supported by a government policy or a regional authority;
— proof of concept fund to support proprietary technology with strong IPR and a defensible technological advantage over the competition. The fund helps to realise a certain method or idea to demonstrate its feasibility. Established TTOs usually support technologies which have the potential to have a disruptive impact, either in new or existing markets. In Slovakia this fund could be backed by the European Regional Development Fund.

5. **TTO development strategy and action plan backed by allocated finances.** Marketing and business development are an integral part of the TTO action plan, they include brochures, presentations, website, participation at conferences, tradeshows and other events, publishing and/or advertising in professional journals, etc.);
6. **Contact points (liaison officers) at faculties.** They inform the TTO of relevant research projects and R&D results;

   Note: To develop good relations with liaison officers it is advisable to allocate money to reward them for their work. Otherwise it may be difficult to motivate them to co-operate. Accumulation of experience of working with different scientists on various projects creates a foundation for developing trust with scientists.

7. **Industry contacts** (industrial and business associations, clusters, innovation associations/forums, groups of venture capital investors, business angels, etc.). These can be developed by active networking in person and through appropriate social sites, e.g. Linked-In, to:

   — find business partners and financial sources;
   — obtain new knowledge and information;
   — seek support for spin-offs;
   — promote R&D results, licenses, etc.

8. **Central databases** - it is recommended for the TTO to use specialised software to manage IP administration, commercialisation projects and contacts including:

   — individual researchers, R&D projects they have worked on and information about them;
   — enquiries from researchers regarding the stage of commercialisation of their IP, e.g. results from searches, analyses, valuations, decisions, publication plans, etc.);
   — enquiries from businesses;
   — marketing activities e.g. targeted campaigns, presentations, seminars, conferences, in relation to industry contacts, etc.) ;
   — inventions (plus related documentation and fees paid/to be paid for their protection), contracts (consultancy, licenses, research, testing, etc.), license fees and spin-offs.

9. **Regular evaluation of TTO's activities and outputs -** this is generally acknowledged and emphasized in the theory of KTT, however, it is often underestimated and neglected in practice.

4.1.2 Attracting interest of researchers to use technology transfer office services

According to survey No.1, most scientists and researchers would not work with a TTO under existing conditions. For the researchers to recognise the added value they could gain by working with the TTO, it is necessary to:

1. **Systematically and continuously raise awareness of the importance of IP protection** directly at the relevant faculties and institutes in the form of interactive workshops and also as part of the curriculum. To gain researchers' interest is a long process and it is essential to also involve students in it. Survey No.1 showed that only 25 % of respondents would not have attended the IP training if they had the opportunity;
2. **Regularly inform the institution management of results and achievements** from collaborative applied research projects and commercialisation, incl. presentations at institution's board meetings;
3. **Deliver high quality professional services** which researchers need. In the early stages of TTO's operations, it is important to focus on the provision of services researchers would value the most, e.g. :

   a) legal advice in relation to R&D project application submissions and during their implementation;
   b) legal advice on contract research, incl. drafting research agreements;
   c) provide IP protection advice on externally funded projects where there is a new IP likely to arise;
   d) assist with searching and obtaining proposals for student graduation thesis from industry partners.

   Note: The aim is to create strong relations and build trust with scientists and researchers.

4. **Focus on researchers who are already engaged in applied research**, are known for good results and who express their willingness to start working with the TTO (response from survey No. 1 showed that 67 % of respondents were interested in industry collaboration). If the TTO does not have a big capacity at the beginning of its operations, it is not advisable to expend resources on a comprehensive mapping of the activities of individual researchers and scientists);
5. **Offer incentives** (e.g. profit share) to those research groups and individuals who enter into contracts with businesses through the TTO or disclose inventions desirable for industry;
6. **Create and establish** (to be authorised by the HEI or research institute management) **an evaluation system** that also recognises successful applied

research projects and commercially valuable IP, e.g. patents, utility model, designs;

7. **Continuously promote TTO services and activities and their benefits to different parties** (mainly through personal contacts, but also using electronic platforms), e.g.:

   a) issue useful concise guidelines for researchers to explain:

      - the importance of IP protection;
      - process of working with the TTO on commercialisation projects;
      - process of working with the TTO on other types of KTT including providing consultancy to industry;
      - reward scheme;
      - process of applying for patents, utility models, designs and trademarks;
      - conditions and process for setting up spin-offs.

   Note: Guidelines should be regularly updated and accessible in paper and electronic formats.

   b) prepare presentations at various fora (internally and externally) ;
   c) organise expert discussions with industry representatives (e.g. round table discussions, workshops, seminars, at trade shows) ;
   d) prepare presentations of TTO results for annual reports, various university brochures, etc.;
   e) issue newsletters for researchers and industry.

8. **Assist the HEI or research institute management to adopt the IP policy across the whole institution** (e.g. organise meetings, presentations and trainings at individual departments at faculties).

4.1.3 Attracting interest of businesses to use technology transfer office services

To succeed in collaborating with industry the TTO should:

1. **Establish a system for providing consultancy services** by researchers to other organisations (incl. the No. of hours for a certain time period, e.g. one year. Consultancy work has to be authorised by the respective line manager. Long/term projects should be preferably delivered as part of a separate employment contract or during an employee's holiday and/or time off in lieu ;
2. **Be flexible, accommodate clients' needs where possible.** Be open to different forms of co-operation, e.g. student internships, graduation thesis, consultancy, sponsored or joint research are generally better forms of engagement than more formal interactions like licensing;

Note. *It would be useful to test proven schemes like Knowledge Transfer Partnerships (see details in section 3.3.1) in the form of pilot projects in Slovakia as well as national and international innovation vouchers which should be applied more widely (beyond the current pilot scheme). Mechanisms supporting the exploitation of public research as a means to gain employees are probably more powerful than mechanisms focused just on research or just on recruitment.*

3. **Disposal of a lawyer to prepare or review relevant agreements.** It is also useful in case of any legal disputes;
4. **Have a good overview of expertise available which can be offered to businesses**;
5. **Disposal of negotiation skills** and realistic expectations at the same time, especially in relation to:

   a) defining rights to created IP;
   b) collaboration management;
   c) profit sharing;
   d) publishing.

   Note. *Some negotiations may require the presence of a lawyer who would subsequently prepare or review the collaboration agreement, research contract etc.*

6. Not passively wait for businesses to come forward, **create a plan for generating new industry contacts (nationally and internationally)**, incl. from industry clusters, associations, etc.;
7. **Be fluent in foreign languages** (at least English and German) in order to gain international clients or partners;
8. **Regularly evaluate work outcomes and outputs of the TTO** against adopted plans. This is particularly important for planning future activities and resources.

4.1.4 Evaluting work and outputs of technology transfer office

To ensure the efficiency of TTO's operations it is essential to regularly evaluate the impact of its activities and review the effectiveness of relevant policies and measures. The TTO manager should report to the institution's management board, submit regular reports and inform on the various results in the institution's annual report. Reports should have a standard format and include the following information:

1) **Information on activities**

   — overview of new invention disclosures;
   — overview of patent, utility model, design and trademark applications;
   — overview of industry enquiries, stage of their progress;

- overview the progress of various joint research projects (applied research with industry partners);
- overview of completed joint research projects and commercialisation of created IP (if any);
- overview consultancy services provided to industry;
- overview internal and external marketing activities, e.g. website, distribution of newsletters on new technologies, products or materials, presentations, campaigns, events, publications, etc.;
- overview of IP and business training provided to researchers and students, incl. feedback from it;
- information on spin-offs (if supported by the TTO);
- information on relevant EU funded projects if they are used to co-finance TTOs work and/or operation;
- overview of planned activities;
- proposal for new activities and any changes.

2) **Financial information**

- budget utilisation;
- TTO's revenue and profit from various activities;
- overview of rewards paid to researchers in accordance with the IP Policy.

3) **System information**

- information on the effectiveness of the IP Policy and recommendations on appropriate updates;
- information on the database administration system;
- information on conflicts of interest which need to be resolved;
- proposals for improvements.

4) **Information on TTO's operation**

- information on employees and their ability and capacity to manage allocated workload;
- information on human resources development;
- recommendations on improving TTO operation.

4.2 Recommendations on development of knowledge & technology transfer in countries with underdeveloped innovation culture

Strategic goal such as the establishment of a TTO with quality services can only be achieved by a radical change of principles and approaches, allocating appropriate financial resources to secure quality staff and services and the TTO sustainability.

The University of Oxford and Cambridge are top examples, but HEIs in the Czech Republic, Poland following the collapse of the communist regime in Eastern Europe started in similar conditions as Slovakia, have managed to achieve better progress in KTT. TTO's sustainability must also be in the interest of government authorities responsible for supporting academia-industry collaboration, innovation in the business sector and the development of innovative entrepreneurship in the regions. Government initiatives should be targeted to stimulate the cooperation of all stakeholders, to promote joint research and innovation activities and to create a favourable business climate.

4.2.1 Short-term to long-term recommendations for HEIs

The following recommendations apply primarily to HEIs wishing to implement KTT, but are at an early stage of their planning like most Slovak HEIs. Recommendations are based on the experience of other HEIs and surveys described above.

1) **Preparation phase:**

    — strategic decision at top management level to establish a TTO, definition of goals and expected benefits for the institution;
    — decision on the form of TTO (e.g. department or a daughter company), TTO management, organisational structure;
    — decision on what services would be provided by TTO employees and what services would be sought externally;
    — allocation of resources for setting up and starting up the TTO's activities, incl. funds for IP protection and proof of concept) for at least 2 years ahead (combination of own funds and appropriate EU project funds);
    — preparation of a framework plan of activities which has to be based on the survey of researchers' needs at relevant faculties and institutes and market research of companies which would be interested in collaborating with academia;
    — obtain advice and support from other well established TTOs;
    — network and co-operate with other partner organisations, e.g. National technology transfer centre, science parks, incubators, Patent Office etc.;
    — preparation of work description for individual TTO employees.

2) **Development phase (approx. first 12 months):**

    — recruit an experienced TTO manager followed by other professionals and plan appropriate training for them;
    — plan and implement internal IP protection and commercialisation related training for researchers and students at individual faculties and institutes, provide day-to-day advice to researchers;
    — TTO Manager amends the original services offer based on feedback from researchers and market requirements. He/she also prepares an action plan,

marketing & business development plan and submits them to the management board for approval;

— TTO staff build relations with support organisations (National technology transfer centre, science parks, Patent Office, relevant government agencies supporting innovations and entrepreneurship);
— HEI management establishes the Advisory Board for KTT and a policy for managing risks and conflicts of interest;
— TTO Manager, in conjunction with the institution's management, co-ordinates the preparation of an IP policy which should include a reward scheme for researchers who disclose their inventions to the TTO;
— TTO Manager co-ordinates the preparation of processes, standard documents, communications plan, information administration system, contact management system and project management system. TTO personnel have to supervise each allocated project using effective software management systems;
— communication to faculty/institute management regarding the importance and benefits of the IP policy;
— establishing contact points/liaison officers at faculties/institutes;
— setting up memberships in relevant KTT associations, e.g. ASTP-Proton;
— communication with a mentor – selected successful TTO;
— knowledge and skills development activities for TTO staff;
— setting up a network of preferred external advisors for providing necessary services unavailable in-house;
— mapping of potential applied research projects various faculties/institutes, particularly with researchers already experienced in such work and would be happy to co-operate;
— adoption of the IP policy across the whole institution;
— TTO identifies market opportunities, partnerships, searches for investors and actively approaches companies with available licenses and services;
— TTO identifies EU projects which can co-finance TTO operations and prepares project applications;
— TTO employees continuously monitor suitable opportunities to present the TTO services at various fora and take advantage of them;
— TTO Manager prepares regular management and an annual evaluation report;
— TTO Manager prepares a development plan for the period of the next 2 years and submits it to HEI management for approval;
— allocation of resources for the TTO development plan approved for the period of the next 2 years.

3) **Development phase (following 1-2 years) – activities are co-ordinated by the TTO Manager:**

- TTO Manager obtains authority to make decisions on commercialisation projects and IP protection (prompt decision making in co-operation with the Advisory Board);
- review of the TTO structure and job descriptions;
- update of services offer;
- preparation of easy-to-follow guidelines for industry collaboration and commercialisation;
- IP Policy (incl. spin-off support if applicable) updates based on experience from the previous phase;
- update of TTO goals and Key Performance Indicators (KPIs) (e.g. No. of enquiries from industry, No. of enquiries internally from researchers, No. of supported collaborative projects, No. of research contracts, No. of patent or utility model applications, No. of consultancy hours provided to external clients, etc.);
- implementation of regular trainings on IP protection, commercialisation and entrepreneurship at faculties/institutes;
- knowledge & skills development trainings for TTO employees CTT;
- active membership in relevant KTT associations, e.g. ASTP-Proton and co-operation with a suitable mentoring TTO;
- development of relations with partner organisations, industry associations, etc.;
- evaluation of TTO's capacity and expert knowledge and meeting its KPIs;
- TTO Manager prepares regular management reports and an annual evaluation report;
- TTO Manager prepares a development plan for the period of the next 2 years and submits it to HEI management for approval;
- allocation of resources for the TTO development plan approved for the period of the next 2 years.

4) **Development phase (next 1-2 years) – activities are co-ordinated by the TTO Manager:**

- IP Policy is adopted and working effectively;
- improving the effectiveness of managing commercialisation projects, increasing the number of outputs and revenues/profits;
- strengthening industry relations and collaboration and business development;
- evaluation of activities, strategic development and TTO financing.

4.2.2 Recommendations for the government on effective knowledge and technology transfer in Slovakia

1. Gradually increase the investment in science and research, and HEI-industry collaboration (as a GDP share) by least 0.05 % to 0.1 % per year, with the aim to increase commercialisation of IP generated by HEI researchers;
2. Allocate financial resources for continuous stimulation of innovation in businesses, particularly SMEs;
3. Amend legislation inhibiting entrepreneurial activities at HEIs, e.g.
   - Higher Education Act – change the criteria for researchers' career growth to increase their interest in applied research and partnership working with businesses, recognize IP rights as an achievement.
   - Act regulating the Slovak Academy of Sciences and Act on budgetary regulation for public administration determine the use of resources and do not allow the institutes of the Slovak Academy of Sciences to engage in entrepreneurial activities.
   - Regulations of projects financed from EU Structural Funds do not allow profit creation for five 5 consecutive years following the project closure – such limitations are in conflict with the very substance of enterpreneurial activities linked to KTT (IP commercialisation).
   - Creation of joint R&D entities between public institutions and industry.
4. Establish structures to support entrepreneurship and innovation in the regions (eg. regional development agencies to engage in innovation support, departments at regional councils to be dedicated to supporting and promoting entrepreneurship and innovation, establishment of technology and innovation centres);
5. Create favourable conditions for the growth of innovative start-up and spin-off companies, allocate resources for setting up venture capital funds for continuing investment in innovation (science parks, technology incubators, innovation centres, industry and R&D clusters, etc.).

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