TECHNOLOGY TRANSFER MODEL FOR AUSTRIAN HIGHER EDUCATION INSTITUTIONS

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Abstract

The aim of this paper is to present the findings of a PhD research (Heinzl, 2007) conducted on the Universities of Applied Sciences in Austria. Four of the models that emerge from this research are: Generic Technology Transfer Model (Section 5.1); Idiosyncrasies Model for the Austrian Universities of Applied Sciences (Section 5.2); Idiosyncrasies-Technology Transfer Effects Model (Section 5.3) ; Idiosyncrasies-Technology Transfer Cumulated Effects Model (Section 5.3). The primary and secondary research methods employed for this study are: literature survey, focus groups, participant observation, and interviews. The findings of the research contribute to a conceptual design of a technology transfer system which aims to enhance the higher education institutions' technology transfer performance.

Keywords: Idiosyncrasies, Technology Transfer, IPR, mechanism, Transfer System, Absorptive Capacity, R&D, Innovation System, Cumulated Effects.

1 INTRODUCTION

Both innovation and technological change are considered drivers of economic growth (OECD, 2002). However, the stimulation of innovation is largely dependent on an effective management of scientific knowledge (European Commission, 2001a). An analysis of the European Trend Chart on Innovation (European Commission, 2002a) reveals that the Austrian innovation performance lags behind other European countries (Fletcher, 2003). One of the suggested reasons for such an innovation gap is a weak linkage between universities conducted research and the industry (European Commission, 2001b). Consequently, a strong interaction between the science base and industry has been identified as a pivotal measure for the enhancement of Austria's innovation system performance. Such a science base may reside within universities, public sector research laboratories, or in independent research and technology organisations (European Commission, 2000). Higher education institutions, being initiators of scientific knowledge flows, could be considered a key stimulant to socio-economic development. However, higher education institutions differ vastly in terms of organisational structure, legal environment, strategy, mission, etc. However, there is little work done to investigate the relationships between such idiosyncrasies and technology transfer. The primary aim of this paper is to present findings on the effects of the idiosyncrasies of Austrian Universities of Applied Sciences on their technology transfer performance. Two of the deliverables, *Idiosyncrasies-Technology Transfer Effects* *and Cumulated Effects Models* (see Section 5), will provide deeper insights into the complex relationships that are prevalent in this context. Additionally, these models contribute to a set of recommendations for the implementation of a technology transfer system involving Austrian Universities of Applied Sciences which aims to enhance their technology transfer performance. Such enhancement has been identified by the Austrian Council (2002) as a core element in a generic strategy for narrowing the Austrian innovation gap.

2 LITERATURE REVIEW

2.1 Innovation System

The innovation system approach forms the basis of the European Trend Chart on innovation (European Commission, 2002a) which provides a framework for research and innovation policy advice for member states. However, the innovation system is a complex system where innovation, technological change, and knowledge management are addressed (Lundvall, 1992). It also encompasses the interaction among multiple actors being: private enterprises, universities, public research institutes, industries, knowledge centres, government, and etc. (Saez et al, 2002; van Looy et. al, 2003).

The National Innovation System concept is widely popularised by Freeman (1987) and it is depicted in Figure 1. It is defined as a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Freeman, 1987 as cited in OECD, 1997) as well as use new and economically useful knowledge which is either located within or rooted inside the border of a nation state (Lundvall, 1992 as cited in OECD, 1997). Such a system could foster successful innovation through the generation, diffusion, and implementation of scientific knowledge (European Commission 2000, 2001) and strong linkages among its actors facilitated through joint research, secondments, cross patenting, and etc. (OECD, 1997).

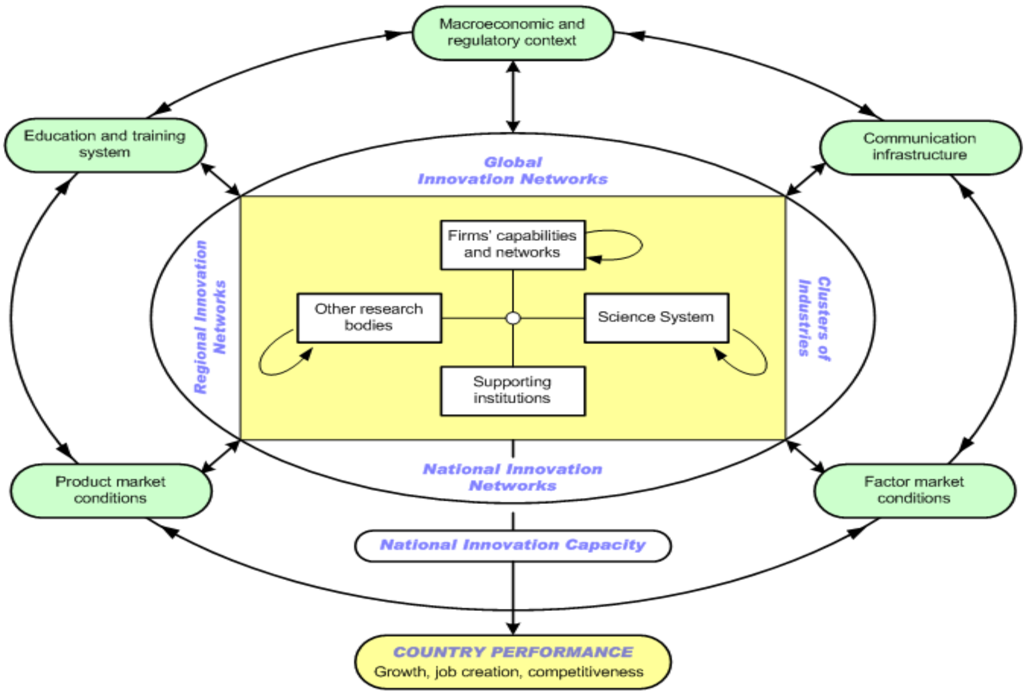

Figure 1: General Model Describing a National Innovation System (OECD, 1997)

2.2 Role of Higher Education Institutions in the Innovation System

As shown in Figure 1, higher education institutions play a pivotal role in the National Innovation System. According to the OECD (199a), academics act as problem solvers, and become innovators by creating new firms while research laboratories become important sources of innovation. The knowledge-related roles of higher education institutions are listed below:

- A provider of diverse and high quality knowledge base through the creation of scientific knowledge (Polt et al., 2000; Jacobsson, 2002; Gornitzka and Maassen, 2000; Jones-Evans et al., 1999; Doloreux, 2002);
- A disseminator of good practice and know-how including competency as well as capability building which is essential for successful problem solving (Polt et al., 2000; Jones-Evans et al., 1999; OECD, 2002);

Inevitably, collaboration among the industries and higher education institutions has to be fostered in order to exploit the latter's rich knowledge, science and technology bases. Through this, the industries will be able to remain competitive (Pyka, 2002).

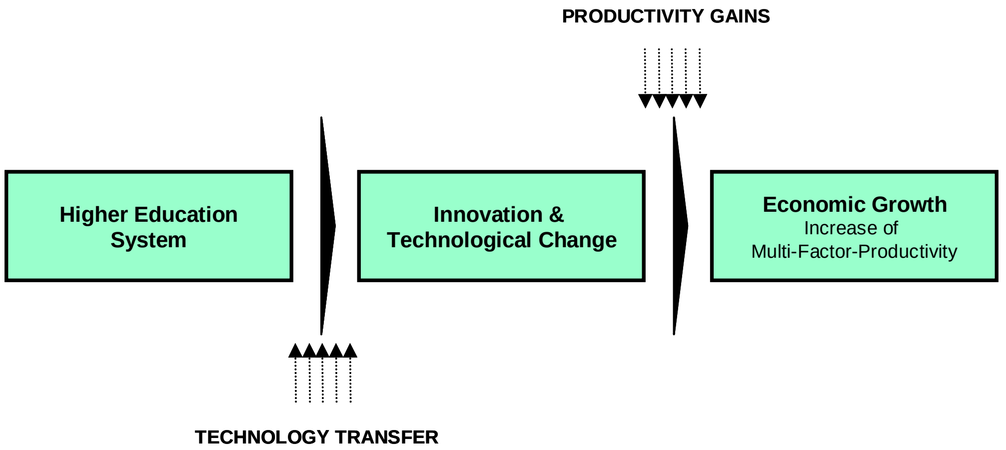

Figure 2: Higher Education System and Stimulation of Economic Growth

Figure 2 summarises the contribution of the higher education institutions to the stimulation of economic growth. First, productivity gains facilitated by an increase in multi-factor-productivity contribute to economic growth besides capital deepening and a rise in labour utilisation (cf. OECD, 2000). An increase in productivity, in turn, rests – besides other important factors – on productivity gains as a result of investments in research and technological development resulting in innovation and technological change on the aggregate level. Thus, it can be argued that innovation and technological change contribute to economic growth. Innovation and technological change is not facilitated by the industry in isolation but within networks of joint research efforts with external institutions (most often institutions of the science base). From the perspective of the science base the process of producing, transfer and utilising scientific knowledge is facilitated through technology transfer. As a result, it can be argued that the higher education system – representing an important part of the overall science system – contributes to economic growth by the means of conducting technology transfer.

2.3 Universities of Applied Sciences in Austria

Like in other European countries a dual system of tertiary education has been established in Austria by the introduction of Universities of Applied Sciences in the mid 1990s. This was part of a fundamental process of reform of the higher education sector in response to changing economic and social conditions in Austria. These changing economic and social conditions relate to an increasing demand for a highly qualified workforce, the advent of the mass-university (i.e. the increase in student numbers) and a growing internationalisation of the educational sector (*cf.* BMBWK, 2002a). Universities of Applied Sciences representing a new form of tertiary education in Austria and they are highly idiosyncratic higher education institutions

The discussion of the structure of the Austrian education system including the Universities of Applied Sciences sector in this education system is illustrated in Figure 3.

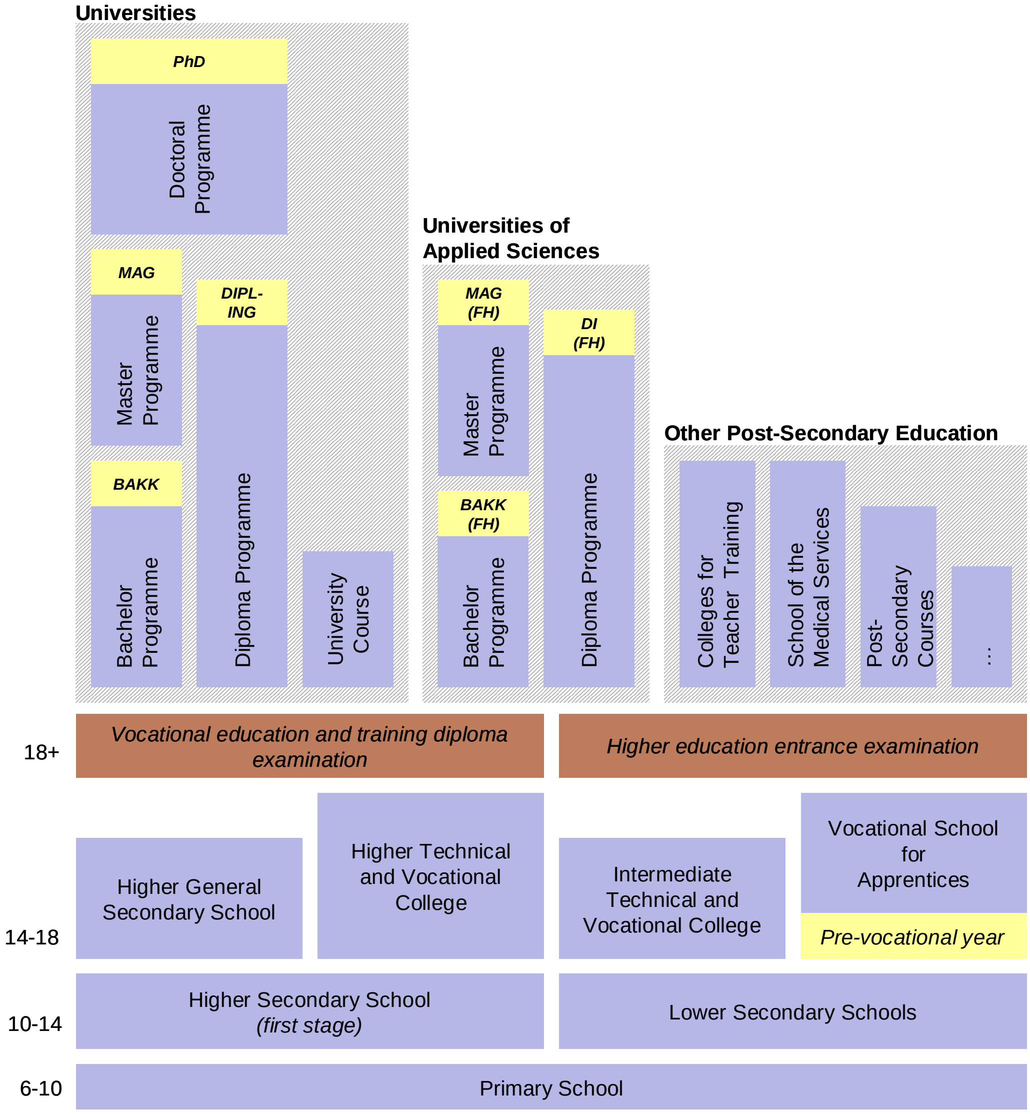

Figure 3: The Austrian (Higher) Education System

First, diversification relates to a wide range of educational provision in the tertiary sector. This diversification is due to widening participation in tertiary education and the demands for new scientific professions in the job market. Second, deregulation relates to a new autonomy for Universities of Applied Sciences in the Austrian higher education system. This new autonomy is based on a new form of governance for which an independent body – the Universities of Applied Sciences Council – is responsible instead of the ministry. Third, permeability relates to the openness between the system of vocational education and higher education as a response to an increasing demand for further training and higher qualifications of the Austrian workforce (*cf.* BMBWK, 2002a). In short, the overall goal for the establishment of the Universities of Applied Sciences higher education sector is to extend tertiary education provision, to create a permeable education system and to provide an education that leads to internationally accredited graduations (*cf.* BMBWK, 2002b). Universities of Applied Sciences are characterised by quality assurance (accreditation and evaluation), mixed funding, private maintainers and work-related design of study programmes. Together with universities (including private universities), colleges for education (for the training of teachers of compulsory and vocational schools) and colleges for health professions at post-secondary level they build the tertiary education system of Austria (Figure 3). The Universities of Applied Sciences sector in Austria is modelled based on other existing vocational non-university education systems in Europe (e.g. *Fachhochschulen* in Germany). One major difference between universities and Universities of Applied Sciences in Austria relates to the qualifications to be awarded to students. While university study programmes are dedicated to providing scientific or artistic pre-professional education, Universities of Applied Sciences provide a scientifically sound professional education (*cf.* BMBWK, 2002a). This specific design of the University of Applied Sciences study programmes is defined in the Study Act regulating the establishment, operation and governance of Universities of Applied Sciences (*cf.* Nationalrat, 2003), wherein the overall mission is defined as the provision of a practical-oriented tertiary education; the combination of skills to facilitate practical scientific problem solving; and the promotion of the permeability of the education system and the professional flexibility of graduates. In summary, the mission to provide practical-oriented scientific professional education is one of the core characteristics defining the nature of Universities of Applied Sciences.

2.4 Idiosyncrasies of Universities of Applied Sciences

The idiosyncrasies of Universities of Applied Sciences are coded into the following categories: educational programmes, funding structures, research activities, the legal environment and the institutional setting (Figure 4). These idiosyncrasies could influence the technology transfer performance and, therefore, have to be properly modelled to establish a value-added technology transfer system. There are several differences between programmes offered at Austrian universities and Universities of Applied Sciences. First, students have to go through an entrance procedure. Second, an internship during the study is mandatory (*cf.* BMBWK, 2003a). Third, graduates of Universities of Applied Sciences are not automatically entitled to enrol for a doctoral programme at universities but have to take additional lectures if the study duration is shorter than the equivalent study at the university (*cf.* FHR, 2003)[1].

Universities of Applied Sciences have shown a rapid enhancement in the R&D activities in recent years. The overall R&D turnover of the whole sector shows an increase before the year 2007 with a strong tendency to surge. Additionally, a high portion of R&D funding stemmed from the industry. In the academic year 98/99 the industry portion of research funding accounted for 25%, whereas the business funding of university research in 1995 accounted for 5.7% only (*cf.* FHR, 2003). This shows the shift of focus on applied research and revised strategy that emphasised industry relevant research.

[1] This restriction will no longer be valid for students graduating in a bachelor-master-system, as within the harmonization of study programmes according to the Bologna Agreement the duration of study is extended equivalent to university study programmes.

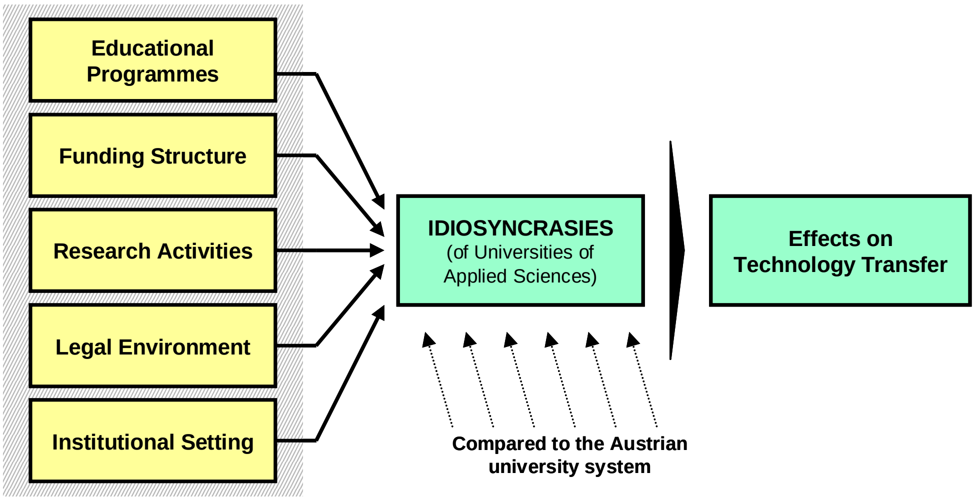

Figure 4: Classification of the Idiosyncrasies of Universities of Applied Sciences

Public funding for Universities of Applied Sciences is based on student numbers and it merely represents a portion of the total study costs. The rest of the costs (e.g. for infrastructure) have to be borne by the provider of the study programmes. Furthermore, research activities of Universities of Applied Sciences are not subject to block-grant-funding. Research activities are instead funded by direct government funding and industry funding. This represents a major problem for enhancing research as the funding for the activities and resources is not guaranteed in the long run. Therefore, investments in R&D are risky endeavours from management perspective.

What is most specific for Universities of Applied Sciences is the legal framework shaping this new type of higher education sector. First, the Universities of Applied Sciences sector is characterised by low regulations. The reason for this low regulation is based on the nature of the study act which specifies only the minimum requirements for a study programme provision (*cf.* Nationalrat, 2003). Furthermore, Universities of Applied Sciences are independent of ministry directives. Consequently, there is flexibility with regard to strategic development focus. Second, due to the necessity to conduct acceptance analysis in the industry for the accreditation of study programmes, Universities of Applied Sciences traditionally have a close linkage to the industry. Third, Universities of Applied Sciences are not entitled to provide doctoral programmes (i.e. to award PhDs) representing a major disadvantage compared to other types of tertiary education institutions.

2.5 Technology Transfer Concepts

2.5.1 Technology Transfer

Technology transfer is defined in many diverse ways subjecting to the discipline of research and the purpose of the research (Bozeman, 2000). The term has been used to explain very different concepts regarding organisational and institutional interaction between academia and business. Viewing the fact that this paper addresses the identification of the effects of idiosyncrasies of Universities of Applied Sciences on their technology transfer performance, thus a narrow definition of technology transfer will be pursued. “Technology transfer is the process of developing practical applications for the results of scientific research. While conceptually the activity has been practised for many years (in ancient times, Archimedes was notable for applying science to practical problems), the present-day volume of research has led to a focus on the process itself”[2]. According to Amessea and Cohendet (2001) technology transfer relates to the intentional interaction of two or more persons, groups or

[2] Labourlawtalk, <http://dictionary.laborlawtalk.com/technology%20transfer>, accessed, July 20, 2004

organisations targeted at the exchange of technology by different mechanisms. Similarly, Bozeman (2000) defines technology transfer as the movement of know- how, technical knowledge or technology from one organisational setting to another. Nevertheless, successful technology transfer does not end with handing over the technology to the industry, but requires the successful utilisation of the technology in new products, processes, or organisational changes. In this context Rogers, Takegami and Yin (2001) note that technology transfer usually involves moving a technological innovation from an organisation of the science base to a receptor organisation and that the transfer is complete when the technological innovation is commercialised. Thus, for the purpose of this paper, technology transfer is defined as the process of moving technology from an institution of the science base (e.g. a higher education institution) to an industrial organisation, which successfully commercialises the technology through the implementation of new processes, the development and launch of new products or the facilitation of a successful and innovative organisational change.

Technology transfer has been extensively discussed in literature (e.g. Buono, 1997; Lin, 2003; Bozeman, 2000; Lee, 1996). Additionally, the concept of knowledge transfer (e.g. Tidd and Trewhalla, 1997; Knoll, 2001; Schartinger *et al.*, 2002) and the concept of industry-science relationships (e.g. Van Looy, Debackere and Andries, 2003; OECD, 2002a; European Commission, 2001c; Polt *et al.*, 2001) are closely related to technology transfer. Although these concepts are not intrinsically different compared to the concept of technology transfer, they are not identical as all of these concepts take a slightly different perspective on explaining the interaction between higher education institutions and the industry. Technology transfer focuses on the transaction of technology from a process point of view and, therefore, covers process-related concepts and is targeted at the successful utilisation of technology to facilitate economic growth. Knowledge transfer[3] ,on the contrary, is concerned with understanding and assimilating of knowledge, learning and related cognitive effects that are crucial for knowledge exchange. Knowledge transfer is therefore focused on the accumulation of knowledge in the receiving institution or department (as knowledge transfer is also often discussed from the viewpoint of intra-company knowledge sharing and knowledge management). The growing amount of literature on knowledge transfer focuses on the transfer of 'tacit knowledge', a concept not explicitly covered when discussing technology transfer (Bozeman, 2000). The concept of industry-science-relationships is used whenever it is required to capture all types of interactions between higher education institutions and industry including informal meeting, the flow of graduates to the industry, etc. (*cf.* Schartinger *et al.*, 2002). Thus, industry-science-relationships cover all types of higher education interaction including technology transfer and knowledge transfer. As a result, to establish a comprehensive technology transfer model, concepts stemming from the discussion of knowledge transfer and industry-science-relationships have to be taken into account where appropriate. These concepts might give useful insights into the complex process of technology transfer and help foster a deeper understanding. Additionally, according to Bozeman (2000) it is not sufficient to focus on the object when pursuing technology transfer, as besides the object (i.e. the technology), knowledge of its use and application is also transferred.

2.5.2 Transfer Object

The transfer object from the perspective of technology transfer relates to the entity transferred (i.e. the content and form of what is transferred). The literature defines different transfer objects in various forms depending on the context discussed. According to the definition of technology which is in use for the purpose of this paper (i.e. technology being a tool to accomplish some task) the identification of the transfer object results in the specification of what is meant by the term 'tool'. According to Bozeman (2000) the object (i.e. the tool) is represented by scientific knowledge, a technological device (i.e. physical technology), a technological design, a process, craft or know-how in general.

[3] Knowledge is a term with many meanings depending on context, but is as a rule closely related to such concepts as meaning, information, instruction, communication, representation, learning and mental stimulus. Thus, knowledge can be defined as the awareness and understanding of facts, truths or information gained in the form of experience or learning. Knowledge transfer can be defined as the process through which an organizational unit is affected by the expertise of another (Argote and Ingram, 2000).

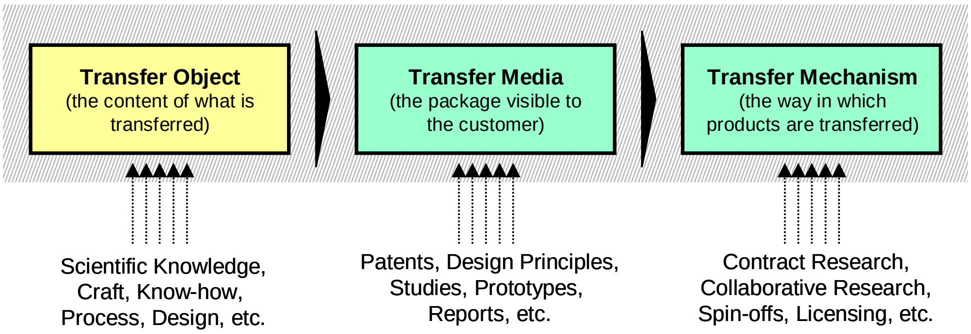

Figure 5: Transfer Object, Transfer Media, and Transfer Mechanism

However, according to the focus and definition taken in this study some portion of the object must be of codified nature in any of the above cases. This codification of the transfer objects may happen in various forms (e.g. scientific knowledge might be available as a patent, a prototype, etc.). Therefore, apart from the definition of the transfer object, the transfer media (i.e. the form of codification of the transfer object) is highly relevant for technology transfer. One might refer to the transfer media as the package visible to the technology recipient (like a transfer product). The transfer media comprises for instance patents, studies, documented design principles, specifications, workflows, prototypes, certificates, reports, etc. (*cf.* ARCS, 2005). As a result, the transfer object must not be mixed up with the transfer media and – consequently – the transfer media must not be mixed up with the transfer mechanism (i.e. the way in which the transfer product is moved over to the transfer recipient). A detailed discussion of the different transfer mechanisms can be found in the next section.

2.5.3 Transfer Mechanisms

Technology transfer mechanisms are frequently discussed in literature (*cf.* Van Looy, Debackere and Andries, 2003; Ciesa and Piccaluga, 2000; OECD, 2002a; Schibany, Jörg and Polt, 1999; Hutschenreiter and Kaniovki, 1999; Mansfield and Lee, 1996). However, the list of technology transfer mechanisms varies according to the specific purpose, focus and the perspective taken in these studies. For example, according to the (OECD, 2002a) these mechanisms comprise joint labs between academia and business, spin-offs, licensing of intellectual property, research contracts, mobility of researchers, co-publications, conferences, expos and special media, informal contact within professional networks and the flow of graduates to the industry. Similar, but still slightly different approaches can be found (e.g. OECD, 1999c; OECD, 1999b; European Commission, 2000a; Pyka, 2002; Polt *et al.*, 2001). For the purpose of this paper, a categorisation of technology transfer mechanisms is derived from multiple literature sources (*cf.* Lee and Win, 2004; Liu and Jiang, 2001; Amessea and Cohendet, 2001; Phillips, 2002; Rogers, Takegami and Yin, 2001; Debackere and Veugelers, 2005; Polt *et al.*, 2001; Schartinger *et al.*, 2002) comprising, spin-offs, licensing of patents, collaborative research, contract research, mobility schemes and monitoring of scientific activities (e.g. studying of publications).

"Licensing is the transfer of less-than-ownership rights in intellectual property to a third party, to permit the third party to use intellectual property" (Lee and Win, 2004, p.435). The third party (in most cases industry) has to present a plan to commercialise the invention, as royalties are calculated as a portion of the economic commercialisation success (e.g. a portion of the annual turnover of a new product based on a licensing agreement). Licensing royalties may represent a considerable income for universities and R&D laboratories (Rogers, Takegami and Yin, 2001). Thus, patents facilitate – besides the protection of inventions – the transfer of scientific inventions (i.e. technology) to industry by allowing firms to licence patents (i.e. to commercialise inventions) held by the science system (*cf.* BMBWK, 2003b). Licensing can be exclusive or non-exclusive, i.e. being restricted to a specific market or a specific industry sector (Lee and Win, 2004). One major advantage of pursuing technology transfer by licensing of patents is the fact that this mechanism is geographically not restricted. Once a patent has been filed (including the application in the US, Japan and Europe) companies around the world might seek access to licensing if the invention is of economic benefit.

Thus, the mechanism of patent offices around the world can be seen as quasi-international sales channel.

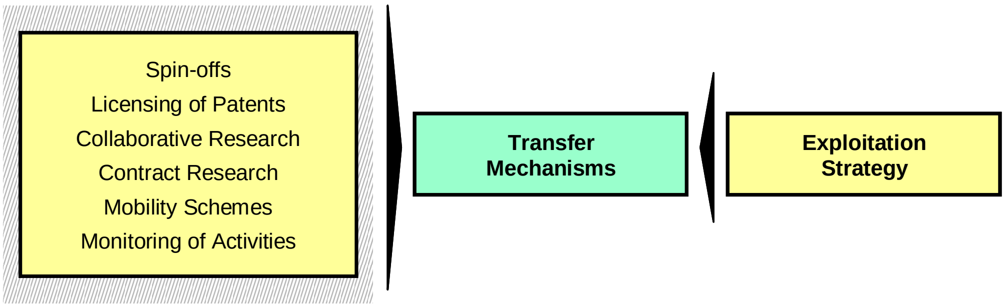

Figure 6: Transfer Mechanisms in Technology Transfer

Spin-offs[4] facilitate the technology transfer by the means of establishing a new company based on a technological innovation (Rogers, Takegami and Yin, 2001). More specifically, spin-offs from higher education institutions are the formation of new companies by higher education institution members. The formation of spin-offs has gained attention during the last years in the mainstream literature (e.g. European Commission, 2000a; European Commission, 2002c; OECD, 2002a; Polt *et al.*, 2001). However, a spin-off does not necessarily represent a technology transfer mechanism, unless if technology from the parent organisation, an invention or a technology is utilised. As Rogers, Takegami and Yin (2001, p.255) put it: "A spin-off is a technology transfer mechanism because it is usually formed in order to commercialise a technology that originated in a government R&D laboratory, a university research centre or a private R&D organisation". Spin-offs are an appropriate means for transferring complex technologies together with the transfer of the knowledge on how to manage, adapt and industrialise it (note: 'tacit' knowledge is also transferred). Nevertheless, focusing on spin-offs for facilitating technology transfer often requires additional support structures like incubators or science parks within or at least close to the higher education institution (Lee and Win, 2004). Similarly, Phillips (2002) argues that since technology business incubators are an appropriate mechanism for commercialising R&D, universities and other research organisations are the major developers of incubation centres. Incubators provide a bundle of services for spin-off companies including direct and indirect financial support (e.g. early stage financing, grants, loan and equity guarantees) as well as enabling measures (consultancy service and intermediation services). The long term effect of forcing spin-offs as technology transfer strategy might lead to an agglomeration of high-tech companies, eventually resulting in a technopolis like Austin Texas (Rogers, Takegami and Yin, 2001).

Joint venture of R&D is a formalised co-operation between a university research centre and a contact person, in which costs associated with the work are shared as specified in the contract and in which the two parties work together from the R&D stage to the commercialisation. More generally spoken the 'joint venture of R&D' belongs to the group of collaborative research mechanisms (*cf.* Lee and Win, 2004). *Collaborative research* comprises the participation of academia and industry in networks and clusters (e.g. European Commission, 2000a), the execution of joints research projects (e.g. Polt *et al.*, 2001), and scientific and technical co-publication (e.g. OECD, 2002a) and industry funded PhDs (e.g. European Commission, 2002b). In all the collaborative R&D efforts, both parties (i.e. academia and business), provide personnel, facilities and other resources for accomplishing some task in a research project. Collaborative research is viewed by Debackere and Veugelers (2005) as defining and conducting joint R&D projects by enterprises and institutions of the science system either on a bi-lateral basis or on a consortium basis. According to Amessea and Cohendet (2001) contractual arrangements in the sense of pure contract research (see below) is increasingly replaced by relational

[4] A *spin-off* is a new company that is formed by individuals who were former employees of a parent organization, and with a core technology that is transferred from a parent organization (Rogers and Steffensen, 1999).

arrangements because joint projects are considered ideal technology transfer mechanisms. In such an arrangement, the facilities and expertise of both the research centre and industry could be complementary. Additionally, collaborative research requires more interaction among the parties involved and, therefore, stimulates the exchange of tacit knowledge and the collaborative scientific knowledge generation. As a result, companies might develop a better understanding of the scientific world while scientists might develop scientific application awareness. Gibbons and colleagues (1994) has discussed such knowledge production which emerges via the interaction of different institutions including universities and colleges, research centres, government agencies, industrial laboratories, think-tanks, consultancies, etc. Therefore, the knowledge production process relies on heterogeneity and organisational diversity.

In contrast to collaborative research, *contract research* requires a contract between the university and the company which defines R&D efforts to be performed by the university or the research centre with the aim of gaining access to unique capabilities for commercial benefit (Lee and Win, 2004). However, contractual arrangements do not only cover research projects but also (technology-related) consultancy conducted by the research centre or the higher education institution (*cf.* Van Looy, Debackere and Andries, 2003; Polt *et al.*, 2001). The *contract research* encompasses fundamental research, feasibility and prototype studies, experiments and the use of equipment (Debackere and Veugelers, 2005). Also, it includes the industry's access to a higher education institution's new equipment and machinery (*cf.* OECD, 1999c) or access to specialized equipment located in a science base (*cf.* Hagen *et al.*, 2003). According to Tidd and Trewhalla (1997), *contract research* is vital for an industry because technology could be exploited to create new opportunities or offerings. On the other hand, scientific institutions could benefit from *contract research* by commercializing their research outputs (OECD, 1999c) thus creating a dynamic and entrepreneurial academic workforce (Etzkowitz, 2003). This is particularly vital especially in times with decreasing public funding. However, *contract research* requires an entrepreneurial transformation resulting in new organisational structures in research centres. Furthermore, *contract research* requires new skills such as negotiating contracts, knowledge of grants and subsidies, marketing and business planning, networking, etc. (Jones-Evans *et al.*, 1999). Consequently, scientists in higher education institutions would require good support structures in the like of technology transfer offices or industry liaison offices (Cooke, 2001).

Mobility schemes are crucially important for the transfer of tacit knowledge (Hutschenreiter and Kaniovki, 1999). They entail the mobility of researchers (e.g. sabbaticals), the flow of graduates to the industry, temporary staff exchange as well as summer jobs and internships of students (e.g. European Commission, 2000a; Cooke, 2001). One major benefit of mobility schemes is the creation of mutual trust and personal networks (Polt *et al.*, 2001). *Mobility schemes* help to build the capabilities in the industry and, therefore, contribute to a successful technology transfer. This is aligned to the European Commission's view (2000a) that the mobility of students, research workers, engineers or scientists from one country or industrial sector to another, and from education or research to industry encourages technology transfer. Due to the importance of *mobility schemes*, there are numerous policy measures in place targeted at the stimulation of mobility schemes by the means of incentives and new legal framework conditions (*cf.* Polt *et al.*, 2001).

The *monitoring of activities of the science base* comprises research on publications and patents, industry participation in research conferences or similar events, etc. According to Lee and Win (2004) this free and informal exchange of information via technical conferences and publications in scientific magazines poses as a mechanism for establishing ties between academia and the industry. Publication is powerful technology transfer tool because information can be disseminated to the largest possible number of individuals with the least effort per individual researcher (Liu and Jiang, 2001). Additionally, publications provide enterprises with updates on new technological advances (Jacobsson, 2002). Together with citation indexes, publications are often used by economists as a proxy for measuring the innovation performance of economies (*cf.* Jacobsson, 2002; OECD, 1999b). Patents and publications are considered personal development for those in scientific careers (Heydebreck, Klofsten and Maier, 2000). However, according to Rogers *et al.* (1999 cited in Liu and Jiang, 2001) scientific journals are written for fellow scientists and these articles are ineffective in reaching practitioners. Increasingly, problem relating to the combination of efficient IPR handling and publications in joint industry-science-project have been reported (*cf.* European Commission, 2000a).

In summary, a list of technology transfer mechanisms suitable for the context of the research cited in this paper are: spin-offs from institutions of the science system; licensing of patents of the sciences system by the industry; collaborative research; contract research; mobility schemes; and monitoring of the activities of the science base.

2.5.4 Intellectual Property Rights

Intellectual capital comprises human capital, structural capital and relational capital, whereby human capital is defined as explicit and tacit knowledge of the organisation's personnel that is of value to an organisation (*cf.* Warden, 2003). Therefore, scientific knowledge can be regarded as intellectual capital. For the protection of intellectual property different mechanisms are in place depending on the intellectual activity, from which intellectual capital is arising. Different forms of intellectual property rights are: patents, utility models, trademarks, copyrights and non-statutory rights like trade secrets and know-how (*cf.* Apke, 1998; WIPO, 2001). European Commission (2001b) stresses the need to protect IPR because it is argued that intellectual property rights, especially patents, copyrights, designs and trade secrets play a crucial role for establishing the rules of the game in research collaboration and technology transfer (European Commission, 2002e). However, it is vital to balance a balanced view of IPRs protection because a "weak protection would undermine incentives to invest in innovation, while excessively strong IPRs can hamper access to technology and discourage research" (ICTSD, 14th July, 2010). Additionally, there is a growing awareness that IPR is essential in an innovative and competitive environment (European Commission, 2001b), however, IPRs could create possibilities either for both expanding or restricting technology transfer (Park and Lippoldt, 2008).

Proper IPR handling includes monitoring of patent violations, decision on alternative routes of research commercialisation (like spin-offs), negotiations with industry partners in collaborative research efforts regarding the ownerships of intellectual capital created, etc. Therefore, it is obvious that for smaller higher education institutions the full potential of intellectual property right management can hardly be exploited, as they cannot afford to run an IPR office. This phenomenon has been observed by the European Commission (2000a) and the European Commission puts forth a recommendation that these smaller scale institutions pool together resources. Another proposed strategy is to enhance the involvement of National Patent Offices in the dissemination of IPR (European Commission, 2001b). Consequently, due to the complexity proper IPR management, smaller higher education institutions might increasingly rely on external IPR intermediary services. On the other hand, larger universities have set up support structures for managing IPR handling with dedicated staff.

2.5.5 Absorptive Capacity

According to Islam (2009), R&D stimulates innovation and also promotes R&D based absorptive capacity by transcending limitations imposed by existing discoveries. Additionally, almost all R&D managers believe that no company can survive as a technological island (Tidd and Trewhalla, 1997). Pyka (2002) maintains that through the acquisition of technology from external sources, it helps a company to keep abreast with new technologies and thus fosters better commercial success. Ensuring a continuous knowledge flow from external technology sources is crucial for sustainable competitiveness in a dynamic business environment. However, the importance of the adoption of technological opportunities depends on the capacities of firms to adapt scientific knowledge stemming from academic research and to customise external generated technology for their own use (Schibany, Jörg and Polt, 1999). It is recommended that organisational change, training and upgrading skills occur at the same time (OECD, 2000). Firms will have to provide the capacity to absorb the external knowledge and technology (Cohen and Levinthal, 1989). The ability of a firm to effectively use external knowledge, ranging from basic research and reverse engineering to the implementation of new production equipment, is known as its absorptive capacity (Schibany, Jörg and Polt, 1999). R&D

not only produces new information but equips the firm (the source of new information) with a specialised “ability to identify, assimilate and exploit other existing external information in a related area” (Niosi and Bellon, 2002, p.2). Zahra and George (2002) highlight the dynamic capability in absorptive capacity which has an effect on the nature and sustainability of a firm’s competitive advantage.

The absorptive capacity model presented in this paper is an adapted model provided by Todorova et. al (2003). The model of absorptive capacity comprises the acquisition, the assimilation or transformation and subsequently the exploitation of scientific knowledge leading to competitive advantage from a company’s perspective (Figure 7). According to Niosi et. al (2002) the acquisition relates to acquiring relevant new and pertinent knowledge which is potential capacity from a company’s perspective. This is the first step associated with absorptive capacity. Due to the fact that this potential has not yet been realised, it is called ‘recognising the value’ which requires scientific and technological skills to evaluate external knowledge in terms of its relevance to the company, its technology base, product or service portfolio. Todorova et. al (2003) prioritise the intensity, speed and effort to gather external knowledge, while Niosi et. al (2002) view the importance on the ability to ‘see’ and ‘understand’ it. In summary, in the first step of the absorptive capacity process (initiated by an activation trigger), comprises the ability to continuously access and gather relevant information, followed by understanding and evaluating the gathered information in terms of its significance to the specific company.

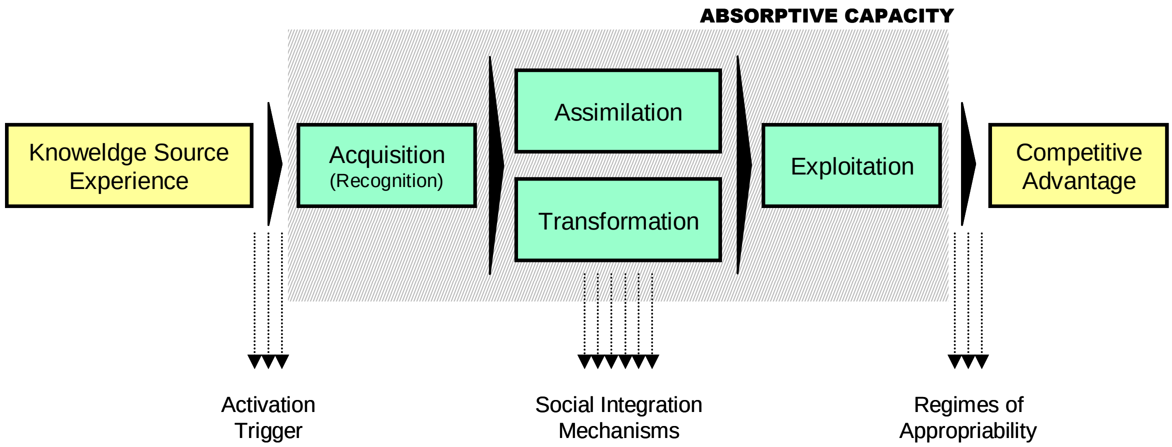

Figure 7: A Model Describing Absorptive Capacity

In order to achieve the potential capacity the next logical step is to realise the potential within the company. This relates to learning, i.e. the development of new or adapted cognitive structures. According to Piaget’s stage-independent theory of cognitive development learning occurs through assimilation, and accommodation (Kor and Orange, 2011). Assimilation means that the new idea can be absorbed into the existing cognitive structures of the individuals in a company (Todorova and Durisin, 2003). Similarly, Niosi and Bellon (2002) explain that the ‘assimilation capacity’ refers to the ability of the individuals to absorb knowledge, interpret, and comprehend in the light of the old cognitive structures. On the contrary, ‘transformation’ occurs when a new idea is not compatible with an existing cognitive structure. This process entails a revision of the existing cognitive structure so as to accommodate and subsequently, absorb the new piece of knowledge (Todorova and Durisin, 2003).

Knowledge sharing among members in an organisation is facilitated by many mechanisms. Examples of the mechanisms listed in Kor et. al (2011) are: instruction, conferences, meetings, workshops, collaborative inquiry, collaborative projects, or problem solving. Additionally, Communities of Practice (Lave and Wenger, 1991; Hildreth and Kimble, 2002) provide a social environment for knowledge sharing. The last step in the process of absorptive capacity is the exploitation of external knowledge to enhance organisational capability. According to Niosi and Bellon (2002) this last step is a mapping of newly imported external competencies onto the internal ones with the sole aim of creating new products, processes and knowledge. The result of the entire process is a new or extended organisational capability.

2.5.6 Support Structures

Support structures are required to assist a research group to cope with the challenges of technology transfer (*cf.* Debackere and Veugelers, 2005) and also to support technology transfer activities within the higher education institution (e.g. Jones-Evans *et al.*, 1999; OECD, 1999c; Cooke, 2001). An example is a technology transfer office (Debackere and Veugelers, 2005) designed to provide administrative support (such as legal arrangements, financial issues) for researchers in technology transfer so that they are free to fully concentrate on R&D efforts. However, these structures not only provide direct services to scientists but also assume the role of an intermediary service provider, i.e. they provide services to the industry (Etzkowitz, 2003). The services provided can be categorised into business incubation services (e.g. Etzkowitz, 2002; European Commission, 2001f; Heydebreck, Klofsten and Maier, 2000) and technology transfer related services (e.g. Cooke, 2001; Jones-Evans *et al.*, 1999). The overall purpose of the structures is for the management of the interfaces between academia and various external institutions, including industry, government, and other research organisations (Schaettgen and Werp, 1996).

The various support structures provided by Etzkowitz (2002) are technology transfer offices, industry liaison offices and incubators (Figure 8). A technology transfer office is generally viewed as mechanisms for reducing information asymmetries encountered in the scientific knowledge market (Debackere and Veugelers, 2005) by bridging the gap between the scientific world and the commercial market. The role of the technology transfer office is to facilitate commercial technology transfer through the licensing of inventions or other types of intellectual property to the industry resulting from university research (Cummings and Teng, 2003). The industrial company then makes or sells products or services based on the licensed rights (Diamant and Pugatch, 2007). The technology transfer office operates as dual search mechanisms identifying technology within the university and, simultaneously, finding a place for it in industry (*cf.* Etzkowitz, 2002). The services provided by technology transfer offices include the handling of industrial research contracts, the general management of intellectual property, the identification of technology transfer opportunities, the commercialisation of inventions/knowledge, assistance in monitoring and applying for research grants and subsidies, the establishment of information flows between academia and business (Cooke, 2001), dealing with the industrial company (on behalf of inventors) in the negotiation of licensing agreements, and industrial contracts (Diamant and Pugatch, 2007).

According to Cooke (2001), the primary functions of the industry liaison office are: marketing the university to companies and other interested partners; responding to external enquiries and acting as an information point (i.e. a single point of contact for the outside world); building information systems, databases for partner search, directories of university technological expertise; conduct non-research activities including continuing education, distance learning, cooperative education and work placements, etc. The industry liaison office can be seen as an intermediary information hub for managing the university-industry interface and providing useful information for value-added industry-science-relationships.

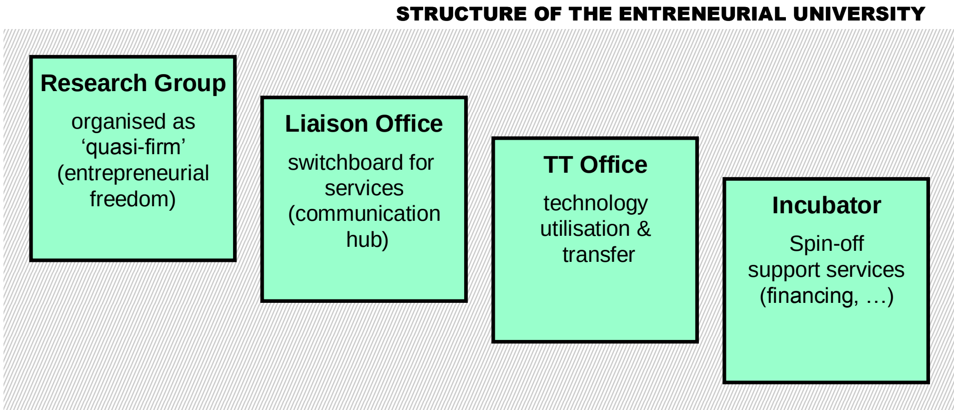

Figure 8: Multi-linearity of University-Industry Relations

Business incubation services provided by incubation units are targeted at the commercialisation of research outputs by supporting the establishment of spin-offs from the higher education sector. According to Heydebreck et. al (2000), relevant services encompasses the following: technology-related services (e.g. technological consulting, support for efficient R&D management, etc.); market-related services (e.g. assist with marketing of products and technologies, provision of a customer and supplier network, etc.); finance-related services (e.g. direct financial support, support in accessing external financing sources like venture capital funds, etc.); soft services (e.g. education and training, information events, etc.). However, the commercialisation of research results by spin-off companies (and the subsequent provision of the business incubation services), has to be matched against technology licensing which represents an alternative route for exploitation (Davenport, Carr and Bibby, 2002). In general, the provision of business incubation services depends on the research exploitation strategy pursued by the higher education institution.

In summary, technology transfer offices, industry liaison offices, and incubation units provide useful services to facilitate technology transfer. However, most often the smaller universities often lack the resources and the technical skills to effectively run a technology transfer office (Debackere and Veugelers, 2005). This has been identified by Polt *et al.* (2001) stating that most intermediary organisations (i.e. support structures) in the European Union are below the necessary critical mass to stimulate efficient industry-science-relationships. In addition, it might not be worthwhile establishing support structures which offer a full range of services. An alternative solution is to seek co-operation with external intermediary structures such as patent offices or regional public intermediary structures (e.g. innovation agencies). Another proposed strategy is to pool together resources of smaller higher education institutions so as to collaboratively set up a joint support structure.

3 RESEARCH AIM

The overall aim of this study is to develop a model describing the effect of the idiosyncrasies of Universities of Applied Sciences in Austria on the technology transfer capabilities of this particular higher education sector. The research objectives of this study are listed as below:

- **Research Objective 1:** The identification of factors influencing the technology transfer performance for Austrian scientific institutions
- **Research Objective 2:** The conceptualisation of a technology transfer model for the Universities of Applied Sciences.
- **Research Objective 3:** The development of an idiosyncrasy-technology transfer effects model for the Universities of Applied Sciences.

4 RESEARCH METHODOLOGY

The research methodology as depicted in Figure 9 consists of three phases:

Phase 1: This phase is primarily a secondary research which comprises a survey of relevant literature and document analysis. A total of more than 300 literature sources has been analysed and has led to the abstraction of factors influencing Austrian Higher Education Institutions' technology transfer performance (collated and presented as a technology transfer model in Section 5) as well as the identification of the idiosyncrasies of the Universities of Applied Sciences.

Phase 2: The ethnographic research conducted in this phase consists of a focus group followed by a participant observation. The goal of this phase is for triangulation purposes and also to refine the factors abstracted in **Phase 1** (or in other words, the technology transfer model). The participants of this phase are involved in the *Tech-Trans-V-Project* commissioned by the federal government in Vorarlberg, which aims to enhance the overall technology transfer performance of the Vorarlberg state.

Phase 3: This phase is preceded by conducting explorative interviews with experts in both the field of technology transfer and Universities of Applied Sciences. This is followed by focused interviews with stakeholders in Universities of Applied Sciences' sector (e.g. industry, intermediary organisation, an Austrian University of Applied Sciences, public funded research laboratory, etc.). The objectives of this phase are to validate and refine the technology transfer model (in **Phase 2**), idiosyncrasies of Universities of Applied Sciences (in **Phase 1**), and finally, explore the relationships between them and presented as an idiosyncrasy model.

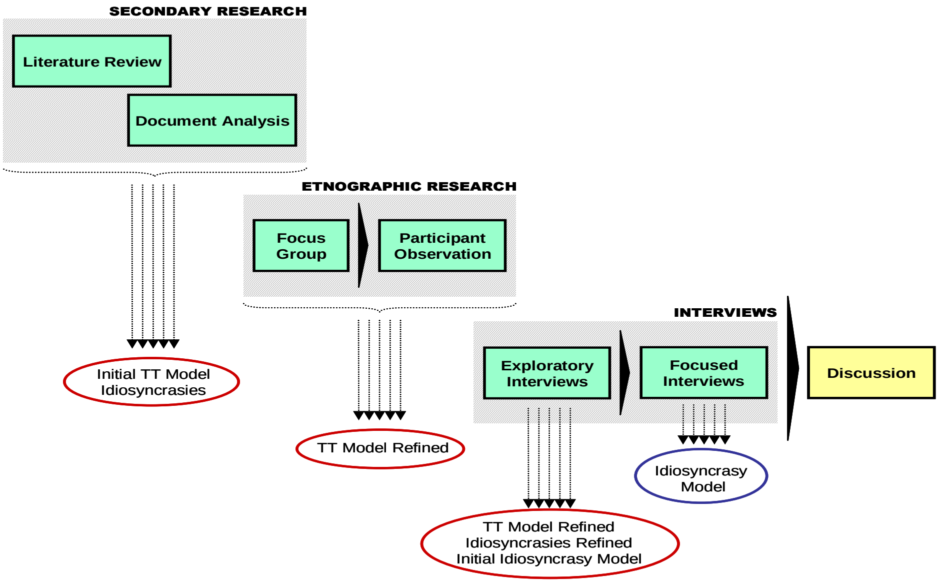

Figure 9: Overview of Research Methodology (Heinzl, 2007, p. 125)

The empirical research methods employed in this study have been summarised in Table 1.

	Phase 2		Phase 3	
	Focus Group	**Participant Observation**	**Explorative Interviews**	**Focussed Interviews**
Purpose	Theory building for behavioural aspects in the TT context	In-depth theory building for behavioural aspects in the TT context; validation of previous findings	Validation of previous findings in the Austrian context; further theory building for TT factors and idiosyncrasies; conceptualisation of idiosyncrasy model	Theory building for idiosyncrasy model
Approach	Inductive-deductive	Deductive	Deductive-inductive	Inductive
Research Objective/s (from Section 3)	1	1	1,2,3	3
Sampling strategy	Predefined by the *Tech-Trans-V-project*	Predefined by the *Tech-Trans-V-project*	Purposive Sampling	Snowball Sampling (Controlled by developing theory)
Sampling Size	3	27 companies, 24 observation events	8	12
Data Collection	Group Discussion	Participant Observation	Semi-structured problem-centred interviews	Semi-structured focused interviews
Data Recording	Note Taking	Research Diary, Observation Records	Electronic recording	Electronic Recording
Interview Guide	yes	--	yes	yes
Pre-Testing	--	--	yes	yes
Analysis	Content Analysis	Analytic Induction	Content Analysis	Content Analysis, Frequency Analysis

Note: TT stands for Technology Transfer

Table 1: Overview of Research Techniques Applied during Empirical Research (Heinzl, 2007, p.128)

5 RESEARCH FINDINGS

5.1 Technology Transfer factors

The survey of relevant literature contributes to the identification of important technology transfer related concepts. These concepts are presented in an initial technology transfer model which is then validated and refined by empirical results of conducted focus groups, participant observation, and interviews. The final technology transfer model is shown in Table 2 while the refinement of the factors is depicted in Table 3. The factors influencing technology transfer performance are coded into three categories namely: providing agent-related factors; receiving agent-related factors; environment and transaction-related factors. The first category concerns institutions which provide the technology while the second, institutions which are at the receiving end. As for the third category, it involves the environment they are in as well as the interface between them.

The discussion on the technology factors will be across the various research methods and also, it will only highlight several key findings:

a. Providing agent-related factors

Strategy and Mission **-** relates to the institution's technology transfer strategy and research mission. The two dimensions of institution's technology transfer addressed in this paper are: the '*thematic R&D focus*' and the '*R&D orientation*'. First, the technology transfer performance of higher education institutions is perceived as dependent on the strategies relating to '*thematic R&D focus*'. The interviewees perceive that thematically focused research (as implemented in research centres) which pools together technical infrastructure, resources, and expertise, would better facilitate technology transfer. Additionally, it is suggested that a research strategy would clearly define the thematic focus, and look into the relevant equipment as well resources. Some of relevant interview excerpts are as follows:

> *"...regarding focusing a mixture represents a crucial success factor. For teaching a broad orientation is required for equipping graduates with a comprehensive bundle of skills, whereas for research a clear focusing on selected relevant areas is required for keeping pace with (and contributing to) the technological development".* (A technology transfer consultant of an intermediary organisation)
>
> *"A clear research strategy has to define the thematic focus and, additionally, takes care for the proper equipment with resources".* (A a higher education consultant)

Technology transfer crucially depends on *R&D Orientation* which is either applied or basic research orientation (note: the former involves the application of scientific or engineering knowledge to solve a defined problem). The following are excerpts of interviews conducted:

> "*…a higher education institution has to focus on applied research for establishing technology transfer…*" (A higher education support structure manager)
>
> "*…one has to be prepared that technology transfer is hardly possible if focusing merely on basic research…*" (A managing director of an intermediary organisation)

There has been a general consensus among the interviewees that strategic decisions concerning the thematic focus and applied research orientation are insufficient to stimulate technology transfer. Another vital dimension to be considered would be the institution's research mission that is formulated by the stakeholders.

The '*institutional research mission*' envelops the expectations of stakeholders' expectations of the institution's research performance and its contribution to economic development via technology transfer. There has been general consensus among the interviewees that applied research and thematic areas foci are shaped by the '*institutional research mission*' of higher education institutions.

> *"...the mission for conducting applied research stimulates technology transfer. As a result, conducting applied research is not only a strategic decision but it is also the duty of higher education institutions as part of the institutional research mission".* (A technology transfer consultant)

Infrastructure and Resources **-** the dimensions of the *Infrastructure and Resources* factor are: financial resources, technical infrastructure, and size of the research teams. There is a general consensus among the interviewees that these factors affect the technology transfer of higher education institutions. First, it is perceived that suitable equipment with 'technical infrastructure' is conducive to technology transfer. However, the infrastructure does not necessarily have to be owned by the higher education institutions. Having access to infrastructure (e.g. via partner networks) is thought to be sufficient in the event of having to solve technological problems.

> *"... additionally, for a properly working technology transfer it is important to have access to material resources and laboratories, except for tasks, for which no infrastructure is required (brain work). The resources do not necessarily have to be owned by the higher education institution as long as the access to the required infrastructure is provided".* (A manager of a higher education research centre)

However, the effect of technical infrastructure on technology transfer performance is perceived as very trivial because it has not been considered a mandatory requirement for all technology-transfer projects. On the contrary, the 'size of R&D' is perceived as having an effect on technology transfer performance. High-quality technology transfer at a project level is not necessarily subjected to the size of a higher education institution but rather, it is dependent on the size of research teams.

Scientific and Technological (S&T) Human Capital **-** based on the survey of literature and ethnographic research findings, the *Scientific and Technological Human Capital* factor is identified as essential for the enhancement of technology transfer performance. *Application Awareness* focuses on the customers - e.g. customer segmentation, customer needs, customer requirements, etc while *Business Excellence* encompasses more generic business skills such as: project management, grant application, communication, business appreciation, etc. The following interview excerpt confirms the need to prioritise the business aspect of technology transfer.

> "*…the activities of researchers change. Whereas formerly the researchers conducted research within the department or the laboratory only, today the researcher has to enter the market as he relies on selling his services…*" (A director of a public funded research laboratory)

Personal Networks and contacts are essential for gathering business intelligence which could facilitate a more successful market entry through increased technology transfer opportunities. Such networks are established through events, employment in the industry, communities of practice, conferences, etc. An interview excerpt to highlight the importance of such networks in technology transfer is as follows:

> "*…personal contacts are crucial for technology transfer and technology transfer rests on personal relationships as the facilitation of technology transfer always has to be seen in the context of acting persons…*" (A managing director of an intermediary organisation)

The interviewees unanimously agree that *Attitude* and *Motivation* are vital for the enhancement of technology transfer. However, motivation is largely dependent on the availability of a proper incentive and reward scheme within the institution.

> "*...performance depends on whether someone is able to do something, whether he is motivated to do something and whether he is allowed to do something".* (A manager of an industrial research department)

Research Organisational Design – the *Research Organisational Structure* dimension of this factor is necessary for a successful technology transfer. The interviewees perceive it as the composition of research teams as well as the overall structural organisation of research within the institution which is either full time versus part-time, or discipline specific versus interdisciplinary. The following excerpt highlights the emphasis of individual researcher's role in technology transfer.

> "*…the organisation is only of minor importance for technology transfer. A well-designed organisation is not responsible for the initiation of technology transfer projects. Technology transfer is initiated by persons. The organisation should not prevent the researcher in conducting technology transfer…*" (A managing director of a public funded research laboratory)

Processes in this context refer to workflows and information flows. Though *Processes* are highly relevant for technology transfer, they could be a barrier when caught in a bureaucratic web.

> "…*the definition of formal processes is certainly important for a properly working technology transfer. Proper communication is required for informing the relevant authorities. After project completion, customer feedback is important for identifying potential for improvement (like quality controlling). However, these formal processes must not become too complicated for not hindering technology transfer…*" (A manager of a higher education research centre)

Support Structures are responsible for providing a range of supporting services to the institutions as well as industry for the purpose of successful technology transfer. Such services relate to technology marketing, competencies building, business incubation, public funding related consultation, Intellectual Property Rights (IPR), Knowledge Transfer Partnership between Higher Education Institutions and the industry, etc. A positive *R&D Image* crucially affects the demand for technology-related services which in turn, stimulates technology transfer. However, specific mechanisms are necessary to build a reputable research image. These relate to research projects, publications, online dissemination, conference presentations etc.

> "…*most important are scientific publications followed by reference projects and internet presentations. Also the participation in scientific conferences belongs to the presentation. As a result, brand development activities regarding the technology-related services are specific compared to other products…*" (A managing director of a public funded research laboratory)

b. Receiving agent-related factors

Industrial Demand – this refers to the demand for scientific knowledge and technology. It is perceived that a high industrial demand for technology does not automatically lead to technology transfer. However, the demand has to be articulated by the industry (*Articulated Demand*) in order to initiate the transfer process. On the other hand, the *Latent Demand* phenomenon is thought to exist when an industry: is not aware of its need for technology; deliberately ignores its need for technology; lacks the appreciation for new technology; is reluctant to embark on knowledge transfer partnership programmes. However, such a demand poses to be a great potential for technology transfer and consequently, has to be stimulated through the following mechanisms: joint universities and industry events, informal meetings, talks, conferences, etc.

Utilisation Capability – it encompasses two concepts being *Absorptive Capacity* and *Commercialisation Capability*. The former refers to the appreciation and absorption of technology into the industry. It is observed that companies with high absorptive capacity regularly assimilate new technology from its environment particularly scientific institutions, which thus result in long-standing collaborative relations with them. However, such a company is likely to be more critical of the reputation of its technology providers and also the quality of their technology. *Commercialisation Capability* is defined as the ability of companies to exploit the technology for commercial use (e.g. development of innovative products and services) and this step is considered the final action in the technology transfer process. The following excerpts highlight the importance of absorptive capacity and technology exploitation.

> "…*a company has to have qualified employees that are capable to absorb and process scientific knowledge. Knowledge does not only mean to grasp something from a cognitive perspective, but also to direct future behaviour and activities for the sake of the transformation of knowledge into financial assets…*" (An Interviewee)

"*…companies have to be capable of transforming technology, which has been delivered to them, into products…*" (A manager of a higher education research centre)

c. Environment and Transaction-related factors

Transaction Modalities – the *Transfer Conditions* dimension is an amalgam of three sub-factors being: costs, distance, and IPR handling. The first concerns the costs of technology projects where portion would have to be borne and viewed as investments by the receiving companies. However, some companies are reluctant to invest in such strategic research endeavours due to uncertain commercial returns and long payback time. Geographical distance is considered an important sub-factor for the success of technology transfer. Stronger collaboration between both providing and receiving agents, is observed when they are geographically nearer to each other. Findings suggest that technology transfer performance would be enhanced when IPR regulations could better meet the requirements of the industry.

Transfer Mechanisms to facilitate technology transfer between higher education institutions and the industry encompass the following: patent licensing, collaborative research, contract research, and mobility schemes (for staff). Findings suggest that easy accessibility to such mechanisms would potentially effect a more successful technology transfer. *Supply-Demand-Matching* is considered a basic requirement for successful technology transfer since technology has to be commercially relevant to companies and their business needs. This sub-factor is defined as the coincidence of the technology-related services provided by the higher education institutions and the demand of the industry.

"*…it does not make sense to build up competencies in thematic fields, in which no demand from the perspective of the regional innovation system is given and which, therefore cannot be commercially utilised…the technology transfer performance depends on the matching of supply and demand. To my mind, this represents the very core of successful technology transfer…this represents a pre-condition for properly working technology transfer…*" (A higher education consultant)

As mentioned earlier, the main reason for collaborative research projects between higher education institutions and the industry is for competitive advantage purposes. Thus, if *Confidentiality* could not be guaranteed by higher education institutions then technology transfer projects could neither start nor resume for ongoing ones. As for the sub-factor *Social Cohesion*, it includes shared language, shared understanding, mutual sympathy and trust. The following excerpts will provide some valuable insights.

"*…basically, persons play a dominating role in technology transfer including both, higher education research staff and persons from industry. The interaction between these persons is of central importance…*" (A managing director of an intermediary organisation)

"*…a common language between actors from the science base and the industry is required. This means a mutual understanding in a way that the industry feels that their demand is properly understood by the professor or research department in charge…*" (An interviewee)

Framework Conditions – the sub-factors *Funding Programmes*, *Intermediary Structures*, as well as *Regulation and Legislation* are abstracted from a survey of relevant literature, and are subsequently confirmed by the findings in the explorative interviews. The first sub-factor represents the public funding system while the second includes institutions which provide value-added networking services. As for the third one, it encompasses rules of the game in the technology transfer market. The *Collaboration Culture* influences the behaviour of companies in technology transfer projects, and it is closely associated with trust, confidentiality, and etc. It is imperative that companies be made aware of the potential benefits when embarking on collaborative R&D endeavours. This is highlighted in the following excerpts:

"…*what influences the technology transfer performance substantially is the collaboration culture. It is all about cultural staff, which hinders co-operation for us like the missing willingness for co-operation…*" (A higher education support structure manager)

"…*from a macro-economic perspective a climate conducive to innovation belongs to the framework conditions. In this context, the economic policy has to become active for sensitising companies for the importance of technology transfer…*" (A higher education consultant)

Categories	Factors Affecting Technology Transfer Performance	Key Dimensions
Providing agent-related factors	Mission and Strategy	R&D Thematic focus R&D Orientation Research Mission
	Infrastructure and Resources	Financial Resources Technical Infrastructure Size of R&D Team
	Scientific and Technological (S&T) Human Capital	Scientific Excellence Application Awareness Business Excellence Personal Networks Motivation
	Research Organisational Design	Research Organisational Structure Processes Support Structures Incentive Schemes R&D Image
Receiving agent-related factors	Industrial Demand	Articulated Demand Latent Demand
	Utilisation Capability	Absorptive Capacity Commercialisation Capability
Environment and transaction-related factors	Transaction Modalities	Transfer Conditions Transfer Mechanisms Supply-Demand-Matching Confidentiality Social Cohesion
	Framework Conditions	Funding Programmes Intermediary Structures Regulation & Legislation Collaboration Culture

Table 2: Generic Technology Transfer Model (Heinzl, 2007)

	SR	FG	PO	EI	Comments
Mission & Strategy					
R&D Thematic Focus R&D Orientation Research Mission	E E E	-- -- --	-- -- --	D D N	The explorative interviews contribute to the elaboration of *R&D Thematic Focus* and *R&D Orientation*
Infrastructure & Resources					
Financial Resources Technical Infrastructure Size of R&D Team	E E E	-- -- --	-- -- --	C C C	The initial conceptualisation iss retained throughout the study
S&T Human Capital					
Scientific Excellence Application Awareness Business Excellence Personal Networks Motivation	E -- E -- E	-- E C -- --	-- C C -- --	C C C E N	The factors (except for *Application Awareness* and *Personal networks*) are abstracted from a survey of relevant literature
Research Organisational Design					
Research Organisational Structure Processes Support Structures Incentive Schemes R&D Image	E E E E --	-- -- -- -- --	-- -- -- -- --	N N C C E	The interviews contribute to the *R&D Image* factor while *Research Organisational Structure* and *Processes* are revised terms
Industrial Demand					
Articulated Demand Latent Demand	E E	N N	C C	C C	The focus group contributes to these revised terms which are initially abstracted from a survey of relevant literature
Utilisation Capability					
Absorptive Capacity Commercialisation Capability	E E	C --	C --	C R	The term *Commercialisation* encompasses market utilisation related factors
Transaction Modalities					
Transfer Conditions Transfer Mechanisms Supply-Demand-Matching Confidentiality Social Cohesion	E E -- -- --	-- -- -- E E	C -- -- C C	R C E C R	The factor *Conditions* is the amalgam of the following factors: *Costs*, *Distance*, and the handling of *Intellectual Property Rights* (*IPR*)
Framework Conditions					
Funding programmes Intermediary Structures Regulation and Legislation Collaboration Culture	E E E --	-- -- -- --	-- -- -- --	C C C E	The interviews contributed to the *Collaboration Culture* while the rest of the factors remained unchanged throughout the study

Note: C – Confirmed; D – Elaborated Concept; E – Establish factors; N – Revised term; R – Reconceptualisation; EI – Explorative Interview; FG – Focus Group; PO – Participant Observation; SR - Secondary Research

Table 3: Refinement of the Factors in the Generic Technology Transfer Model (Heinzl, 2007)

5.2 Idiosyncrasies of Universities of Applied Sciences

The idiosyncrasies of the Universities of Applied Sciences are abstracted from document analysis (e.g. Austrian Ministry of Education official reports, the University Applied Sciences Council official reports, audit reports, statistics reviews, etc.). The idiosyncrasies of Austrian Universities have been coded into the following dimensions: study programmes, legal environment, funding structure, institutional setting, and research activities. These dimensions and their related idiosyncrasies are depicted in Table 4.

Categories	Idiosyncrasies
Study Programmes	Mandatory internship during study Entrance procedure for study enrolment No automatic enrolment into a PhD programme Focus on applied education
Legal Environment	Lax regulation (higher autonomy) Private/regional ownership No right to award PhDs Legal structure
Funding Structure	No block-grant funding for research Mixed funding structure (public and private funding)
Institutional Setting	Smaller in size compared to public universities Recently formed High teaching commitment of staff
Research Activities	Main focus being on applied research

Table 4: Idiosyncrasies of the Universities of Applied Sciences (Heinzl, 2007, p.166)

5.3 Effects of Idiosyncrasies on Technology Transfer

The effects of idiosyncrasies on technology transfer are abstracted from the analysis of qualitative data collected from the focused interviews. A total of 75 positive or negative effects established in this study are depicted in Table 5. The intensity of the effects is rated by the interviewees according to the following scale: *3* for high impact, *2* for medium impact, *1* for low impact, and *0* for no impact. Together with the direction of impact (i.e. positive or negative), a seven-step rating scale is employed: [-*3*, -*2*, -*1*, *0*, *1*, *2*, *3*]. As shown in the findings, not all technology transfer factors are affected by the idiosyncrasies. They are: *Research Mission*, *Business Excellence*, *Incentive Schemes*, *Social Glue*, and *Confidentiality* with regard to the outcome of collaborative research. Further discussion of the positive and negative effects is found in Heinzl (2007, Chapter 5).

Technology Transfer factors	IDIOSYNCRASIES								
	No PhD Award	Higher Autonomy	Block Grant Funding	Applied Research	R&D Image	Teaching Commitment	Small Size	Recently Formed	External Lecturers
Mission and Strategy									
R&D Thematic Focus		+	--			--	+	--	
R&D Orientation		+	+	+					
Research Mission									
Infrastructure and Resources									
Financial Resources	--		--	+	--				
Technical Infrastructure			--	+			--	--	
Size of R&D Team	--		--			--	--	--	--
Scientific and Technological Human Capital									
Scientific Excellence	--	+	--	--	--	--	--	--	
Application Awareness				+					+
Business Excellence									
Personal Networks	--		--	+	--	--	--	--	+
Motivation		+	--	+		--		+	
Research Organisational Design									
Research Organisational Structure		+					+		
Processes				+					
Support Structures			--	+			--	--	
Incentive Schemes									
R&D Image	--			+	--	--	--	--	+
Industrial Demand									
Combined Articulated and Latent Demands			--	+	--	--	--	--	+
Transaction Modalities									
Transfer Conditions	--	+	--		--				
Transfer Mechanisms				+				--	
Supply-Demand-Matching		+		+					+
Confidentiality									
Social Cohesion									

Key: [black box] High Intensity Effect [grey box] Medium Intensity Effect [white box] Low Intensity Effect

+ or -- : positive or negative effect Empty Cell : no effect

Table 5: Idiosyncrasies-Technology Transfer Effects Model (Heinzl, 2007)

Cumulated Idiosyncrasies Effects for Each Technology Transfer Factor

In this section the rating of each idiosyncrasy-technology transfer effect is extracted from the focussed interviews followed by an analysis of the cumulated effects of the idiosyncrasies per individual factor influencing the technology transfer performance. The results of this analysis reveal the advantages as well as the disadvantages for the Universities of Applied Sciences technology transfer system. This section introduces the formulae for the calculation of the cumulative effects. The mean cumulated effect of each idiosyncrasy on technology transfer is calculated and represented by S_{ij} (see first equation in Table 6). As a result, the cumulated idiosyncrasy effect, S_j, for each technology transfer factor is derived (see second equation in Table 6).

$$s_{ij} = \frac{\sum_{m=1}^{12} v_{ij}^{\ m}}{12}$$

$$s_j = \sum_{i=1}^{9} s_{ij}$$

$$s_j^{\ *} = \left(\frac{s_j}{\left|\max\left(s_j\right)\right|} \right) * 3$$

s_{ij}	*arithmetic mean of individual ratings*
v_{ij}	*individual rating value*
m	*interview number index (1..12)*
s_j	*cumulated ratings per technology transfer factor*
j	*technology transfer factor index (1..22)*
i	*idiosyncrasy factor index (1..9)*
s_j^*	*standardised cumulated ratings*
$max(s_j)$	*maximum value of cumulated rating*

Table 6: Formulae for the Calculation of the Idiosyncrasy-Technology Transfer Cumulated Effect (Heinzl, 2007, p.253)

For analysing the standardised cumulated effects of the idiosyncrasies, the third formula in Table 6 is applied. The standardised cumulated rating, S_j*, is calculated by dividing each corresponding S_j by the maximum value of the set of S_j values (S_1 to S_{22}) as represented by (max(S_j)) multiplied by 3 (which correlates to the maximum value of the rating scheme). This standardisation is conducted for every cumulated rating factor and shown in Table 6.

Impact of the Cumulated Idiosyncrasies on the Technology Transfer Factors

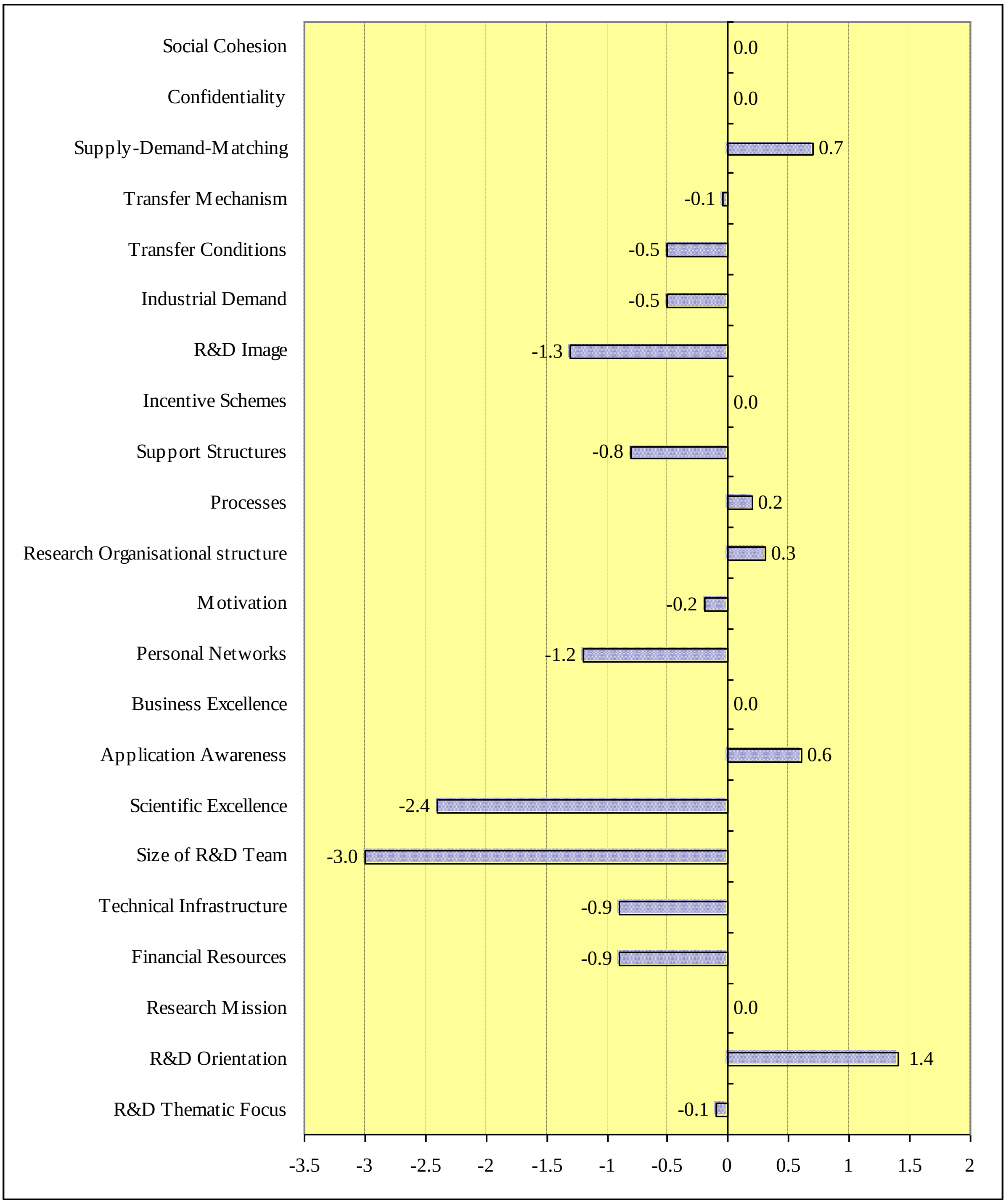

Figure 10: Idiosyncrasies-Technology Transfer Cumulated Effects Model

Based on the findings shown in Figure 10, the idiosyncrasy-technology transfer null cumulated effects seem to be true for the following technology transfer factors: *Transfer Mechanism*, *Confidentiality*, *Incentive Schemes*, *Business Excellence*, and *Research Mission*. The findings suggest that idiosyncrasies have very great negative cumulated effects on the *Size of R&D* as well as *Scientific Excellence*. It is also noted that there are more and generally greater negative idiosyncrasy-technology transfer cumulated effects than the positive ones.

6 DISCUSSION AND CONCLUSION

Both the *Idiosyncrasies-Technology Transfer Effects* and *Cumulated Effects Models* have been developed based on the Austrian Universities of Applied Sciences context. Consequently, they cannot be applied directly to other European countries. However, the three-phase research methodology could be replicated in other contexts in order come up with their respective *Effects Models*. These models have provided valuable insights into the higher education institutions' idiosyncratic factors which affect their technology transfer performance.

The findings in this research contribute to a conceptual design of the Universities of Applied Sciences technology transfer system as depicted in Figure 11. The strategies embedded in this system primarily aim at reducing the negative effects of idiosyncrasies in technology transfer.

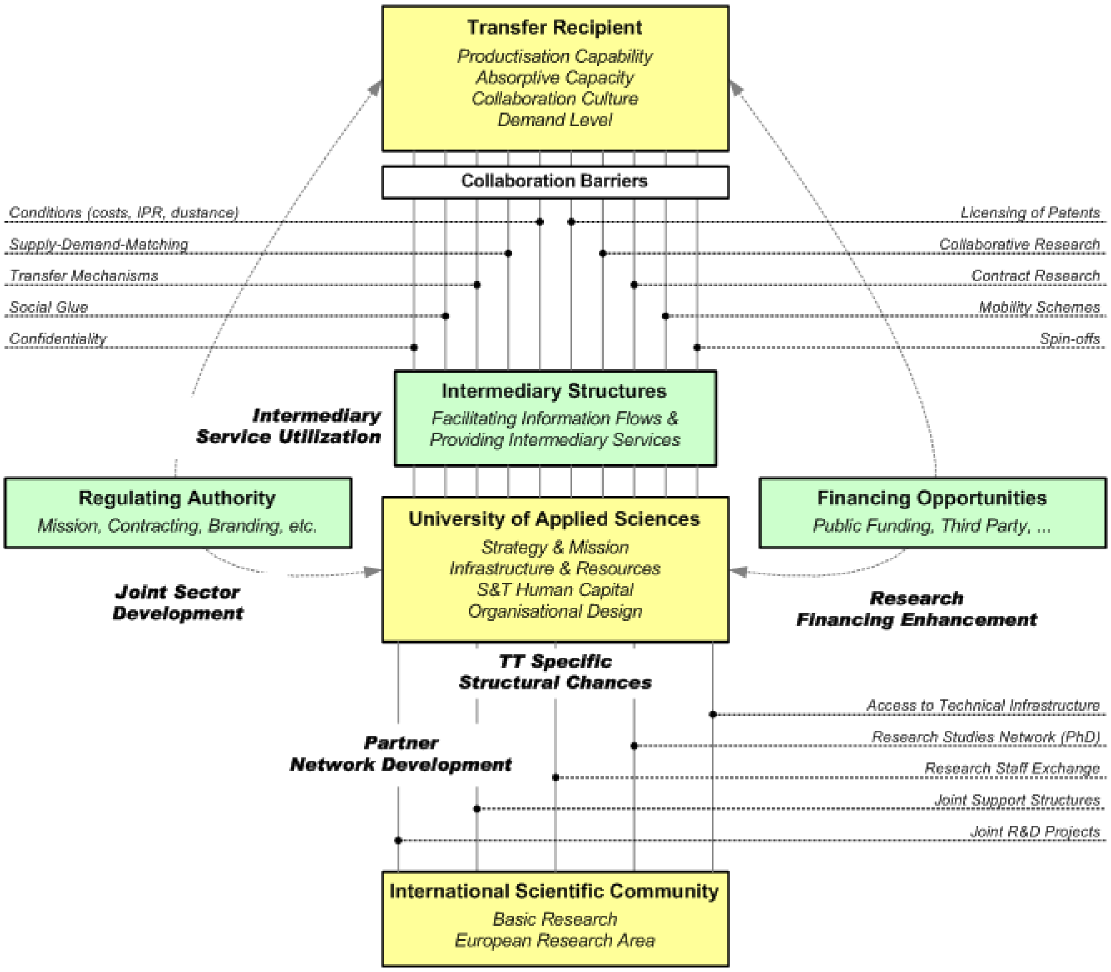

Figure 11: Conceptual Design of the Universities of Applied Sciences Technology Transfer System (Heinzl, 2007, p. 284).

Some of the recommendations for the Universities of Applied Sciences (note: could be relevant to other European Higher Education Institutions with similar characteristics) are to: create strategic partnerships with other institutions in the science base through research networks; establish consortia to build a better research image; increase research funding; effect research structural changes relating to research staff, groups, centres, and etc.; exploit the services of intermediary institutions (e.g. regional development agencies, patent offices, funding consultancy agencies, etc.).

Technological innovation commercialization is viewed as a process which aims to profit from marketing an innovative product, process, service (US Congress of Technology assessment, 1995) and it ought to transcend the technology transfer phase. It is viewed as an alternative funding option (Underwood, 2009). However, many technological innovations have not been fully commercially exploited due to great financial and managerial resources constraints, and lack of an appropriate support infrastructure. A technological innovation commercialization ecosystem aims to provide an appropriate infrastructure and also stimulating environment to transfer a university technology to the market.

6.1 An Ecosystem for Technological Innovation Commercialization

According to Markman and colleagues (2008), an ecosystem of research and technology commercialization comprises the following organizational forms: science parks, university-industry research centres, incubators, technology transfer offices (within the organization), and etc. Ecosystems will allow firms to create values that no single firm could have created alone (Adner, 2006). Thus, the success of having an emerging market is subject to the collective performance of all the interdependent stakeholders within the ecosystem. It is imperative to have an effective and efficient two-way transfer of knowledge and expertise. Additionally, barriers such as lack of trust, secrecy and confidentiality issues (McAdam and McAdam, 2006) would have to be overcome.

Science, Technology, or Research Parks

Link and Scott (2011) view science, technology, and research parks as having a unique place in a national innovation system because they could help enhance an innovation, accelerate economic growth and increase competitiveness. They have conducted empirical researches which facilitates a two-way transfer of knowledge between firms, as well as between firms and universities. A university science park incubator is typically located in close proximity to a university (ibid), generally attached to research laboratories, and financed by regional or national governments (Wright et. al, 2007). Its primary priorities are: to provide start-ups with access to a range support infrastructure (ibid); to promote technology transfer, academic entrepreneurship, and commercialization of an innovation stemming from a leading-edge research (McAdam and McAdam, 2006) and this is facilitated by the provision of common infrastructures and shared facilities (e.g. open innovation platforms, virtual networks, and online marketplaces (Markman et. al, 2008).

Technology Transfer Offices (TTOs)

Technology Transfer Offices have been established by research intensive universities in the US and Europe to commercialize their technological innovation-related intellectual property (IP). They play the role of an “intermediary” between the sources of innovations (universities), and those who could help commercialize them (e.g. venture capitalists, entrepreneurs, firms, etc.) (Siegel et. al, 2007). Licensing and spin-offs have been the primary modes of technological commercialization (ibid; Wood, 2009). Licensing involves the signing of technological innovation license agreements between the university and entrepreneurs, venture capitalists or existing firms. Typically spin-offs are created with investments from venture capital firms (Markman et. al, 2008). However, spin-offs and the universities supporting them generally lack sufficient internal resources and thus, it is necessary for them to have industrial partners so as to have access to key resources (Wright et. al, 2004). Such new ventures are known as joint venture spin-offs where a technological innovation assigned to a firm is jointly owned by a university and its industrial partner (Markman et. al, 2008). In order to be successful, spin-offs will require a strong support infrastructure which provides a wide range of support for their commercialization activities (Wright et. al, 2007).

Proof of Concept Centers

Gulbranson and Audretsch (2008) introduce the notion of "Proof of Concept" centers with the main responsibility of accelerating the process of commercializing a university's technological innovation. Based on this organisational form, seed funding for novel research is self-provided, and research is conducted in the relevant university's laboratory. Gulbranson and colleague has recommended that a new "Proof of Concept" center be placed within a university which produces an innovative and marketable technology and supportive infrastructure for further development and commercialization of the innovation (e.g. TTOs, industrial partners, etc.).

Innovation and Commercialization Networks

Markman and colleagues view open innovation networks (e.g. Yeti.com, InnoCentive, TelScout, etc.) connect the industry, academic institutions, public and non-profit organizations with a global network of research scientists to manage intellectual property (IP) and provide innovative solutions a challenging problem. The emerging trend is that most organizations are pushing their innovations into the open market and this is where a commercialization network is essential. Such a network comprises a wide range of stakeholders (e.g. competitors, distributers, buyers, consultants, suppliers, universities, government agencies, industry associations, etc.) that could provide the necessary resources: technical competence, industrial experience, customer and market intelligence, product knowledge, communication, etc. (Aarikka-Stenroos and Sandberg, 2012).

In conclusion, we view an effective ecosystem for technological innovation commercialization as one with an interrelated cognitive, cultural and structural embeddedness (adapted from Zukin and DiMaggio, 1990). Kor and Orange (2011) has discussed mental models as knowledge structures which affects our perception of our world. In order to invoke cognitive embeddedness, these individual mental models would have to be shared so as influence each other's thinking and consequently produce shared mental models (Senge, 1990) within the ecosystem. Hass (2007) perceives culture as a powerful force in economic behaviour and economic behaviour is said to be "culturally" embedded when there is shared collective understandings in shaping economic strategies and goals (Zukin and DiMaggio, 1990). Both cognitive and cultural embeddedness are intertwined because shared mental models will effect shared understanding that will result in deeply shared visions (includes goals, values and missions) for the ecosystem and the "intertwining" of the two has been reiterated by Dequech (2003). Hass (2007) defines a "structure" as patterned relations which can assume various forms (e.g. "micro" structure is a social network, etc.) while Granovetter (1985) views structural embeddedness as "contextualization of economic exchange in patterns of ongoing relations". Such concrete and systems of social relations (ibid) can create trust which facilitates the sharing of information and resources within the ecosystem. From here, we could see that structural embeddedness is a means to facilitate both cognitive and cultural embedded which have been discussed. The ecosystem will be an effective means to promote academic entrepreneurship (Wright et. al, 2008) because it could provide a stimulating and rich environment for commercialization-related activities that transcend beyond typical licensing to the creation of new business ventures (e.g. spin-offs).

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