Enhancing Knowledge-Based Regional Economic Development:

Potentials and Barriers for Technology Transfer Offices

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Berlin, den 09. Oktober 2009

Acknowledgement

This thesis is the product of research I conducted as a participant in the NEURUS-program of 2008/2009. The program allowed me to study as a visiting scholar at the University of North Carolina at Chapel Hill (UNC). At UNC's Department of City and Regional Planning (DCRP), I was not only granted access to relevant literature through the excellent scientific infrastructure, but my efforts were especially pushed forward by a steady exchange with the department's faculty and fellow students. Here, I received helpful feedback during my work and was introduced to experts in the field of my research. The interviews I was able to conduct and additional on-site studies of UNC's Technology Transfer Office were crucial input for the success of my work, as they provided cutting-edge knowledge in the field of university-industry technology transfer.

In this regard, I want to thank my parents for supporting me at all times and for helping making my last year's experiences abroad possible. I also would like to thank Prof. Dr. Elmar Kulke and Dr. Peter Dannenberg for giving me the chance to participate in the NEURUS-program and for supporting me with words and deeds during the last year. Additionally, I would like to thank Prof. Dr. Harvey Goldstein and Prof. Dr. Emil Malizia for inviting me to study at the DCRP and for having giving me valuable hints on how to get settled during my first weeks abroad. Especially, I would like to thank Prof. Dr. Maryann Feldman, Mr. Mark Crowell, Mr. Dwight Bassett, and Mr. Martin Mahn for sharing their knowledge and providing deep insight into different aspects of this thesis' topic. In addition, I would like to thank Dr. Meenu Tewari and Dr. William Rohe, who not only let me audit their classes but also provided helpful information and pointed me in the right direction. I also want to thank my fellow students at the DCRP for giving valuable feedback and for engaging in interesting cultural exchanges. Finally, I as well want to thank all other members of the NEURUS-family for enriching my studies and giving honest and helpful feedback to my presentations.

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ArbEG	Arbeitnehmererfindungsgesetz
AUTM	Association of University Technology Managers
Cf.	Confer
Ed.	Editor
e.g.	exempli gratiā
i.e.	id est
EI	Expert Interview
EU	European Union
GREMI	Groupe de Recherche Européen sur lex Milieux Innovateurs
HUB	Humboldt-Universität zu Berlin
HUI	Humboldt-Innovation GmbH
IP	Intellectual Property
LEI	Law of Employee Inventions
MIT	Massachusetts Institute of Technology
OECD	Organization for Economic Co-Operation and Development
PCC	Proof of Concept Center
R&D	Research and Development
SME	Small- and Medium-Sized Enterprise
TTO	Technology Transfer Office
UITT	University-Industry Technology Transfer
UNC	University of North Carolina at Chapel Hill

1 Introduction

The transformation of modern highly industrialized economies towards knowledge-based societies turns information and knowledge into the most fundamental economic resources and the very basis of innovation and production in an increasingly globalized world. Realizing that the creation, dissemination, and deployment of knowledge is crucial for keeping its economic area globally ahead, the European Union (EU), for instance, places emphasis on fostering research and development in order to become the most competitive economic area in the world.[1] Similar, many governments around the world are experimenting with means and initiatives to enhance their innovative capacity in order to reach the same goal. The way in which the elements of an economic system interact with each other in creating and applying knowledge seem to determine a region or economic area's innovative performance. The focus of innovation policy is gradually shifting away from influencing single factors, such as investments in research or subsidies for private businesses, towards the adjustment of the institutional fit between the different stakeholders that constitute an innovation system. One internationally widespread approach to enhancing regional and national innovation environments is therefore the strengthening of universities in their role of producers and distributors of knowledge and the fostering of university-based knowledge and technology transfer. Steady increases in licensing and patenting of research results and intensified formation of start-up companies across universities in the USA, Europe, Australia, and other advanced economies indicate their emerging role for knowledge-based regional economic development. Several governmental initiatives, such as the 'High-Tech-Strategy' of the German Federal Ministry of Education and Research, therefore aim at fostering the connections between science and business. Research, however, shows that particularly in the EU, the linkages between business enterprises and the higher education sector are rather weak and that the transfer of knowledge between universities and industry is still underlying a persistent ineffectiveness.[2] Hence, the process of transferring knowledge from universities to industry seems to require further examination and a search for best practice examples in order to derive improvements for the interactions between academic science and business. In this context, an attempt to improving the university-industry technology transfer (UITT) process, namely the widespread establishment of 'Technology Transfer Offices' (TTOs) at universities, will be examined in this paper.

[1] Basing on the 'Lisbon Strategy' of the European Union. Cf. EUROPEAN COMMISSION (2000).
[2] Cf. for instance EUROPEAN COMMISSION (2008), p. 16; MACHO-STADLER *et al* (2007), p. 484.

The following examinations of the potentials and barriers for TTOs for enhancing regional economic development are primarily based on a review of literature in the field of 'university entrepreneurship'. Here, the aim lies on depicting the current theoretical framework for three aspects. First, the recently emphasized role of knowledge, and especially its creation and dissemination through universities, is derived from the literature. In this regard, the theoretical background is kept to the essentials. Second, the current theoretical understanding of the actual process of university-based knowledge and technology transfer is depicted. In the course of this, the specific focus lies on identifying major barriers that seem to impede the UITT process. Third, the specific functions of TTOs in order to bearing down some of these barriers are examined. In this regard, the to-date identified major challenges for TTOs in for enhancing their productivity are presented. In addition to the literature review, expert interviews were conducted with representatives of academia, public policy, and two different TTOs in order to get further insight into the subject matter described above. The interviews particularly aimed on getting validation for theoretical findings from the literature on the one hand, and to identify additional aspects, especially in regard to the barriers that impede UITT and the major challenges for TTOs, on the other hand. As this paper proceeds, the relevant findings from the interviews are hence used to both underpin as well as complement the aspects that have been derived from the literature. Furthermore, some of the respective explanations regarding the potentials and barriers of TTOs in this paper are elaborated with appropriate case-examples that were observed at the TTOs of the University of North Carolina at Chapel Hill (UNC) and Humboldt-Universität zu Berlin (HUB).

This paper proceeds as follows: *Section 2* gives an overview of current approaches to regional economic development and focuses particularly on the role of knowledge and its diffusion as the critical basis for innovative activity. Here, especially the importance of university-based knowledge and technology and its dissemination is depicted, before the relevant research questions for the proceeding of this paper are developed. *Section 3* introduces an approach to frame the complex process of university-industry technology transfer. In this regard, the relevant elements, mechanisms, and barriers that have been identified so far are presented. *Section 4* analyzes the role and functions of a TTO. Specifically, the main challenges and factors that influence the performance of a TTO in enhancing UITT are shown. In order to give a more comprehensive overview of the topic, two further examples of recent developments on how to foster UITT are introduced. Finally, *section 5* gives a conclusion of this paper.

2 Background

2.1 A new Focus for Regional Economic Development Theory

The perception of economic development as a determinant for local and regional prosperity and well-being has stimulated scholars of wide-ranging economic disciplines to identify the relevant factors that lead to its occurrence.[3] Classical economists already put the relation between technological advance and economic growth at the core of their work, before these topics disappeared with the neoclassical revolution in economic thinking in the late nineteenth and twentieth century.[4] For regional growth theory, technological advance also played a rather inferior role in the beginning of the twentieth century. However, it became widely accepted that growth rates of globally and regionally concurring economies could not be explained by the quantitative growth of labor and capital alone.[5] During the 1980's, the role of knowledge and innovation for technological advance were moved into the spotlight of regional economic growth analysis.[6] Emphasis was especially placed on the regional availability of knowledge in the form of universities and research institutes, highly qualified labor, and industrial research and development (R&D).[7] Hence, the world economy's increasing degree of globalization and the already ignited transformation of highly industrialized countries towards knowledge-based societies led to an increased search for alternative approaches going beyond traditional concepts of regional growth theory.[8] At the end of the 1980's, rise eventually was given to a new evolving paradigm of spatial analysis of the economy, today referred to as 'New Economic Geography'.[9] Under its umbrella, several approaches try to explain spatial-economic phenomena by examining the cultural, organizational, social, and societal framework of economic activity.[10] A set of concepts highlights the role of specific networks and relations between individuals, companies, and institutions and the 'embededdness' in their environment.[11] Lately, several concepts of the 'New Economic Geography' especially accentuate the diffusion of knowledge between economic actors and its role for the creation of innovation.[12]

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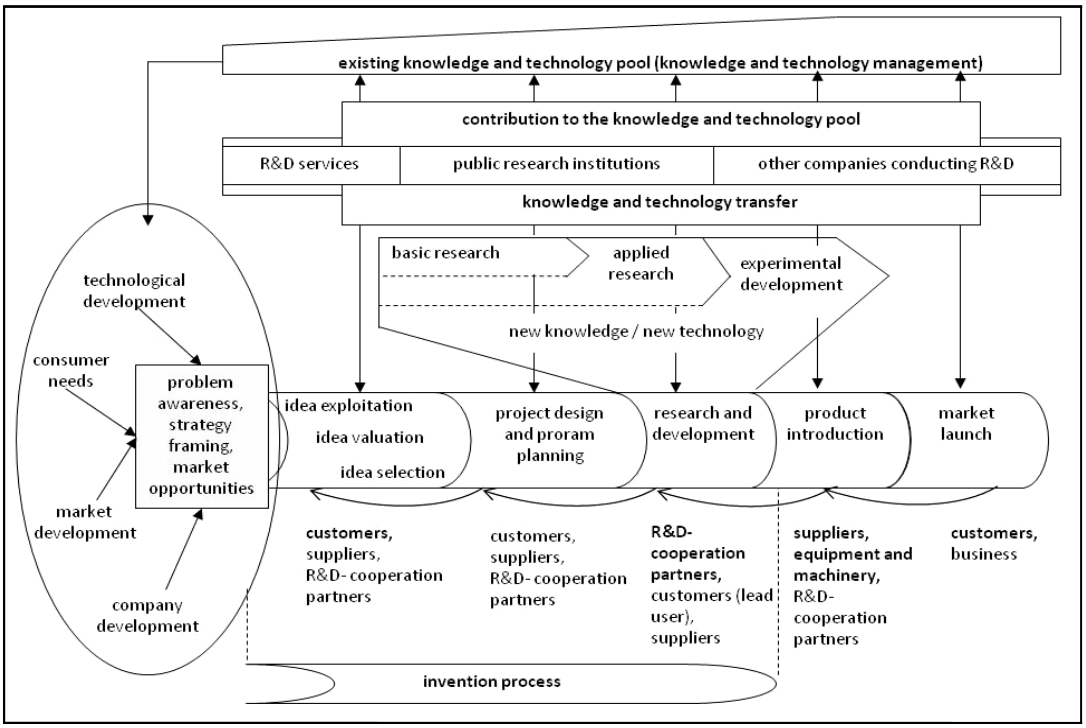
[3] Cf. PIKE *et al.* (2007), p. 1254.
[4] VERSPAGEN (2005), p. 489.
[5] Cf. TROEGER-WEIß & WAGNER (2006), p.24.
[6] Cf. FRANZ (2004), p. 111; SCHÄTZL (2003), p. 29.; SCOTT (2000), p. 23.
[7] Cf. FRANZ (2004), p. 111.
[8] Cf. HAGEN (2006), p. 9
[9] Especially become popular by publications of KRUGMAN (1991;1998). Cf. SCHÄTZL (2003), pp. 202-211.
[10] Cf. KULKE (2008), p. 16; SCHÄTZL (2003), pp. 211-244.
[11] Cf. KULKE (2008), p. 16.
[12] Cf. TROEGER-WEIß & WAGNER (2006), p. 29.

2.2 Knowledge and Innovation

Innovation is broadly accepted to be the driver for economic development, as it is the recombination of resources rather than their simple additional usage that leads to economic growth and wealth.[13] In many highly industrialized countries, regional development strategies are therefore based on innovative and high-technological products and services.[14] Previous studies show that firms, which establish links with external entities, get access to knowledge that differs from their own technology portfolio, what in turn increases their innovative capability.[15] Hence, innovative activity is often carried out in division of labor, where various organizations such as private enterprises, universities, and other public research facilities or educational institutions cooperate with each other for the purpose of reconfiguring existing knowledge, problems, and solutions.[16] This process can be understood as a collective learning process, which requires the transfer of knowledge between the involved stakeholders.[17] Figure 1 gives a detailed overview of the feedback mechanisms and the interactive processes between the actors involved in innovative activity.

Figure 1: The innovation process.



Source: Based on TROEGER-WEIß & WAGNER (2006).

[13] Cf. for instance FRITSCH & STEIGENBERGER (2007), p. 11; KULKE (2008), pp. 93-107; SCHÄTZL (2003), pp. 115-121.
[14] Cf. FRITSCH *et al.* (1998), p. 244.
[15] Cf. BERCOVITZ & FELDMAN (2006), p. 181.
[16] Cf. FRITSCH & STEIGENBERGER (2007), p. 17.; POWELL & GRODAL (2006), p. 75.
[17] Cf. FRITSCH & STEIGENBERGER (2007), p. 17.

Knowledge is accepted to be a crucial input for inducing innovation.[18] It can be differentiated into *explicit* and implicit, or *tacit*[19], knowledge.[20] Explicit knowledge can be articulated, codified, and stored, making it easily transferrable between different entities and over variable distances. In contrast, tacit knowledge evolves from individual skills, customs, and experiences and is not easy to codify. Tacit knowledge is therefore person-bound and requires face-to-face contact in order to be transferred. For the innovation process, tacit knowledge is assumed to play a superior role as it becomes more valuable and productive in the altering process of its acquisition and application.[21]

The ways in which knowledge of both forms can be acquired by third parties, are shown in Table 1. Important channels for the occurrence of knowledge spillovers seem to be different forms of cooperation in the field of R&D, the fluctuation of employees between scientific institutions and private companies, and sheer mutual observation of concurring companies and institutions.[22]

Table 1: Forms of knowledge and the ways of their acquisition.

	Explicit knowledge as a		**Implicit/Tacit knowledge**
	Public good	**Private good**	
On-market acquisition	-	- Purchase of patents, licenses, software - Contracted research	- Hiring and service contracts with carriers of implicit knowledge
Off-market acquisition	- Apprenticeship in public institutions - Learning through texts and software	Spillover in form of: - Reverse engineering - Learning-by-watching - Learning on basis of patent documentations	Spillover in form of: - Learning-by-doing - Learning-by-watching - Learning-by-interacting

Source: Based on FRANZ (2004).

Because the generation of innovation seems to have accelerated during the last decades and the half-life of knowledge is therefore gradually decreasing, it is generally accepted that regions in which knowledge is being created and transferred have a higher potential for development than others do.[23] The possession of capable knowledge-related institutions, dedicated to education, research, cooperation, and knowledge transfer, promises a higher innovation

[18] Cf. for instance KULKE (2008), p. 95; SCHÄTZL (2003), pp. 115-116.
[19] The notion of *tacit knowledge* was introduced into literature by POLANYI (1966).
[20] Cf. for this and in the following BRENNENRAEDTS *et al*. (2006), pp. 4-7; POWELL & GRODAL (2006), p. 75.
[21] Cf. for instance BRENNENRAEDTS *et al*. (2006), p. 2.
[22] Cf. FRANZ (2004), pp. 111-112.
[23] Cf. KULKE (2008), p. 95; TROEGER-WEIß & WAGNER (2006), p. 24.

capacity for the region.[24] As innovation is the pivotal leverage point for policy makers aiming at growth for both national and regional economies, the preconditions and mechanisms that lead to the effective exploitation of knowledge are at the heart of recent research.[25]

2.3 The Relevance of Inter-Institutional Knowledge Diffusion

Several dynamic-evolutionary approaches to knowledge-based regional development emphasize the role of interactions between the public, academic, and private sectors for the creation and dissemination of knowledge. The concept of the *innovative milieu*[26], for instance, highlights the role of regional networks and spatial proximity of individual actors that generate positive economic effects.[27] Informal and social relationships, characterized by trust and exchange of tacit knowledge would lead to synergetic learning effects and hence increase the local innovative capability.[28] A similar approach is the basis for the concept of the *learning region*[29]. Here, the basic idea is that the bundling of all regional actors' potentials can initialize, stabilize, and institutionalize a self-organizing, self-responsible, feed-backed, and self-reflective process, which, along with the integration of actors from the domains of policy, business, and science, would help to foster continuous collective learning processes and eventually lead to an increased innovative capacity of the region.[30]

A more comprehensive framework is being used in the concepts of *regional and national systems of innovation*[31] as well as the *triple-helix-model*[32], which emphasize the complementary roles of academic research institutions, the private business sector, and the government of an economy.[33] According to these approaches, the academic, private and public domains are about to become increasingly interwoven. Especially the emerging role of universities for the support of industrial innovation, which had been preserved for industry, the government, or a bilateral interaction of these two institutional spheres in previous perceptions, is highlighted. While former economic development policy often focused on improving the business cli-

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[24] Cf. KRÄTKE (2004), p. 95.
[25] Cf. FRITSCH & STEIGENBERGER (2007), p. 11.
[26] The concept of the *innovative milieu* has been developed by the French group of researchers 'Groupe de Recherche Européen sur les Milieux Innovateurs' (GREMI). Cf. AYDALOT (1986); CAMAGNI (1991).
[27] Cf. SCHÄTZL (2003), p. 233; TROEGER-WEIß & WAGNER (2006), pp. 29-30.
[28] Cf. FRITSCH *et al.* (1998), p. 246; KULKE (2008), pp. 131-132.
[29] The concept of the *learning region* is based on work of FLORIDA (1995) and MORGAN (1997).
[30] Cf. SCHÄTZL (2003), pp. 234-235; TROEGER-Weiß & WAGNER (2006), p. 34.
[31] The concept of *Regional Systems of Innovation* has been developed by COOKE *et al.* (1991) and BRACZYK *et al.* (1998). The concept of *National Systems of Innovation* is based on work of FREEMAN (1987), LUNDVALL (1992) and NELSON (1993).
[32] The *triple-helix-model* is based on work of ETZKOVITZ & LEYDESDORFF (1999).
[33] Cf. for this and in the following ETZKOWITZ *et al.* (2000), pp. 314-315.

mate, for instance by providing tax reliefs or subsidies, the university is increasingly expected to become a key element for innovation systems by providing human capital and by functioning as a seed-bed for new firms in the knowledge-based economy.[34]

According to the theoretical models outlined above, innovation is perceived to be the result of interactions between actors of different spheres and competencies through informal and formal networks. Among these actors, academic research institutions seem to play an important role for economic development, as their importance for the creation and dissemination of knowledge is especially highlighted.[35]

2.4 Universities as the 'Great White Hope' for Regional Economic Development

While first medieval universities of the 'Bologna-' or 'Sorbonne-type' saw themselves as pure accumulators of knowledge, it was Wilhelm von Humboldt's idea to unifying research and teaching, which became a model for universities worldwide during the nineteenth century.[36] Increased research and training in technical disciplines was going along with educating students to meet the needs of the emerging industrialized society. During the 20th century, industrial mass production and its features of linear organization, economies of scale and dedicated systems influenced the role of universities, where inputs like students and research funding were transformed into outputs, such as prospective employees and research papers.

After research and teaching have long been recognized as the two central missions for a university, recent observations suggest that a third mission of economic development is evolving as of the end of the 20th century.[37] Because universities create and possess the most important source for innovation, namely knowledge, and the sphere of public research is much more accessible for policy implementations than the private sector, academic institutions become increasingly important for economic development strategies.[38]

It is the creation, acquisition, diffusion, and deployment of knowledge that constitutes today's role for universities, which YOUTIE & SHAPIRA (2008) term the 'knowledge-hub'-function (Figure 2).[39]

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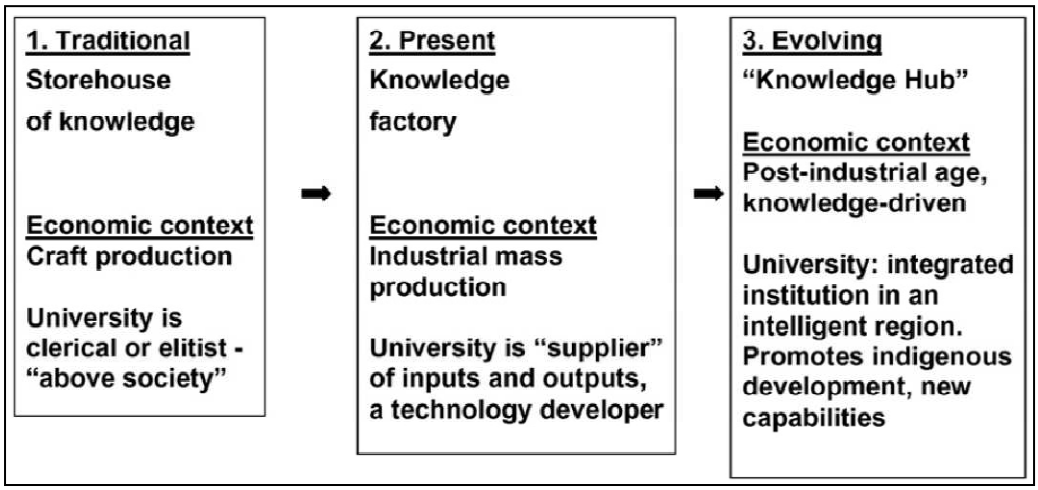
[34] Cf. ETZKOVITZ *et al.* (2000), p. 315.
[35] Cf. TROEGER-WEIß & WAGNER (2006), p. 30.
[36] Cf. for this and in the following YOUTIE & SHAPIRA (2008), p. 1189.
[37] Cf. for instance ETZKOVITZ *et al*. (2000); YOUTIE & SHAPIRA (2008).
[38] Cf. FRITSCH & STEIGENBERGER (2007), p. 11.
[39] Cf. YOUTIE & SHAPIRA (2008), p. 1189.

Figure 2: Evolving university contexts and missions.



Source: YOUTIE & SHAPIRA (2008).

Universities fill this role by generating explicit and tacit knowledge autonomously as well as in cooperation with public research institutions or private organizations, accumulating internally and externally created knowledge, and transferring this knowledge to other entities in its environment.[40] The transfer of outputs, such as human-capital in the form of qualified graduate students on the one hand, and basic scientific knowledge as foundation for applied research on the other hand, is assumed to have a positive impact on the production and supply opportunities of the economy.[41]

Going along with this new role for universities, a process that seems to affect to a greater or lesser degree all institutions of higher learning has been observed by ETZKOVITZ *et al.* (2000), who see universities having arrived at a common entrepreneurial format in the late 20th century.[42] According to their concept of the 'entrepreneurial university', academic institutions seem to undertake increased efforts to create, identify, and commercialize their intellectual property (IP), i.e. research results, in order to improve the regional or national economic situation and to generate additional income for the university and its faculty.

Two additional recent concepts that have to be mentioned regarding the increasing entrepreneurial activity of universities are the *principal-agent-theory* and the *concept of property rights*. The principal-agent theory bases on the assumption, that the distribution of information between a principal and an agent in a mutual transaction is uneven. The principal may not

[40] Cf. FRITSCH & STEIGENBERGER (2007), p. 19; YOUTIE & SHAPIRA (2008), p. 1189.
[41] Other economic effects caused by the presence of universities such as demand-side effects, provision-effects, or image effects also contribute to regional development but are not main focus of this paper. For an overview cf. FRANZ *et al.* (2002), p. 12.
[42] Cf. for this and in the following ETZKOWITZ *et al*. (2000), pp. 316-317.

know the agent's entire characteristics, abilities, and motives, what may lead to unsatisfying results for the principal due to possible prior overestimations. Here, it is helpful for the principal to possess indicators for the agent's quality ex ante on the one hand, and appropriate incentives for motivating the agent on the other hand. This 'asymmetric information' problem seems to plays a rather important role in interactions between universities and industry, as elaborated on below. The concept of property rights, in turn, highlights the role of the rights to use, exploit, sell, or transfer a tangible or intangible goods or processes. These rights, for instance in form of patents or licenses, play an essential role for entrepreneurs in the process of technology transfer, as they provide the right to exclude, for a fixed time, all others from making, selling, or using the product or process without authorization.[43]

2.5 Development of Research Questions

The previous sections gave an overview of recent approaches to explain regional economic development in the knowledge-based society. The role of knowledge and its diffusion as the crucial input for the innovation process has been pointed out. In addition, the importance of universities for enhancing the regional and national knowledge base was depicted. As shown, universities play a central role in national and regional systems of innovation by creating, acquiring, storing, and disseminating knowledge.

As academic research is increasingly near to being translated into economic development, the question arises, how the transfer of knowledge from a university into its economic environment can be facilitated most effectively. A look into the literature, however, reveals that the mechanisms and causalities of knowledge and technology transfer are still rather unclear and not understood in entire detail yet.[44] Eliminating barriers within innovation systems requires therefore further studies of how to effectively facilitate the knowledge and technology transfer process and what the key resources and capabilities are.[45]

The following sections examine the process of university-based knowledge and technology transfer and identify important mechanisms on the one hand and inhibiting barriers that are related to this process on the other hand. Furthermore, the potentials and challenges of the so-called 'Technology Transfer Office', a recently emphasized mean to enhance university-based knowledge and technology transfer, are being analyzed. The questions that are going to be pursued are therefore:

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[43] Cf. MASKUS (1997), p. 5.
[44] Cf. for instance BERCOVITZ & FELDMAN (2006), p. 175; ZADEMACH & RIMKUS (2009), p. 416.
[45] Cf. ROTHAERMEL *et al.* (2007), p. 708.

- What are the most common ways to transfer knowledge from a university into its economic environment?
- Which barriers have to be overcome in the university-based knowledge transfer process?
- What is the potential role of a Technology Transfer Office for the enhancement of the university-based knowledge transfer process?
- Which challenges do Technology Transfer Offices particularly face in their knowledge transfer strategies?

3 University-Industry Technology Transfer – Towards a Comprehensive Framework

3.1 An Approach to Defining University-Based Knowledge and Technology Transfer

During recent years, a rapidly growing amount of literature has focused on the field of university entrepreneurship and university-based knowledge and technology transfer.[46] Due to its relative fragmentation, this literature is yet to reveal a detailed and comprehensive framework for understanding all stakeholders' motives and relationships, involved mechanisms, influencing factors, and inhibiting barriers.[47] However, there are some approaches towards a definition to be found in the literature. The consortium RESEARCH COUNCILS UK (2006), for instance, defines *knowledge transfer* as

> "(…) the two-way transfer of ideas, research results, expertise or skills between one party and another that enables the creation of new knowledge and its use in the development of innovative new products, processes and/or services (and) the development and implementation of public policy. Knowledge transfer will encourage the dissemination and assimilation of knowledge and stimulate engagement between wider society, including business, government and public, and the research community"[48].

Another definition by the 'ALBERTA PUBLIC SERVICE' describes knowledge transfer as "(…) a systematic approach to capture, collect and share tacit knowledge in order for it to become explicit knowledge (…) (whereas) this process allows for individuals and/or organizations to

[46] Cf. ROTHAERMEL *et al.* (2007), p. 692
[47] Cf. ALDRICH & BAKER (1997), p. 396; MEISSNER & SULTANIAN (2007), p. 5; ROTHAERMEL *et al.* (2007), p. 692.
[48] RESEARCH COUNCILS UK (2006), p. 35.

access and utilize essential information, which previously was known intrinsically to only one or a small group of people"[49].

Similar, the terms *technology transfer*[50] and in a narrower sense *UITT* are broadly used in the literature.[51] BREMER (1999) defines technology transfer rather simply as "(…) the transfer of the results of research from universities to the commercial sector (…)"[52]. The 'ASSOCIATION OF UNIVERSITY TECHNOLOGY MANAGERS' (AUTM) (2007) refers to technology transfer as "(…) the practice of licensing research institution-owned intellectual property to commercial and non-profit organizations"[53].

In this context, TORNATZKY *et al.* (1998) define knowledge as the result of research, while the application of this knowledge, leading to practical value and utility, is called technology.[54] MOWERY & ROSENBERG (1989), in turn, argue that "a new technology is a complex mix of codified data and poorly defined 'know how'"[55].

As there seems to be no sharp differentiation between knowledge transfer and technology transfer, the notion of UITT is used in this paper and refers to the formal and informal transfer of applicable research results and university IP, including tacit and explicit knowledge, from a university to private companies and entrepreneurs.

3.2 Main Elements of University-Industry Technology Transfer

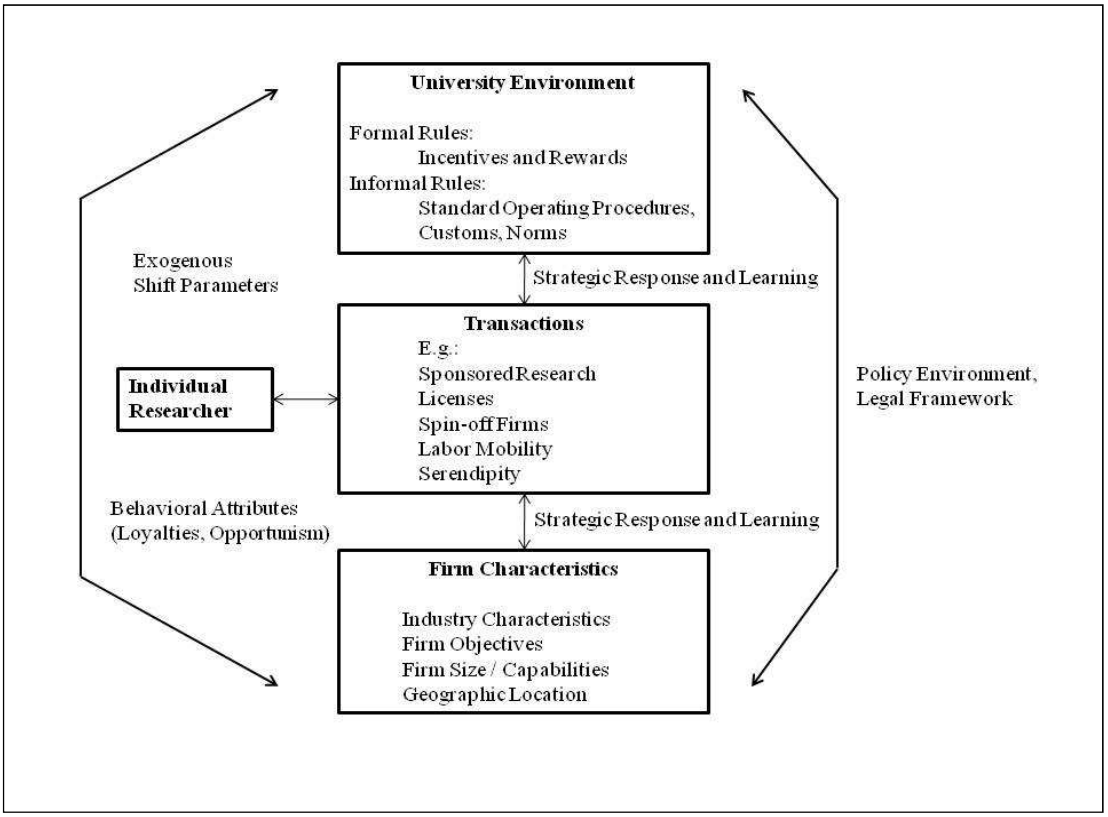
3.2.1 Conceptual Approach to University-Industry Technology Transfer

BERCOVITZ & FELDMAN (2006) developed a conceptual model as an approach to frame the complex process of UITT (See Figure 3).[56] In this model, the basic elements are the researcher who is inventing a new technology, the university holding the rights to the technology, the company interested in acquiring the technology, and the transactions among these three stakeholders that consitute the actual mechanisms of technology transfer. The interdependet elemets are furthermore embedded in a political and legislative environment,

[49] ALBERTA PUBLIC SERVICE, cited in RESEARCH COUNCILS UK (2006), p. 35.
[50] In earlier literature, the notion of technology transfer mainly referred to the process of exporting knowledge and technology from industrialized to developing countries. More recent studies, in turn, tend to refer to inner- and inter-institutional transfer processes. Cf. MEISSNER & SULTANIAN (2007), p. 5.
[51] Cf. RESEARCH COUNCILS UK (2006), p. 11.
[52] BREMER (1999), p. 2.
[53] AUTM (2007), p. 8.
[54] Cf. TORNATZKY *et al.* (1998), p. 219.
[55] MOWERY & ROSENBERG (1989), p. 7.
[56] Cf. for this and in the following BERCOVITZ & FELDMAN (2006), pp. 176-177.

which sets the formal rules for the technology transfer process. The particular elements of the conceptual framework of Bercovitz & Feldman (2006) are described in the following.

Figure 3: University-Industry relationship evolutionary schema.



Source: Based on BERCOVITZ & FELDMAN (2006).

3.2.2 Characteristics and Motives of Stakeholders in University-Industry Technology Transfer

3.2.2.1 Firms and Entrepreneurs

Private firms and entrepreneurs have the aim of profit-maximization.[57] As innovation is one of the key factors for competitive advantages on the market, it is important for them to obtain control over cutting-edge technologies. By commercializing university-based IP, they acquire crucial input to their development and production processes, can keep other competitors from acquiring critical technology, and may possibly reduce their own R&D costs.[58] Dependent on the speed of the transfer process, they can gain a 'first-mover' advantage by securing exclu-

[57] Cf. for this and in the following SIEGEL *et al.* (2007), p. 642.
[58] Cf. DECTER *et al*. (2007), p. 150.

sive rights to a technology.[59] In order to implement a newly acquired university-based invention successfully, firms need to have a certain ability to 'translate' university outputs into commercially useable inputs.[60] This ability to recognize, assimilate, and apply new scientific knowledge for the purpose of innovation and new product development is referred to as the 'absorptive capacity' of firms.[61] Here, the ability to learn from external sources is dependent on tacit knowledge, which plays a crucial role for utilizing externally acquired scientific knowledge.[62] Hence, for firms it is not only important to strive for codified technology in the form of patents or similar, but also to seek interactions with university scientists in order to recruit and train staff for enhancing their 'absorptive capacity'.[63]

3.2.2.2 Academic Scientists

At the heart of technology transfer is the faculty member, who is motivated by a set of personal and institutional incentives.[64] Scientists often seek the rapid and broad dissemination of their research findings. They reach this goal through traditional means like publication in recognized scientific journals or presentations at prestigious conferences. The aim of disseminating their ideas and breakthroughs is to gain recognition and increase their stature inside the scientific community through citations and access to key social network in academia.[65] In addition, pecuniary rewards may function as an incentive for faculty to engage in UITT, as it can be invested into new laboratory equipment, graduate students, or research assistants.
According to the life cycle model of STEPHAN & LEVIN (1992), scientists often tend to invest in human capital in their early careers in order to build reputation and expertise and typically seek an economic return in the later years.[66]

3.2.2.3 University Administration

Universities can be seen as complex bureaucracies with their own rules, rewards and incentive structures, and a variety of functions based on educational and societal duties as well as interests of faculty members and the broader scientific community.[67] For a university, UITT is foremost a means to implement federal and university policies and disseminate knowledge

[59] Cf. SIEGEL *et al*. (2007), p. 642.
[60] Cf. for this and in the following KODAMA (2008), p. 1226.
[61] The concept of 'absorptive capacity' was introduced by COHEN & LEVINTHAL (1989).
[62] Cf. KODAMA (2008), p. 1226.
[63] Cf. DECTER *et al.* (2007), p. 150.
[64] Cf. for this and in the following BERCOVITZ & FELDMAN (2006), p. 180.
[65] Cf. for this and in the following SIEGEL *et al.* (2007), p. 642.
[66] Cf. BERCOVITZ & FELDMAN (2006), p. 180; STEPHAN & LEVIN (1992), p. 126.
[67] Cf. BERCOVITZ & FELDMAN (2006), p.176.

and technology for social and economic benefit.[68] In this regard, university administrators may tend to see themselves as the "(…) guardians of the university's IP portfolio (…)"[69] and may have the aim to generate revenue and tap new sources of research funding by marketing and commercializing university-based technologies. However, in order to protect the university's general mission and research environment, university administrators may be anxious to avoid negligently giving away the results of university research and try to legally and financially hedge possible commercialization activities, which may eventually slow down the transfer process.[70]

3.2.3 Policy Environment and Legal Framework

The process of UITT is embedded in a policy environment and legal framework that influences its functioning and effectiveness.[71] In the US, for instance, state governments increasingly demand that their academic institutions foster economic development and innovation within their localities.[72] Also, federal governments of the US, Japan, Europe, and other advanced economies try to promote the linkages of universities to technology transfer, innovation and economic development.[73]

Perceived as one of the first and at the same time most important policy implementations regarding UITT is the enactment of the 'University and Small Business Patent Procedures Act', proposed by US-Senators Birch Bayh (Indiana) and Bob Dole (Kansas) in 1980. Later unofficially named the 'Bayh-Dole Act', it decreased the bureaucratic and institutional difficulties that universities and small- and medium-sized enterprises (SMEs) faced when seeking ownership of federally funded research results. The 'Bayh-Dole Act' regularized the transfer of property rights of university-based discoveries from the federal government to the universities. Therewith, universities eventually became allowed to independently patent research outcomes funded by federal government agencies and to commercialize these inventions, for instance, by granting licenses to industry and obtaining the respective revenues.[74] The aim of 'Bayh-Dole' was to increase the economic returns for governmental-funded research and to foster innovation by stimulating UITT.[75] During the 1990's, increased commercialization

[68] Cf. DECTER *et al.* (2007), pp. 149-150.
[69] SIEGEL *et al.* (2007), p. 642.
[70] Cf. SIEGEL *et al.* (2007), p. 642.
[71] Cf. BERCOVITZ & FELDMAN (2006), p. 177.
[72] Cf. YOUTIE & SHAPIRA (2008), pp. 1189.
[73] Cf. YOUTIE & SHAPIRA (2008), p. 1190.
[74] Cf. GROSS (2009), p. 119; RAFFERTY (2008), p. 29; SHARMA *et al.* (2006), p. 111.
[75] Cf. SHARMA *et al.* (2006), p. 111.

strategies of universities became furthermore formalized through a range of legislations promoting the 'third mission' activities of universities as being equally important as the traditional activities of research and teaching.[76] Most European countries have meanwhile adopted 'Bayh-Dole'-like legislations, which transfer the IP rights of federally funded research to the universities. In the UK, Belgium, and France, the IP rights now generally belong to the university and the governments of Sweden and Finland are as well discussing the introduction of similar legislations.[77] In Germany, the reformation of the 'Law of Employee Inventions' (LEI) (§42 new version)[78] of July 2002 led to the abolition of the former privilege of faculty to own the exclusive rights to their inventions stemming from university funded research and transferred these rights from the reverse side to the employing university. Goal of this refinement of the LEI was as well to promote patent applications of university-based research outcomes. This strategy bases on the assumption, that the patent application process is tied to certain monetary and other opportunity costs. Here, faculty are perceived as having a lack of incentives to file for patents, while, in turn, a university is perceived as having the required resources and organizational capabilities to effectively seek patent protection and commercialization opportunities for its faculty's research results.[79]

3.2.4 Mechanisms of University-Industry Technology Transfer

3.2.4.1 Mechanisms Identified To-Date

BRENNENRAEDTS *et al.* (2006) present a list of ten formal and informal channels through which UITT is facilitated (See Table 2).[80] The authors argue that the traditional way of disseminating research findings through their *publication* in scientific journals is a rather ineffective means for technology transfer, as only codified knowledge is involved, which requires investment in personnel that can translate the explicit knowledge in order to be applied. *Conference* attendance is in turn an important mechanism for detecting new trends in science and for building networks as a base for further interactions between the spheres of academia and industry. Social *networks*, such as alumni foundations, may also arise from the education sys-

[76] Cf. for this and in the following WRIGHT *et al.* (2008), p. 1208.
[77] Cf. SIEGEL *et al.* (2007), p. 643.
[78] The German 'Law of Employee Inventions' regulates the ownership rights of inventions made by employees in the private and public sector as well as for inventions made by public officials and servicemen. §42 regulates ownership rights particular for employees of universities.
[79] Cf. for instance UNIVERSITÄT DUISBURG-ESSEN (2005), p. 2.
[80] Cf. for this and in the following BRENNENRAEDTS *et al.* (2006), pp. 4-7.

Table 2: Identified channels of university-industry technology transfer.

Publications	Scientific publications of companies Co-publications Consulting of publications
Participation in conferences **Professional networks and boards**	Participation in conferences Participation in fairs Exchange in professional organizations Participation in boards of knowledge institutions Participation in governmental organizations
Mobility of people	Graduates Mobility from public knowledge institutes to industry Mobility from industry to public knowledge institutes Mobility between public knowledge institutes Trainees Double appointments Temporary exchange of personnel
Other informational contacts/networks	Networks based on friendship Alumni societies Other boards
Cooperation in R&D	Joint R&D projects Presentation of research (vice versa) Supervision of a trainee or Ph.D. student Financing of Ph.D. research Sponsoring of research
Sharing of facilities	Shared laboratories Common use of machines (vice versa) Common location or building (Science parks) Purchase of prototypes (vice versa)
Cooperation in education	Contract education or training Retraining of employees Working students Giving information to students Influencing curriculum of university programs Providing scholarships Sponsoring of education
Contract research and advisement	Contract research Contract advisement
Intellectual property (IP) rights	Apply for patents Information via patents Co-patenting Emitting licenses Acquire licenses Copyright and other forms of intellectual property
Spin-offs and entrepreneurship	Spin-offs Start ups Incubators at universities Stimulating entrepreneurship

Source: BRENNENRAEDTS *et al*. (2006).

tem. The channel of *joint research* seems to be only important to relatively large firms, who, in contrast to many SMEs, have the resources to engage in research with long-term goals and can offer interesting knowledge and facilities to the university. Cooperation in *education* is another means, which provides retraining of a company's employees through workshops or seminars, while faculty and students get in touch with current needs and developments of an industry when hired by firms.

In their model, BERCOVITZ & FELDMAN (2006) especially emphasize the mechanisms of *sponsored research, licensing* agreements regarding university IP, the *hiring of graduate students* and *spin-off formation*, which will be depicted more detailed in the following sections.[81]

3.2.4.2 Sponsored Research

Sponsored research or contract research is based on an agreement between an academic entity and a private company and usually consists of applied research commissioned through a university in order to create specified formal knowledge at an early stage of a new technology.[82] Here, it is often advantageous for the contracting company to have employees directly collaborating in the research project, as a certain amount of tacit knowledge is being created during the research process that may be worth transferring to the company in addition to the reported research results. So, the company is not only able to acquire new knowledge that may be crucial for the development of new products or processes, it is also able to obtain training effects for its employees, which enhances their skills and knowledge, leading to an increased firm's 'absorptive capacity'. Furthermore, sponsored research projects grant access to further sources of knowledge in form of potential prospective employees, namely graduate students that were involved in the research project. In exchange for the acquired knowledge, the company provides funding to the university, which is, for instance, used for enhancing the research infrastructure, employing graduate students, or course releases and financial support for faculty.

In practice, the amount of industrially funded research projects in universities varies significantly between countries. For the US, the relative share of funding of higher education R&D from business enterprises was rising from 4% in 1981 to 7% in 1992 but declined again reaching about 5% in 2003. In Germany, the industrial expenditures for higher education R&D rose steadily from 2% in 1981 to 8% in 1992 and reached 13% in 2003, making Germany one of

[81] Cf. BERCOVITZ & FELDMAN (2006), p. 178; WRIGHT *et al.* (2008), p. 1207.
[82] Cf. for this and in the following BERCOVITZ & FELDMAN (2006), p. 177; WRIGHT *et al.* (2008), p. 1207.

only five countries in the OECD, to have a share of more than 10% of higher education R&D sponsored by business enterprises.[83]

3.2.4.3 Hiring of Students

Another important mechanism leading to the diffusion of academic knowledge is the hiring of graduate students by firms and the transfer of employees from public research institutions to industry in general.[84] Because knowledge, obtained by university graduates and researchers, is likely to be at least partially person- and organization-bound and difficult to codify, this form of knowledge transfer is highly effective for business companies in order to receive critical tacit knowledge input. However, the employee transfer between the two different realms may create friction. There may be possible constraints especially to smaller businesses to appoint a graduate student due to higher salary demands, as compared to a non-graduate, or pre-conceived ideas that may exist about graduates. Also, missing business skills of graduates, needed to make a career outside of the scientific community, may be another factor.

BERCOVITZ & FELDMAN (2006) therefore emphasize the model of the advanced research student, basing on the so-called 'German model', which essentially provides an apprenticeship as being part of the academic education at universities, leading to a much smoother transition from academia to business.[85] Other factors influencing the transfer of employees from university to business include motivation, security awareness, and familial wealth of the individual.[86] The transfer is assumed a mainly local or regional process, as the existence of crucial face-to-face contacts and networks are crucial for starting a company. In addition, personal factors such as the costs of social disconnection of the graduate or scientist and his family members as well as losses from sales of real estate may increase the tendency to stay inside the specific region.

3.2.4.4 Licensing Agreements

Licensing agreements consist of a contract, where a university sells the right to use an invention to an established or start-up company in exchange for up-front fees and regular annual royalty payments, depending on the success of the technology in a downstream market.[87] In the US, licensing up-front fees typically range from $10,000 to $50,000, but can reach up to

[83] OECD (2006), pp. 10-13.
[84] Cf. for this and in the following TROEGER-WEIß & WAGNER (2006), pp. 66-67; WRIGHT *et al*. (2008), p. 1208.
[85] Cf. BERCOVITZ & FELDMAN (2006), p. 179.
[86] Cf. for this and in the following TROEGER-WEIß & WAGNER (2006), p. 67.
[87] Cf. BERCOVITZ &FELDMAN (2006), p. 178.

$250,000 in particular cases, while the rate of annual royalties typically lies between 2-5% with particular peaks of 15%.[88] As the contractual mechanism, which is used to transfer certain IP rights from a university to a company, is structured as a free market transaction, the terms and conditions are mutually negotiated and voluntarily agreed upon.[89] Typically, such contracts include agreements over the specific usage rights that the seller grants the buyer, the rewards that are paid and possible penalties for mistreating the agreement.[90] Critical factors for the negotiation of licensing contracts include the specific attributes of the technology, the characteristics of the corporate partners, the IP policies of the licensing university, the history of the relationship between the to contractual partners, and others.[91] Subsequent contracts about consultation or maintenance services with faculty that were engaged in the invention may follow, as the licensed technology may require further development before eventually ending up in a marketable product.[92]

3.2.4.5 Spin-Off Firms

University spin-off firms are an important subset of start-up companies, which are basically formed around a university's patent or license.[93] This includes different variations such as firms formed by university faculty, start-up firms that have joint research projects with a university, or firms that are formed by graduate students or post-docs on the basis of research conducted at a university. In exchange for providing a license to a researcher that wants to form a spin-off, universities often take equity in it in order to keep the financial burden for the young company low and to maintain close relations. According to AUTM, spin-off firms of US-universities have alone contributed 280,000 jobs to the US-economy and $33.5 billion in economic value-added between 1980 and 1999.[94] Spin-offs are furthermore often locally anchored. While licenses do not have spatial constraints and can be transferred globally without loss of value, spin-offs heavily benefit from proximity to the inventive institution as it provides skilled labor, specialized facilities, and expertise related to the firm's core-technology. It has furthermore been observed that faculty, who are partially involved in the formation of a spin-off, tend to split their time between the firm and the university, making proximity of the

[88] Cf. BRAY & LEE (2000), p. 387.
[89] Cf. BERCOVITZ & FELDMAN (2006), p. 178.
[90] Cf. TROEGER-WEIß & WAGNER (2006), p. 72.
[91] Cf. BERCOVITZ & FELDMAN (2006), p. 178.
[92] Cf. SIEGEL *et al*. (2004), p. 118.
[93] Cf. for this and in the following BERCOVITZ & FELDMAN (2006), p. 179.
[94] Cf. O'SHEA *et al.* (2007), p. 662.

two institutions advantageous.[95] ZUCKER *et al.* (2000) studied the role of the location of firms for their innovative performance and concluded that firms benefit from proximity to coryphées in academic research related to the firm's technology portfolio. Ties between these 'star scientists' and a firm positively influence the firm's number of patents granted, number of products in development, and number of products on the market.[96]

AUTM (2007) reports, that three-quarter of all reported university spin-offs had their primary place of business inside the parent university's home state in 2006.[97] Because they often belong to an economically powerful group of high-technology companies and hence are a promising tool for transforming the local economy and reap the benefits of proximity to a research university, spin-offs are seen as the favored mechanism to commercialize a university's technology for both university administrators and regional governments.[98]

3.3 Barriers to University-Industry Technology Transfer

3.3.1 Institutional Barriers

As mentioned in section 3.2.3, the institutional frame for UITT affects the commercialization of university-based IP. Previous research concluded, that there are certain barriers for UITT that especially arise from the way the federal, or respective economic area's patent system, and the universities' IP policies are shaped.[99] MEISSNER & SULTANIAN (2007) observed that excessive bureaucracy and high transaction costs related to the acquirement of patents and licenses are critical factors for a firm's willingness to cooperate with academic research institutions.[100] NELSON (2001) gives cause to consider the impeding effects an over-protection of fundamental discoveries may have for the dissemination of scientific basic knowledge and argues that a government policy's aim to foster innovation is foiled by excluding any parties from exploring further research on publicly funded inventions, amongst others caused by a too static patent system.[101] A survey conducted by PROTON (2007) concludes, that the less favorable European patent system[102] is one of the main reasons why EU universities lag be-

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[95] Cf. BERCOVITZ & FELDMAN (2006), p. 179.
[96] Cf. ZUCKER *et al*. (2000).
[97] Cf. AUTM (2007), p. 38.
[98] Cf. BERCOVITZ & FELDMAN (2006), p. 179; O'SHEA *et al.* (2007), p. 662.
[99] Cf. BERCOVITZ & FELDMAN (2006), p. 181.
[100] Cf. MEISSNER & SULATANIAN (2007), p. 18.
[101] Cf. NELSON (2001), p. 18.
[102] Differing aspects of the EU vs. US patent systems are for instance the handling of simultaneous patent applications ('First-to-File' vs. 'First-to-Invent' approach), the grace period ('exclusion when previoussly publishing' vs. 'one year grace period after publishing'), or the related bureaucratic issues ('one EU patent turns into

hind their US-American counterparts, who file on average 5 times more patents and collect 15 times more licensing revenues.[103] DEBACKERE & VEUGELERS (2005) therefore suggest that a more transparent regulation of ownership titles and property rights should be prior for EU policymakers regarding the enhancement of UITT.[104] However, in order to generate a generally more favorable framework for UITT, the EU recently launched a pan-European policy program named 'Putting Knowledge into Practice', aiming at implementing a common market for technology transfer expertise, supporting the set-up of flagship programs, and supporting the personnel exchange between industry and science.[105] Furthermore, the European Patent Office has recognized insufficiencies in the European patent system and works on developing a European patent culture similar to that of the US.[106]

Regarding the university level, BERCOVITZ & FELDMAN (2006) argue that inventive researchers must have the possibility to obtain some rights over their intellectual property in order to win them over for commercial activity.[107] Although most universities are the exclusive owners of IP generated within their sphere of influence, particular arrangements allow researchers to use these rights in order to commercialize their inventions. HUB's patent and licensing strategy, for instance, grants IP rights to the respective inventor in exchange for equity in an up-following firm or spin-off.[108]

3.3.2 Cultural Barriers

Cultural differences between academia and business on the one hand, and between scientists with differing attitudes towards commercial activity on the other hand, are further key barriers for UITT.[109] According to observations by DOUGHERTY (1992), it is likely that differing cultures in academia and business lead to differing mindsets with distinct languages and different organizational structures and customs, which may hinder effective technology transfer.[110] As private firms and research universities have profoundly different missions, i.e. acquiring exclusive knowledge vs. disseminating knowledge, they may furthermore often display mutual

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a bundle of national patents' vs. 'one federal US patent'). Cf. EUROPEAN PATENT OFFICE (2009a); US PATENT AND TRADEMARK OFFICE (2009).

[103] Cf. PROTON (2007), p. 2.
[104] Cf. DEBACKERE & VEUGELERS (2005), p. 339.
[105] Cf. EUROPEAN COMMISSION (2006).
[106] Cf. EUROPEAN PATENT OFFICE (2009b).
[107] Cf. BERCOVITZ & FELDMAN (2006), p. 180.
[108] Cf. HUMBOLDT-UNIVERSITÄT ZU BERLIN (2008).
[109] Cf. SIEGEL *et al.* (2007), pp. 647-648.
[110] Cf. DOUGHERTY (1992), pp. 195-197.

distrust.[111] In fact, in a qualitative study of SIEGEL *et al.* (2004), 90% of the interviewed company managers and entrepreneurs and 74% of the interviewed scientists mentioned a lack of understanding the opponent's norms and environments as a barrier to UITT.[112] Moreover, the willingness of faculty to engage in UITT seems to be strongly based on social norms and practices inside academia.[113] A scientist's mindset regarding commercialization may be influenced by the university's and the respective department chair's attitude towards technology transfer as well as by the peer scientists' and colleagues' attitude regarding commercialization activities.[114]

MAHN (2009, Expert Interview 4) argues, that *"Business sometimes has a bad image per se. This has been recently especially boosted by the financial crisis"*[115]. In addition, some representatives of academia generally believe that commercial activity is not appropriate for an academic scientist.[116]

FELDMAN (2008, Expert Interview 1) observes, that *"There is some concern in the scientific community, that university research is about to become too much focusing on applied research"*[117]. Commercial activity may sometimes even be decreasing a scientist's credibility.[118]

CROWELL (2008, Expert Interview 2) notes, that *"Within their profession, if their peers read a paper by Prof. X and they know that Prof. X has a start-up company, they automatically say he's writing this because it makes the commercialization of his technology look better. (…) There are still some elements, old left-over's, and biases that research that is done for commercial use is not as good as research that is done because it is interesting"*[119].

Researchers may furthermore be confronted with criticism that they would endanger the 'open-science environment' by cooperating with industry, which would lead to "(…) *secrecy about research results in the departments hallways*"[120]. In order to cushion this kind of criticism and to handle possible conflicts arising from a scientist's simultaneous engagement in commercial and academic activity, many universities have set up so-called 'conflict of interest' policies.[121]

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[111] Cf. BERCOVITZ & FELDMAN (2006), p. 175; SIEGEL *et al.* (2004), p.136.
[112] Cf. SIEGEL *et al.* (2004), p. 128.
[113] Cf. BERCOVITZ & FELDMAN (2006), p. 181; SIEGEL *et al.* (2007), p. 653.
[114] Cf. BERCOVITZ & FELDMAN (2006), p. 180.
[115] Expert Interview (EI) 4.
[116] Cf. ETZKOWITZ *et al.* (2000); THURSBY & THURSBY (2002).
[117] EI 1.
[118] Cf. SIEGEL *et al.* (2004), p. 134.
[119] EI 2.
[120] EI 2.
[121] Cf. Nelson (2001), p. 17.

All together, it seems to be of superior importance to furthermore clarify the mission of today's universities and to establish a more entrepreneurial culture inside them in order to enhance UITT activities.[122]

3.3.3 Informational Barriers

An insufficient flow of information seems to be another important barrier to UITT.[123] One reason, why companies may not want to acquire university technology is the lack of information about a technology's quality.[124] According to their motives mentioned in section 3.2.2.1, companies usually prefer to invest in licenses and patents that promise cash flows. However, they often cannot assess a university-based invention's potential ex ante. This phenomenon of 'asymmetric information' seems to be a typical problem on the scientific knowledge market and seems to be traceable to the scientist's difficulties in realizing the commercial potential of their inventions, while in turn companies may assume that their technological needs are not interesting enough for academic research.[125] *"The involved parties do not know what the other side is doing. The companies do not know what is going on behind the laboratory doors and scientists do not know what the needs of industry are. There is no functioning platform yet, that could intermediate this."*[126] This informational barrier seems to be one of the key issues that need to be addressed in order to enhance UITT.[127]

3.3.4 Organizational Barriers

Another determinant that affects the outcomes of UITT programs seems to be the organizational practice inside the university.[128] In this regard, key issues seem to be sufficient pecuniary and non-pecuniary incentive structures for faculty involvement as well as the particular structural organization of technology transfer.[129] As highlighted in section 3.2.2.2, academic scientists usually seek to publish their research results in top-tier journals, present at prestigious international conferences and obtain federal research grants, in order to gain a distinguished reputation, as it is still the most important measure towards credit and tenure inside

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[122] Cf. CLARKE (1998); ROTHAERMEL *et al.* (2007), p. 708; SIEGEL *et al.* (2007), p. 642.
[123] SIEGEL *et al.* (2007), pp. 647-648.
[124] Cf. for this and in the following MACHO-STADLER *et al.* (2007), p. 483; SIEGEL *et al.* (2007), p. 644.
[125] Cf. MEISSNER & SULTANIAN (2007), p. 18; THURSBY & THURSBY (2002), p. 93.
[126] EI 4.
[127] Cf. for instance ROTHAERMEL *et al.* (2007); SIEGEL *et al.* (2004).
[128] Cf. BERCOVITZ & FELDMAN (2006), p. 182; GEIGER (1993).
[129] Cf. SIEGEL *et al.* (2007), pp. 647-648.

academia.[130] *"For scientists, the ability to publish is important. It is their currency"*[131]. Hence, researchers may not want to risk publication delays because of a time consuming patenting process and therefore may have insufficient incentive to engage in UITT.[132] In this case, it seems to be necessary to evaluate current reward structures inside the academic system and offer sufficient incentives, in order to elicit more effort from researchers.[133] A case-example can be found at UNC, where "*(…) some departments and schools, pharmacy on the forefront, are actually incorporating patenting, licensing, and other technology transfer activities worthy of credit when one of the faculty members is up for tenure. (…) They don't have to do this but if they do, it is as valuable as a paper in 'Science' or 'Nature'"*[134]. In addition, pecuniary rewards seem to play a role, as according to LINK & SIEGEL (2005) universities with higher percentages of royalty going to faculty members are more efficient in technology transfer activities.[135] Regarding the case-examples, at HUB 30% of license or patent revenues go to the researcher, whereas at UNC, the share ranges from 40% up to 70%.

In terms of the organizational structure of UITT inside the university, a decentralized management of technology transfer seems to be a factor for success, because a dedicated, separate unit inside the university could be more sensitive to the needs of the UITT stakeholders.[136] MACHO-STADLER et al. (2005) observed that universities with strong links to industry tend to have a decentralized model of technology transfer compared to universities without a strong link to industry.[137] ETZKOVITZ *et al.* (2000) state, that the interface between a university and other institutional spheres like industry requires intelligence, monitoring, and negotiation. These requirements may give rise to the work of interface specialists, which have a potential for assessing the commercial value of research findings and the encouraging of interactions with external partners.[138] This implication will be followed up more detailed in section 4.

3.3.5 Environmental Barriers

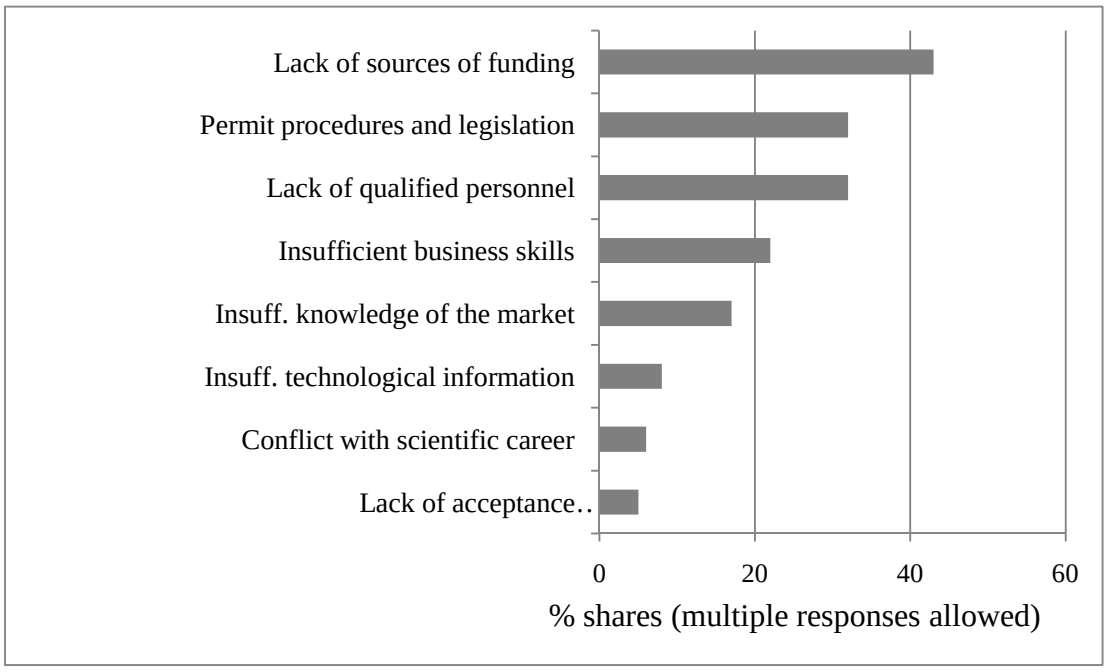
Two important factors for the effectiveness of UITT that are based on the specific environment of a university seem to be the availability of external funding and the local or regional pool of labor. The success of spin-off companies seems to depend especially on the regional

[130] SIEGEL *et al.* (2004), p. 118.
[131] EI 4.
[132] Cf. THURSBY & THURSBY (2002), p. 93.
[133] Cf. JENSEN *et al.* (2003).
[134] EI 2.
[135] Cf. LINK & SIEGEL (2005).
[136] Cf. DEBACKERE & VEUGELERS (2005).
[137] Cf. MACHO-STADLER *et al.* (2005), p. 486.
[138] Cf. ETZKOWITZ *et al.* (2000), pp. 316-317.

availability of seed and venture capital. *"Spin-offs need an initial funding in order to reach their proof-of-concept. There is no sufficient funding of this kind yet. There may be public funding, for instance in form of the 'High-Tech Fund' but often just for two or three years. With some luck, they would reach their proof-of-concept. But between this stage and the critical size for the market launch, there is nothing"*[139]. In addition, the supply of qualified personnel seems to influence the technology transfer effectiveness inside the university's region. BASSETT (2008, Expert Interview 3) reports, that *"One researcher started a company, but he went to California, despite working and living here in Chapel Hill for a long time. He was looking for a particular type of engineer to head the company, to be the chief executive officer. The pool of applicants was just much stronger there than in our region. (…) Part of the reason is also, that Silicon Valley has more venture capital"*[140].

A survey conducted through the 'Center for European Economic Research' reveals the importance of the two depicted environmental factors (Figure 4). A lack of sources of funding and a lack of qualified personnel are among the most important barriers for the formation of university spin-offs in Germany.

Figure 4: Barriers to spin-off formation.



Source: Based on EGELN *et al*. (2002).

[139] EI 4.
[140] EI 3.

4 Technology Transfer Offices – Enhancing University-Industry Technology Transfer

4.1 Emergence and characteristics of the Technology Transfer Office

In order to address the barriers related to the process of UITT, intermediation between the domains of academia and industry by third can play a crucial role.[141] On the one hand, specialized intermediaries can be external to the university and take the form of venture capital firms or public and private development agencies. On the other hand, internal intermediaries, which are in some way affiliated with the respective university, could take the form of business incubators or specialized departments inside the university. These internal intermediaries are often called TTO[142].

SHARMA *et al*. (2006) define a TTO as "(…) a unit within the university, not a corporation or an entity separated from the university created specifically for the purpose of technology commercialization"[143]. MACHO-STADLER *et al.* (2007) describe a TTO as a technology seller, pooling inventions from several research labs within a university.[144] Thus, TTOs can be seen as the formal gateway between a university and industry and some researchers even tend to understand the entire entrepreneurial activity of a university as a function of the productivity of its TTO.[145] The creation of TTOs with staff and resources solely dedicated to technology transfer was stimulated by the passage of the 'Bayh-Dole Act'[146], which led to increased patenting and licensing activities among US universities since 1980.[147] In the period of greatest TTO initiation between 1983 and 1996, every year 5-10 new TTOs were founded at US universities.[148] While there were only 20 such offices in the whole US in 1980, the number increased to 220 in 1990.[149] Today, virtually every US university, and the majority of universities in other advanced countries, have established TTOs.[150]

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[141] Cf. for this and in the following WRIGHT *et al*. (2008), p. 1208.

[142] In the literature, further expressions for describing a university institution dedicated to technology transfer are for instance 'Industrial Liaison Office' or 'Technology Licensing Office'. However, the most often used term seems to be 'Technology Transfer Office'.

[143] Cf. SHARMA *et al.* (2006), p. 113.

[144] Cf. MACHO-STADLER *et al.* (2005), p. 485.

[145] Cf. ROTHAERMEL *et al.* (2007), p. 740.

[146] See Section 3.2.2.

[147] Between 1979 and 1984, the number of annually issued university-based patents in the US doubled from 177 to 408, doubled again to 1.008 between 1984 and 1989, and in turn doubled again in the first half of the 1990's. Cf. CARLSSON & FRIDH (2002), pp. 200-201.

[148] Cf. AUTM (2007), p. 15.

[149] Cf. SHARMA *et al.* (2006), pp. 110-111.

[150] Cf. SHARMA *et al.* (2006), pp. 110-111; VINIG & RIJSBERGEN (2009), p. 2.

4.2 The Roles for Technology Transfer Offices

4.2.1 Enhancing Faculty Engagement

As shown in section 3.3.2, some faculty may not want to participate in commercialization activities because of social norms and insufficient incentives. One role for a TTO is to therefore persuade faculty to engage in the UITT process.[151]

MACHO-STADLER *et al.* (2007) argue that a university needs to have separate units (i.e. a TTO) to maintain close relationships with researchers in the universities' departments and have incentives available to encourage them to disclose their inventions.[152] The 'Humboldt-Innovation GmbH' (HUI), which is the TTO of HUB, pursues a strategy of explaining their motives to faculty. *"We want to give some ideas by holding 'entrepreneurship seminars', for instance in the department for computer science, in which practitioners with academic background, who kept being common people, report their experiences they made in the business world. (…) and we want to establish promoters inside the departments. That would be professors or post-graduates, who are open for our purposes and who would become technology transfer representatives and carry our ideas into the departments"*[153]. Furthermore, some studies show that some TTO officials try to create licensing contracts that include special, mostly pecuniary incentives for faculty to disclose and to engage in future cooperation with industry.[154]

4.2.2 Assistance in the Commercialization of University-Based Research Results

An individual inventor often lacks the time and resources it takes to commercialize his invention successfully, because this process often requires time and financial investment.[155] A TTO can decrease these opportunity costs of searching for marketing opportunities and potential business partners, as it possesses the required commercial networks and expertise in business development, in contrast to the individual scientist. An important function concerning the support of the commercialization of university-based inventions is the management of university IP (See Figure 5).[156] After collecting invention disclosures from faculty, a TTO can make 'sunk investments' in order to evaluate the quality of the invention and to find appropriate

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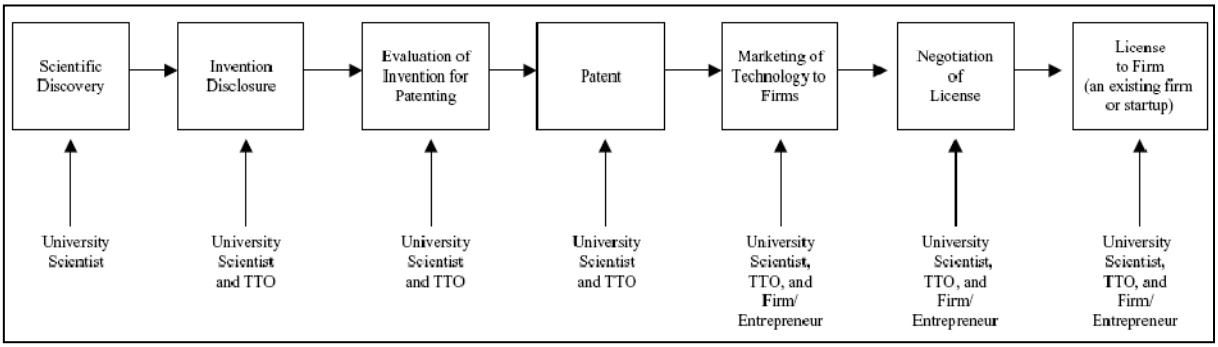
[151] Cf. THURSBY & THURSBY (2002), p. 93.
[152] Cf. MACHO-STADLER *et al.* (2007), p. 484.
[153] EI 4.
[154] Cf. for instance JENSEN *et al.* (2003); THURSBY *et al.* (2001).
[155] Cf. for this and in the following MACHO-STADLER *et al.* (2007), p. 486.
[156] Cf. MACHO-STADLER *et al.* (2007), p. 502.

Figure 5: University technology commercialization process.



Source: SIEGEL *et al.* (2004).

licensees, which the individual researcher probably could not afford.[157] At the same time, a patent application for inventions can be relatively expensive and as universities have limited budgets for these expenditures. Hence, TTOs may evaluate the market potential and decide whether to seek a less costly domestic patent protection or rather a stronger, but more expensive global patent protection. After a patent is filed, the TTO can assist or even individually manage negotiations about licensing agreements with interested business partners.

A further aspect of supporting the commercialization of university-based IP is providing help in the search for external funding, especially for spin-off activities. A TTO's access to important commercial networks of venture capitalists, investment bankers, and patent attorneys is therefore of significant importance.[158] In addition, a TTO may provide assistance in the development of business plans, market assessment, and coaching in crucial business skills for prospect entrepreneurs.

The HUI uses an approach to acquire funding for spin-offs by collaborating with a London-based investment bank. Together, they created the so-called 'Humboldt-fund' of about €50 Million. "*We use this in order to bridge funding gaps. We send concepts for potential spin-offs to the bank and their analysts decide if something is interesting for them. If something looks convincing to them, the money flows. This thing is brand new, and there is no precedence case I know of*"[159].

4.2.3 Reduce Informational Barriers

A TTO can develop means to enhance the flow of information between academia and industry on the one hand and can solve the 'asymmetric information problem' described in section

[157] SIEGEL *et al.* (2007), p. 645.
[158] SHARMA *et al.* (2006), p. 109.
[159] EI 4.

3.3.3, based on its ability to make 'sunk investments' and sort promising from not promising inventions, on the other hand.[160] Basically, the aim of creating a dedicated TTO is to establish and to cherish links between a university and industry.[161] This function, which is also referred to as a 'boundary-spanning' function, includes scanning the external environment for new markets that bare potential commercialization opportunities and to make contact to relevant representatives of the business world.[162] It furthermore includes the transmission of the needs and interests of industry to the university scientists, and vice versa, and can eventually end up in building relationships and networks between these two stakeholders of UITT.[163] In order to enhance the flow of information from academia to business and vice versa, TTOs have come up with different tools. Face-to-face contact can be facilitated through several means, such as the arrangement of showcase and information events, through which researchers and entrepreneurs can get in touch with each other. For instance, the HUI plans to create a 'spin-off café', where scientists and entrepreneurs have the ability to meet, and which would have *"(…) the infrastructure and the atmosphere to push spin-offs forward"*[164].

Furthermore, modern information technology is helpful for connecting university research groups to interested firms. UNC's TTO, for instance, runs a newsletter, which firms can subscribe to in order to receive information about invention disclosures in a science field of their interest.[165] The TTO of HUB, in turn, has set up an online platform, which research groups can use in order to document the progress of their current research projects and which is accessible for companies interested in the specific technology.[166]

Furthermore, MACHO-STADLER *et al*. (2007) develop a model, in which a TTO can decrease the 'asymmetric information problem' by shelving disclosed inventions of minor quality and only offering inventions with a guaranteed minimum quality to potential licensees.[167] Thus, the licensees' perception of invention quality offered by the TTO rises gradually with every successful transaction. In addition, the university's general reputation for quality increases. However, the ability of TTOs to pool inventions from several laboratories and sort out the promising ones from the less promising ones is dependent on the overall innovative activity of the parent university. A certain stream of invention disclosures is needed in order to have

[160] Cf. for instance HOPPE & OZDENOREN (2005); MACHO-STADLER *et al*. (2007).
[161] Cf. JONES-EVANS *et al.* (1999), p. 50.
[162] Cf. SIEGEL *et al.* (2004), p. 121.
[163] Cf. SIEGEL *et al.* (2004), p. 121.
[164] EI 4.
[165] See Appendix 2.
[166] See Appendix 3.
[167] Cf. for this and in the follwing MACHO-STADLER *et al*. (2007), p. 487.

enough cases to build a reputation for quality. The authors conclude that a TTO's strategy of shelving some inventions leads to fewer but more valuable licenses.[168]

4.2.4 Role of an 'Institutional Entrepreneur'

JAIN & GEORGE (2007) discuss another role for TTOs, which goes beyond commercialization activities like patenting, licensing, or spin-off creation.[169] They observe the potential of a TTO to actively shape the characteristics of the institutional environment that influences the development and commercialization of new technologies. By influencing the rules, norms, and attitudes related to a technology, a TTO could build legitimacy for its successful development and social and financial exploitation. In their specific study, the authors examined the Wisconsin Alumni Research Foundation (WARF)[170] and its role for the support of human embryonic stem cell technology. Through active lobbying, negotiating, litigating, self-regulating, and educating other actors, WARF was able to help set the legal and political stage for further progress in this scientific field in the US.[171]

For the HUI, is seems to be a concern to influence the IP policy of HUB. *"We are trying to make the university run all technology transfer related processes with us, as it is paradox, that a professor, who wants to start a spin-off, first has to negotiate a license for his own invention with IPAL*[172]*"*[173]. Furthermore, the European association of technology transfer managers 'ProTon' tries to actively influence the EU-patent system and demands discounts regarding costs for public research institutions.[174]

4.3 Challenges for Technology Transfer Offices

4.3.1 Organization and Structure of the Technology Transfer Office

How a TTO's structure and organization is shaped, seems to have an influence on its productivity.[175] BERCOVITZ *et al.* (2001) take a look at the organizational structure of the TTOs of DUKE University, Johns Hopkins University, and Pennsylvania State University. They diffe-

[168] Cf. MACHO-STADLER *et al*. (2007), p. 502.
[169] Cf. for this and in the following JAINS & GEORGE (2007).
[170] WARF can be seen as the TTO of the University of Wisconsin-Madison.
[171] Cf. JAINS & GEORGE (2007), p. 555.
[172] IPAL (Innovation, Patents, Licenses) is the central patent agency for all major research universities in Berlin.
[173] EI 4.
[174] PROTON (2007).
[175] Cf. for instance BERCOVITZ *et al*. (2001), BERCOVITZ & FELDMAN (2006), SIEGEL *et al*. (2007).

rentiate between four forms of organizational structure[176] and find certain evidence, that the organizational form of a TTO generally influences its transaction output, its ability to coordinate licensing and sponsored research activities and its incentive alignment capability in a rather predictable manner.[177] However, in order to draw more tangible conclusions, the authors suggest more research in this regard. SIEGEL *et al*. (2004) suggest that a TTO's organizational structure should aim to foster good relationships between scientists and entrepreneurs in order to make UITT more effective.[178] Furthermore, previous studies showed furthermore that a TTO's degree of financial independence from the parent university influences its choice between licensing and taking equity in a spin-off.[179]

In practice, manifold reasons seem to influence the organizational structure of a TTO. While the 'Office of Technology Development' at UNC is an entity inside the university system, the TTO at HUB is structured as a limited company owned by the university. *"In 2004, an EU judgment regarding turnover tax was pronounced. (...) Now contract research is liable to turnover tax. That's why it is advantageous to found a limited company in order to obtain tax related benefits for the university"*[180].

4.3.2 Staffing

The staffing of TTOs seems to be another challenge for its managers. The size of a TTO differs across universities. While almost one third of the TTOs at US universities have three or fewer employees, another 34% have 7 to 14 staff members.[181] In a study by HERTZFELD *et al.* (2006), firms report that they face certain difficulties in dealing with TTO staff because they encounter missing experience, business knowledge and a tendency to over-evaluate patents during licensing negotiations.[182] This negative experience may in turn lead to an opportunistic behavior of firms, who might want to bypass the TTO and contract directly with the scientist.[183]

Although there seems to have been little research about staffing practices of TTO managers yet, SIEGEL *et al*. (2003) observed that TTOs started to hire employees with both scientific

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[176] BERCOVITZ *et al*. (2001) differentiate between the functional or unitary form (U-Form), the multidivisional form (M-form), the holding company (H-form), and the matrix form (MX-form).
[177] Cf. for this and in the following BERCOVITZ *et al.* (2001), p. 32.
[178] Cf. SIEGEL *et al*. (2004), p.121.
[179] Cf. for instance BERCOVITZ *et al*. (2001); FELDMAN *et al.* (2002).
[180] EI 4.
[181] Cf. AUTM (200), p. 18.
[182] Cf. HERTZFELD *et al*. (2006), pp. 833-835.
[183] Cf. HERTZFELD *et al*. (2006), p. 834; BERCOVITZ & FELDMAN (2006), p. 182.

and business backgrounds in order to build a competent and complementary staff.[184] It furthermore seems like TTOs are creating jobs that are more and more specialized. *"We would like to hire someone, who would just concentrate on the intensive start-up work so that the others could do more technology sourcing and early stage work with faculty. As I look at our peer institutions, I see that many of them are creating functional areas. They hire start-up specialists, have a communication specialist, and one person who does only the marketing work for every invention, prepares posters, advertises on websites and so on"*[185]. SIEGEL *et al.* (2007) found, that another challenge related to TTO staffing seems to be the relatively high turnover of TTO employees, which inhibits the rise of long-term relationship with firms.[186]

4.3.3 Funding

Funding is an important factor for the productivity of TTOs. While smaller universities may even lack the resources for implementing a TTO at all, many established TTOs complain about insufficient monetary resources.[187] Insufficient funding may lead to a decrease of patenting university IP, as the protection of inventions is tied to certain patenting costs. TTOs in turn have to invest more time and labor resources into evaluating inventions in regard to their patentability what may slow down the commercialization process. SIEGEL *et al.* (2003) found, that more than half of all interviewed TTO managers see insufficient monetary resources as an inhibiting factor to their work.[188]

It looks like insufficient funding is a chronic problem for TTOs. *"I worked in three TTOs and always when you approve budget to hire more people and do more patenting, the level of demand rises and fills out the new capacities very quickly, so you always operate stressed"*[189].

4.3.4 Technology Characteristics

The stage and the nature of a potential to-commercialize technology influences the way it is handled by a TTO and thus its marketing potential.[190] In order to create a successful Spin-Off, the invention, which the company is going to be formed around, usually has to be a significant

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[184] SIEGEL *et al.* (2003), p. 45.
[185] EI 2.
[186] SIEGEL *et al.* (2007), pp. 647-648.
[187] Cf. for this and in the following JONES-EVANS *et al.* (1999), p. 53; MACHO-STADLER *et al.* (2005), p. 484; SIEGEL *et al.* (2003), p. 44.
[188] Cf. SIEGEL *et al.* (2003), p. 41.
[189] EI 2.
[190] Cf. MARKMAN *et al.* (2005), p. 242.

breakthrough or serve an obvious market need.[191] In a study at Stanford University and the University of California System, MOWERY *et al.* (2001) found, that six years after disclosure, only about 20% of the disclosures had been patented.[192] This may be caused by insufficient resources for applying for patent protection, as described above, but also relates to a technology's characteristics. *"Some of the inventions are so early that the best thing we can do is help the inventor find more research funding. Others are kind of ready to go and are almost licensed the minute we see them. Most of them are somewhere in between"*[193].

4.3.5 Measuring the productivity of Technology Transfer Offices

One of the most important challenges for TTOs seems to be a lack of comprehensive metrics for evaluating a TTO's productivity. Scholars in the field of UITT seem to have not entirely agreed upon what the most justifiable metrics for measuring the productivity and overall 'success' of a TTO might be.

However, in the literature, about two thirds of all studies focusing on a TTO's productivity use quantitative regression methods, mostly taking into account quantifiable outputs like the number of patent filings and licensing agreements, or the amount of equity positions and revenues for the university.[194] Other indicators, such as the number of invention disclosures or the number of sponsored research agreements facilitated through a TTO, are also accepted to be applicable indicators for the successful mediation of UITT. These and similar quantifiable indicators are typically put into 'input/output' ratios and are subsequently compared to a 'best-practice frontier', which derives from benchmarking observations at TTOs.[195]

The depicted benchmarking approach seems to be at least partially questionable. Universities with a high-end output regarding spin-off creation, patenting, and licensing may benefit from certain prerequisites that allow for more effective UITT, regardless of a TTOs supportive work. Predominant US-institutions around Boston and the San Francisco Bay area, for instance, possess an environment of readily available venture capital as well as a strong labor-pool of scientist and engineers. These factors alone are probably leading to the occurrence of measurable UITT even without taking into account a TTO's assistance.[196] "*Stanford sits in a 10-mile radius to 40% of the nation's venture capital. The Massachusetts Institute of Tech-*

[191] Cf. BRAY & LEE (2000), p. 388.
[192] Cf. MOWERY *et al.* (2002), p. 82.
[193] EI 2.
[194] Cf. for this and in the following ROTHAERMEL *et al.* (2007), p. 705.
[195] Cf. SIEGEL *et al.* (2007), p. 645.
[196] Cf. SIEGEL *et al.* (2004), p.122.

nology the other 40%. (…) in contrast, the University of Gainesville in Florida is very isolated. There is no venture capital within 500 miles. The TTO manager there takes faculty to venture capital conferences literally in the whole US, because they will not come to him. He should not be measured by the same metrics. (…) So you really need to look at the environment (…)"[197]. The problem of measuring the impact of support institutions regarding knowledge-based economic development is critical, as GRILICHES (1990) already states that "the dream of getting hold of an output indicator of inventive activity is one of the strong motivating forces for economic research in this area"[198].

Some scholars question the value of sheer quantitative measures for the productivity of a TTO in general. CARLSSON & FRIDH (2002) for instance demand that the goals of a TTO have to be broader than just maximizing income and have to be integrated with the entire mission of the university, namely knowledge dissemination for the benefit of society.[199] GOEGHAGEN & PONTIKAKIS (2008) furthermore demand, that performance measures for TTOs should not simply be based on narrow metrics, but should also take into account more nuanced outcomes of university technology transfer, such as industrial training opportunities for researchers, the creation of latent expert networks, or the concurrent build-up of local capabilities.[200]

Another aspect that might have to be considered is that the image of a TTO may be influenced by the way its productivity is measured. A TTO, evaluated by the above mentioned quantifiable measures may strive to maximize its output in terms of emitting numerous licensing agreements and collecting as much revenue as possible. Hence, the TTO may be perceived as 'greedy' in the view of traditional-minded faculty, who may see themselves confirmed in a possible UITT-critical mindset. *"One of the critical questions is, whether a TTO manager has a long-term or rather short-term thinking. (…) the image of a TTO certainly influences faculty participation"*[201]. In order to improve the public information on UITT activities, AUTM recently launched the 'Better World Project'.[202] This project consists of an internet platform, which is used to publish successful UITT projects that were facilitated through TTOs at US-universities. *"(…) It was a wonderful way to begin emphasizing outcomes and impacts different than just on how many patents or how many royalties are generated. (…)"*[203].

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[197] EI 2.
[198] GRILICHES (1990), p. 1669.
[199] Cf. CARLSSON & FRIDH (2002), p. 201.
[200] Cf. GOEGHEGAN & PONTIKAKIS (2008), p. 469.
[201] EI 1.
[202] See Appendix 4.
[203] EI 2.

4.4 Other Examples for University-Based Technology Transfer Intermediation

4.4.1 Proof-of-Concept Centers

GULBRANSON & AUDRETSCH (2008) examine the functioning of the so-called 'Proof-of-Concept Center' (PCC), using the examples of the 'Deshpande Center' at MIT and the 'Von Liebig Center' at the University of California at San Diego (UCSD).[204] Both centers, which were founded at their parent university in 2001 and 2002 respectively, focus on supporting university spin-off formation by providing seed funding to selected research projects and offering other crucial supportive services. One of the basic elements at both centers is the precedent evaluation of research groups, where a panel of experts with scientific and business backgrounds chooses potential projects worth funding and supporting. The annually 10-16 chosen projects at each university are in turn funded with seed capital ranging from $15,000 to $75,000 at UCSD and $50,000 up to $250,000 at MIT. Furthermore, a commercialization plan is set up with the help of the centers' advisory staff, who possess expertise in technical disciplines and connections to local companies and further sources of funding. The commercialization plans include several milestones that have to be taken in order to receive the maximal amount of funding, and after one year of support, the research groups have to report their progress. In addition to the support of the actual research project, educational programs are offered to the involved students and faculty, in order to prepare them for the challenges of a potential entrepreneurial work environment. Eventually, the centers arrange networking parties and annual showcase events, where the supported projects are shown to venture capitalists, entrepreneurs, and peer researchers in order to connect the respective projects to potential business and scientific partners for an aspired spin-off formation. According to the authors of the study, evaluating the performance of the centers is still difficult. Given the relatively short existence and the fact that there are no accepted benchmarks of peer institutions, it is difficult to measure aspects such as how much faster a particular invention is marketed or how much the involved students' tendency to pursue a business career has increased. However, there seem to be certain indicators for success at both centers, as "(…) a well defined organizational structure that provides capital, guidance, and contacts to university innovators (…) provides customizable support for researchers and fills an early-stage funding gap"[205]. By combined spending about $10 million in grants, the centers helped to establish 26 spin-offs that in turn

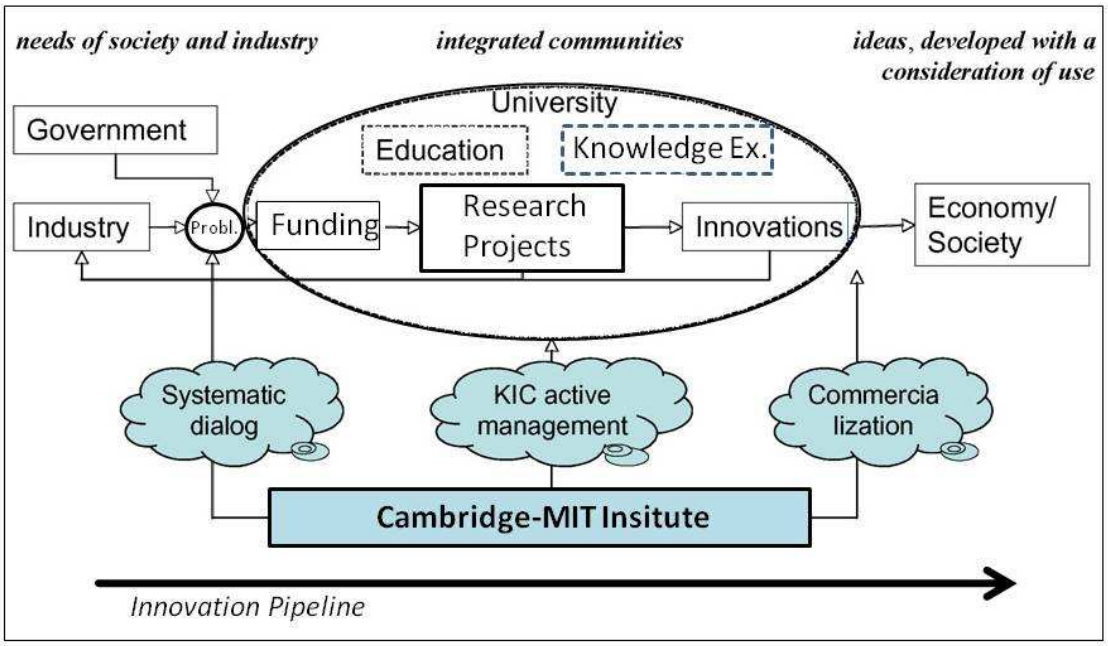
[204] Cf. for thins and in the following GULBRANSON & AUDRETSCH (2008), pp. 249-257;
[205] Cf. GULBRANSON & AUDRETSCH (2008), pp. 255-256.

accumulated $159 million in capital until 2007. It has to be taken into account that both centers are located at excellent research universities in existing networks of angel investors and venture capitalists. GULBRANSON & AUDRETSCH (2008) conclude that the set up of PCCs is likely to be successful at universities with a certain output of innovative and marketable technology and whose policies are open to collaboration with external scientific and business networks and groups. In addition, the question of funding for PCCs arises, as both case-examples were founded by private multi-million Dollar donations while a publicly funded PCC may be imaginable as well.

4.4.2 The 'Knowledge Integration Community'

The English Cambridge-MIT Institute (CMI), founded in 2000, established an experimental concept of multidirectional knowledge exchange in the form of their so-called 'Knowledge Integration Community'-projects (KICs).[206] This approach not only focuses on the transfer of knowledge from a university to industry, but also tries to establish linkages in a wider context between the four spheres of research, education, industry, and government in order to jointly identify, and find soluti ons to common problems. Basic components of the projects are the representatives of research universities, education, industry, and government who engage in collective knowledge exchange. Figure 6 clarifies the processes inside a KCI and shows the

Figure 6: Schema of the 'Knowledge Integration Community'.



Source: Based on ACWORTH (2008).

[206] Cf. for this and in the following ACWORTH (2008), p. 1242-1254.

relations between the spheres of industry, government, education, and research. Basically, a KIC is set up after a research proposal regarding problems to society and industry, jointly developed by the four stakeholder groups, is presented for evaluation. The selected projects are awarded funding by the CMI and are furthermore organizationally led by a KIC Manager who coordinates the KIC's various activities and maintains its focus on knowledge exchange, which is facilitated by annual and semi-annual workshops for all stakeholder groups, personal exchanges, internet-websites, e-newsletters, video-conferencing, and the like. Multidisciplinary university researchers, in turn, lead the research project and ought to place strong emphasis on the consideration of usability. Additionally, strong industry participation is desired in order to ensure input of practical needs of industry and to establish a network of effective university-industry relationships. In a KIC, any industry sectors, even future ones, can be involved and are represented by all sizes and types of businesses, from SMEs to large corporations or even an entire industry or economical sector. Hence, the governmental sphere is interested in obtaining 'lessons learned' concerning the effective transfer of knowledge and indentifying ways to engage with public and private organizations in order to foster economic development. Furthermore, regional and federal administrations can help to improve the political, legal, and regulatory framework for the respective field of research, influencing the success of different projects, especially those operating at the frontier of science. The educational sphere of KICs is served by offering undergraduate and post-graduate degree programs at the university that have a strong practical component and which are related to the different supported research projects. In summary, the CMI prefers many-sided knowledge exchange, rather than its mere transfer, at the heart of its mission and highlights its multidirectional characteristics.

5 Conclusion

This paper examined the main mechanisms of university-industry technology transfer and the barriers that impede the successful commercialization of university-based intellectual property. In addition, the particular potentials and barriers for Technology Transfer Offices, which are created to foster regional economic development by intermediating the knowledge and technology transfer process between universities and private businesses, were examined.

Among the most effective channels for UITT seem to be contract research, the licensing of university-based intellectual property, and the hiring of graduate students. Also and foremost, the formation of spin-off companies seems to be a very promising tool for transforming uni-

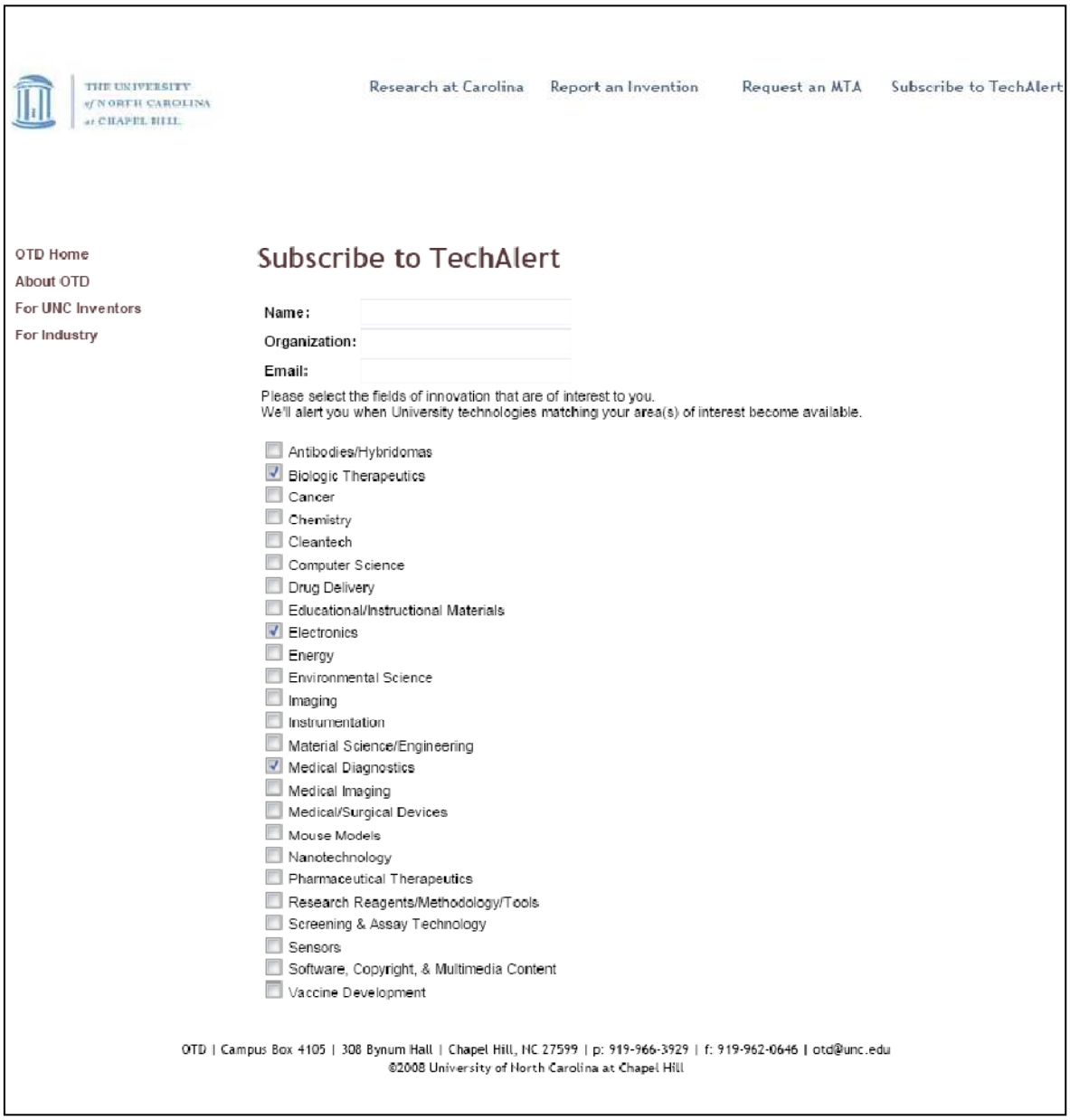
versity-based technology into regional economic development. In turn, the major barriers for UITT seem to be of an institutional, informational, organizational, cultural, and environmental nature. Especially insufficient federal IP regulations, differing cultures in academia and business, and an insufficient flow of information between university researchers and industry seem to be major barriers to UITT. In this context, a TTO can function as an intermediate and fulfill several functions in order to take down some of these impeding barriers. The assistance in the commercialization of university-based intellectual property through the negotiation of licensing agreements and the support of spin-off formation seems to be one of the major roles for a TTO. Further functions include bridging the realms of academia and business by installing communication platforms, and the general persuasion of faculty to engage in commercialization activities. However, TTOs often have to struggle with challenges related to their organizational structure, staffing, and funding. Furthermore, the lack of means to measure a TTO's productivity and the related mistrust of faculty towards commercial activity seem to be major challenges.

In summary, the creation of a TTO at a university seems to be an effective means for enhancing the commercialization of academic research results and for boosting regional economic development. At the same time, it seems to be a major challenge for TTOs to balance the interests of faculty and industry. While private companies seek exclusive licenses and a certain profitability of a transferred technology, some faculty still see the primary mission of a university in disseminating knowledge for the betterment of mankind in general. Therefore, taking down biases and mistrust between academia and business seems to be one of the major focal points for TTOs in order to further enhance the UITT process. Further research is especially needed on how the productivity of a TTO might be evaluated in a more comprehensive way, taking into account the motives and goals of all stakeholders that are involved in the UITT process. It is only when both academic researchers and representatives of industry have a common interest in the development of UITT that it will be facilitated more successfully.

Appendix 1: Interviewed Experts.

Expert Interview 1	**Mrs. Prof. Dr. Maryann Feldman** *SK Heninger Distinguished Chair for Public Policy at the University of North Carolina at Chapel Hill* November 18, 2008, Chapel Hill, NC.
Expert Interview 2	**Mr. Marc Crowell** *Chief Executive Officer of the Office of Technology Development at the University of North Carolina at Chapel Hill / Former president of the Association of University Technology Managers (AUTM)* November 20, 2008, Chapel Hill, NC.
Expert Interview 3	**Mr. Dwight Bassett** *Officer for Economic Development of the Town of Chapel Hill* December 12, 2008, Chapel Hill, NC
Expert Interview 4	**Mr. Martin Mahn** *Authorized Officer of Humboldt-Innovation GmbH* January 26, 2009, Berlin

Appendix 2: E-Newsletter subscription form of the Office for Technology Development at UNC.



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- [ ] Medical Imaging
- [ ] Medical/Surgical Devices
- [ ] Mouse Models
- [ ] Nanotechnology
- [ ] Pharmaceutical Therapeutics
- [ ] Research Reagents/Methodology/Tools
- [ ] Screening & Assay Technology
- [ ] Sensors
- [ ] Software, Copyright, & Multimedia Content
- [ ] Vaccine Development

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Source: http://www.research.unc.edu/otd/subscribe_to_tech_alert.php

Appendix 3: Online platform for research groups at HUB (Example: research group of Prof. Dr. Hecht, Ph.D., Department of Chemistry).

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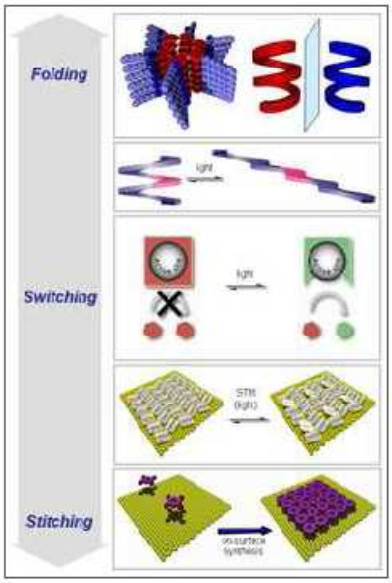
Organic synthesis enables the precise generation of functional molecular building blocks and constitutes the basis of chemical approaches that our group is developing to address various aspects of materials science. We are convinced that the design of custom-tailored molecular nano-objects and their integration into functional nanosized structures will be key to the future bottom-up fabrication of miniaturized devices and the creation of new responsive "smart" materials. Our work is primarily focused on the synthesis of (macro)molecules with defined shape and function. Complementing our synthetic efforts, we investigate structure-property relationships of the resulting materials on both the single molecule and the ensemble levels in solution and in the bulk as well as at interfaces.

WHAT WE DO



Currently our main efforts are directed towards:

- Designing functional foldamers, in particular hollow as well as responsive helically folding oligomers and polymers for the design of organic nanotubes and sensing applications.
- Developing photoresponsive (switchable and triggerable) catalyst and transport systems for signal amplification, controlled release, and smart materials/surfaces.
- Controlling conformation, self-assembly, and chemical reactivity (switching and covalent bond formation) of individual molecules on

NEWS

June-July 2009
Matthew Golder (University of Rochester, New York) just joined the group over the summer as a DAAD-RISE student.

June 2009
Marie has just been selected to receive a prestigious *Kekulé Doctoral Fellowship* of the Fonds der Chemischer Industrie - Corgratulations!

May 2009
The collaborative research center SFB 658 "Molecular Switches at Surfaces" will be funded for a 2nd period of four years - this is good news and motivation as there is certainly plenty of work ahead.

February 2009
In collaboration with the groups of Dr. Leonhard Grill (Dept. Phys., FU Berlin) and Prof. Christian Joachim (CEMES-CNRS, Toulouse) we were able to exploit our recently developed on-surface polymerization methodology to prepare long defect-free polyfluorene wires and charge transport was measured through a single wire continuously as a function of its length. The publication just appeared in *Science*

January 2009
Our joint efforts with the group of Prof. Paolo Samori (ISIS Strasbourg) to utilize conformational changes in "clickates" induced by changes in pH or metal ion coordination to switch 2D self-assembly at the liquid-solid interface are described in a recent communicaton in *Chemistry A European Journal*.

Source: http://www.hechtlab.de/

Appendix 4: Homepage of the 'Better World Project'.

Source: http://www.betterworldproject.org/

References

Acworth, E. B. (2008): University-Industry Engagement: The Formation of the Knowledge Integration Community (KIC) Model at the Cambridge-MIT Institute. In: *Research Policy*, Vol. 37, No. 8, pp. 1241-1254.

Aldrich, H. E.; Baker, T. (1997): Blinded by the Cities? Has there been Progress in Entrepreneurship Research? In: Sexton, D. L.; Smilor, R. W. (eds.): *Entrepreneurship 2000*. Upstart Publishing, Chicago, pp. 377-400.

Association of University Technology Managers (AUTM) (2007): AUTM Licensing Activity Survey Fiscal Year 2007. AUTM, Deerfield.

Aydalot, P. (ed.) (1986): Milieux Innovateurs en Europe. GREMI, Paris.

Bercovitz, J; Feldman, M.; Feller, I.; Burton, R. (2001): Organizational Structure as a Determinant of Academic Patent and Licensing Behavior: An Exploratory Study of Duke, Johns Hopkins, and Pennsylvania State Universities. In: *Journal of Technology Transfer*, Vol. 26, No.1-2, pp. 21-35.

Bercovitz, J.; Feldman, M. (2006): Entrepreneurial Universities and Technology Transfer: A Conceptual Framework for Understanding Knowledge-Based Economic Development. In: *Journal of Technology Transfer*, Vol. 31, No. 1, pp. 175-188.

Braczyk, H.-J.; Cooke, P.; Heidenreich, M. (eds.) (1998): Regional Innovation Systems: The Role of Governance in a Globalised World. UCL, London.

Bray, M. J.; Lee, J. N. (2000): University Revenues from Technology Transfer: Licensing Fees vs. Equity Positions. In: *Journal of Business Venturing*, Vol. 15, No. 5-6, pp. 385-392.

Bremer, H. W. (1999): University Technology Transfer Evolution and Revolution. Working Paper. http://www.cogr.edu/docs/Bremerarticle.htm (last access: September 01, 2009)

Brennenraedts, R.; Bekkers, R.; Verspagen, B. (2006): The Different Channels of University-Industry Knowledge Transfer: Empirical Evidence from Biomedical Engineering. Working paper. Eindhoven.

Camagni, R. (1991): Introduction: From the Local ‚Milieu' to Innovation through Cooperation Networks. In: Camagni, R. (ed.): *Innovation Networks: Spatial Perspectives.* John Wiley & Sons, London.

Carlsson, B.; Fridh, A. C. (2002): Technology Transfer in the United States Universities: A Survey and Statistical Analysis. In: *Journal of Evolutionary Economics,* Vol. 12, No. 1-2, pp. 199-232.

Clarke, B. R. (1998): Creating Entrepreneurial Universities: Organizational Pathways of Transformation. IAU Press, New York.

Cohen, W. M.; Levinthal, D. A. (1989): Innovation and Learning: The Two Faces of R&D. In: *The Economic Journal,* Vol. 99, No. 397, pp. 569-596.

Cooke, P.; Gomez Uranga, M.; Etxebarria, G. (1991): Regional Systems of Innovation: Organisational Dimensions. In: *Research Policy,* Vol. 26, No. 4-5, pp. 475-491.

Debackere, K.; Veugelers, R. (2005): The Role of Academic Transfer Organizations in Improving Industry Science Links. In: *Research Policy,* Vol. 34, No. 3, pp. 321-342.

Decter, M.; Bennett, D.; Leseure, M. (2007): University to Business Technology Transfer – UK and USA Comparisons. In: *Technovation,* Vol. 27, No. 3, pp. 145-155.

Dougherty, D. J. (1992): Interpretive Barriers to Successful Product Innovation in Large Firms. In: *Organization Science,* Vol. 3, No. 2, pp. 179-203.

Egeln, J.; Gottschalk, S.; Rammer, C.; Spielkamp, A. (2002): Public Research Spin-offs in Germany - Summary Report. Working paper, Mannheim.

Etzkowitz, H.; Leydesdorff, L. (1999): The Future Location of Research and Technology Transfer. In: *Journal of Technology Transfer,* Vol. 24, No. 2-3, pp. 111-123.

Etzkowitz, H.; Webster, A.; Gebhardt, C.; Terra, B. R. C. (2000): The Future of the University and the University of the Future: Evolution of Ivory Tower to Entrepreneurial Paradigm. In: *Research Policy,* Vol. 29, No.2, pp. 313-330.

European Commission (2000): Presidency Conclusions of the Lisbon European Council. http://europa.eu/scadplus/glossary/lisbon_strategy_en.htm (last access: August 07, 2009).

European Commission (2006): Putting Knowledge into Practice: A Broad-Based Innovation Strategy for the EU. European Commission, Brussels.

European Commission (2008): Science, Technology and Innovation in Europe – 2008 Edition. Office for Official Publications of the European Communities, Luxembourg.

European Patent Office (2009a): Law. http://www.epo.org/patents/law.html (last access: September 23, 2009)

European Patent Office (2009b): Rich in intellectual property: The economic importance of patents. http://www.epo.org/topics/innovation-and-economy/economic-impact_de.html. (last access: September 23, 2009).

Feldman, M.; Feller, I.; Bercovitz, J.; Burton, R. (2001): Understanding Evolving University-Industry Relationships. In: Feldman, M.; Link, A. (ed.): *Innovation Policy in the Knowledge-Based Economy.* Kluwer Academic Publishers, Boston/Dordrecht/London, pp. 171-188.

Feldman, M.; Feller, I.; Bercovitz, J.; Burton, R. (2002): Equity and the Technology Transfer Strategies of American Research Universities. In: *Management Science*, Vol. 48, No. 1, pp. 105-121.

Feldman, M.; Gertler, M.; Wolfe, D. (2006): University Technology Transfer and National Systems of Innovation: Introduction to the Special Issue of Industry and Innovation. In: *Industry and Innovation,* Vol. 13, No. 4, pp. 359-370.

Florida, R. (1995): Toward the Learning Region. In: *Futures*, Vol. 27, No. 5, pp. 527-536.

Franz, P.; Rosenfeld, M. T. W.; Roth, D. (2002): Was bringt die Wissenschaft für die Wirtschaft in einer Region? Empirische Ergebnisse zu den Nachfrageeffekten und Hypothesen über mögliche Angebotseffekte der Wissenschaftseinrichtungen in der Region Halle. Working paper. Halle.

Franz, P. (2004): Innovative Milieus in Ostdeutschen Stadtregionen: „Sticky Places" der Kreativen Klasse? In: Matthiesen, U. (ed.)*: Stadtregion und Wissen. Analysen und Plädoyers für eine wissensbasierte Stadtpolitik.* VS Verlag für Sozialwissenschaften, Wiesbaden, pp. 109-122.

Freeman, C. (1987): Technology Policy and Economic Performance: Lessons from Japan. Pinter, London.

Fritsch, M.; Koschatzky, K.; Schätzl, L.; Sternberg, R. (1998): Regionale Innovationspotentiale und innovative Netzwerke. In: *Raumforschung und Raumordnung,* Vol. 56, No. 4, pp. 243-252.

Fritsch, M.; Steigenberger, N. (2007): Hochschulen, Innovation, Region. Wissenstransfer im räumlichen Kontext. Edition Sigma, Berlin.

Geiger, R. L. (1993): Research and Relevant Knowledge: American Research Universities since World War II. Oxford University Press, New York.

Goeghegan, W.; Pontikakis, D. (2008): From Ivory Tower to Factory Floor? How Universities are changing to the meet the Needs of Industry. In: *Science and Public Policy,* Vol. 35, No. 7, pp. 462-474.

Griliches, Z. (1990): Patent Statistics as Economic Indicators: A Survey. In: *Journal of Economic Literature,* Vol. 28, No. 4, pp. 1661-1707.

Gross, C. M. (2009): Technology Transfer: Opportunities and Outlook in a challenging Economy. In: *Journal of Technology Transfer,* Vol. 34, No. 1, pp. 118-120.

Gulbranson, C. A.; Audretsch, D. B. (2008): Proof of Concept Centers: Accelerating the Commercialization of University Innovation. In: *Journal of Technology Transfer,* Vol. 33, No. 3, pp. 249-258.

Hagen, M. (2006): Wissenstransfer aus Universitäten als Impulsfaktor regionaler Entwicklung. Ein institutionenökonomischer Ansatz am Beispiel der Universität Bayreuth. Dissertation, Bayreuth.

Hertzfeld, H. R.; Link, A. N.; Vonortas, N. S. (2006): Intellectual Property Protection Mechanisms in Research Partnerships. In: *Research Policy,* Vol. 35, No. 6, pp. 825-838.

Hoppe, C. H.; Ozdenoren, E. (2005): Intermediation in Innovation. In: *International Journal of Industrial Organization,* Vol. 23, No. 5-6, pp. 483-503.

Jain, S.; George, G. (2007): Technology Transfer Offices as Institutional Entrepreneurs: The Case of Wisconsin Alumni Research Foundation and Human Embryonic Stem Cells. In: *Industrial and Corporate Change,* Vol. 16, No. 4, pp. 535-567.

Jensen, R. A.; Thursby, J. G.; Thursby, M. C. (2003): Disclosure and Licensing of University Inventions: 'The Best we can do with the S**T we got to work with?'. In: *International Journal of Industrial Organization*, Vol. 29, No. 9, pp. 1271-1300.

Jones-Evans, D.; Klofsten, M., Andersson, E.; Pandya, D. (1999): Creating a Bridge between University and Industry in Small European Countries: The Role of the Industrial Liaison Office. In: *R&D Management*, Vol. 29, No. 1, pp. 47-56.

Kodama, T. (2008): The Role of Intermediation and Absorptive Capacity in Facilitating University-Industry Linkages – An Empirical Study of TAMA in Japan. In: *Research Policy*, Vol. 37, No. 8, pp. 1224-1240.

Krätke, S. (2004): Kreatives Wissen in stadtregionaler Perspektive. Medienwirtschaft im Metropolenraum Berlin. In: Matthiesen, U. (ed.): *Stadtregion und Wissen. Analysen und Plädoyers für eine wissensbasierte Stadtpolitik.* VS Verlag für Sozialwissenschaften, Wiesbaden, pp. 93-107.

Krugman, P. (1991): Geography and Trade. MIT Press, Cambridge/ Mass.

Krugman, P. (1998): What's new about the 'New Economic Geography'? In: *Oxford Review of Economic Policy*, Vol. 14, No. 2, pp. 7-17.

Kulke, E. (2008): Wirtschaftsgeographie. Schöningh, Paderborn.

Link, A. N.; Siegel, D. S. (2005): Generating Science-based Growth: An Econometric Analysis of the Impact of Organizational Incentives on University–Industry Technology Transfer. In: *European Journal of Finance*, Vol. 11, No. 3, pp. 169–82.

Lundvall, B.-A. (ed.) (1992): National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter, London.

Macho-Stadler, I.; Pérez-Castrillo, D.; Veugelers, R. (2007): Licensing of University Inventions: The Role of a Technology Transfer Office. In: *International Journal of Industrial Organization*, Vol. 25, No. 5, pp. 483-510.

Markman, G. D.; Phan, P. H.; Balkin, D. B.; Gianiodis, P. T. (2005): Entrepreneurship and University-Based Technology Transfer. In: *Journal of Business Venturing*, Vol. 20, No. 2, pp. 241-263.

Maskus, K. E. (1997): The International Regulation of Intellectual Property. Working Paper, Nottingham.

Meissner, D.; Sultanian, E. (2007): Wissens- und Technologietransfer – Grundlagen und Diskussion von Studien und Beispielen. Center for Science and Technology Studies, Bern.

Morgan, K. (1997): The Learning Region: Institutions, Innovation and Regional Renewal. In: *Regional Studies*, Vol. 31, No. 5, pp. 491-503.

Mowery, D.C.; Rosenberg, N . (1989): Technology and the Pursuit of Economic Growth. Cambridge University Press, Cambridge.

Mowery, D. C.; Sampat, B. N.; Ziedonis, A. A. (2002): Learning to Patent: Institutional Experience, Learning, and the Characteristics of U.S. University Patents After the Bayh-Dole Act, 1981-1992. In: *Management Science*, Vol. 48, No. 1, pp. 73-89.

Nelson, R. R. (ed.) (1993): National Systems of Innovation: A Comparative Study. Oxford University Press, Oxford.

Nelson, R. R. (2001): Observations on the Post-Bayh-Dole Rise of Patenting at American Universities. In: *Journal of Technology Transfer*, Vol. 26, No. 1-2, pp. 13-19.

Organisation for Economic Co-operation and Development (OECD) (ed.) (2006): What is changing in Academic Research? Trends and Futures Scenarios. OECD Publishing, Paris.

O'Shea, R.; Chugh, H.; Allen, T. (2007): Determinants and Consequences of University Spinoff Activity: A Conceptual Framework. In: *Journal of Technology Transfer*, Vol. 33, No. 6, pp. 653-666.

Pike, A.; Rodriguez-Pose, A.; Tomaney, J. (2007): What Kind of Local and Regional Development and for Whom? In: *Regional Studies*, Vol. 49, No. 9, pp. 1253-126.

Polanyi, M. (1966): The Tacit Dimension. Doubleday, New York.

Powell, W. W.; Grodal, S. (2005): Networks of Innovators. In: Fagerberg, J.; Mowery, D. C.; Nelson, R. R. (eds.): *The Oxford Handbook of Innovation*. Oxford University Press, New York, pp. 56-85.

ProTon (2006): Examples of Good Practice. http://www.protoneurope.org/ExamplesofGoodPractice. (last access: August 13, 2009).

ProTon (2007): ProTon Europe recommends improvements to the Patent System in Europe in order to facilitate Knowledge Transfer from Public Research. http://www.protoneurope.org/Files/PatentPolicyStatement/attachment_download/file (last access: September 18, 2009)

Rafferty, M. (2008): The Bayh-Dole Act and University Research and Development. In: *Research Policy*, Vol. 37, No. 1, pp. 29-40.

Research Councils UK (2006): Knowledge Transfer in the Eight Research Councils. Independent External Challenge Report to Research Councils UK. http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/documents/exchallenge.pdf (last access: September 01, 2009).

Rothaermel, F. T.; Agung, S. D.; Jiang, L. (2007): University Entrepreneurship: A Taxonomy of the Literature. In: *Industrial and Corporate Change*, Vol. 16, No. 4, pp. 691-791.

Schätzl, L. (2003): Wirtschaftsgeographie 1: Theorie. Schöningh, Paderborn.

Scott, A. J. (2000): Economic Geography – The Great Half Century. In: Clark, G. L.; Feldman, M. P.; Gertler, M. S. (eds.): *The Oxford Handbook of Economic Geography*. Oxford University Press, New York, pp. 18-44.

Sharma, M.; Kumar, U.; Lalande, L. (2006): Role of University Technology Transfer Offices in University Technology Commercialization: Case Study of the Carleton University Foundry Program. In: *Journal of Services Research*, Vol. 6, Special Issue July 2006, pp.109-139.

Siegel, D. S.; Waldman, D. A.; Link, A. N. (2003): Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study. In: *Research Policy*, Vol. 32, No. 1, pp. 27-48.

Siegel, D. S.; Waldman, D. A.; Atwater, L. A.; Link, A. N. (2004): Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies. In: *Journal of Engineering Technology Management*, Vol. 21, No.1-2, pp. 115-142.

Siegel, D. S.; Veugelers, R.; Wright, M. (2007): Technology Transfer Offices and Commercialization of University Intellectual Property: Performance and Policy Implications. In: *Oxford Review of Economic Policy*, Vol. 23, No. 4, pp. 640-660.

Stephan, P. E.; Levin, S. G. (1992): Striking the Mother Lode in Science: The Importance of Age, Place and Time. Oxford University Press, New York.

Thursby, J. G.; Jensen, R. A.; Thursby, M. C. (2001): Objectives, Characteristics and Outcomes of University Licensing: A Survey of major U.S. Universities. In: *Journal of Technology Transfer*, Vol. 26, No. 1-2, pp. 59-70.

Thursby, J. G.; Thursby, M. C. (2002): Who is selling the Ivory Tower? Sources of Growth in University Licensing. In: *Management Science*, Vol. 48, No. 1, pp. 90-104.

Tornatzky, L.; Fleischer, M.; Gray, D. O. (1998): Knowledge and Technology Transfer in Cooperative Research Settings. In: Gray, D. O.; Walters, G. S. (eds.): *Managing the Industry - University Cooperative Research Center: A Guide for Directors and other Stakeholders*. Battelle Press, Columbus, OH, pp. 217–240.

Troeger-Weiß, G.; Wagner, N. (2006): Wissensbasierte Regionalentwicklung. Diskussion der Bedeutung außeruniversitärer Forschungseinrichtungen für den Transfer von Wissen und Technologie in kleine und mittlere Unternehmen. Das Beispiel des Fraunhofer Instituts für Experimentelles Software Engineering in Kaiserslautern. Fraunhofer IESE, Kaiserslautern.

United States Patent and Trademark Office (2009): Policy & Law. http://www.uspto.gov/main/policy.htm. (last access: October 09, 2009)

Universität Duisburg-Essen (2005): Patent- und Verwertungsstrategie der Universität Duisburg-Essen. Duisburg. http://www.uni-due.de/imperia/md/content/fft/transfer/patente/patent_und_verwertungsstrategie.pdf. (last access: August 13, 2009).

Verspagen, B. (2005): Innovation and Economic Growth. In: Fagerberg, J.; Mowery, D. C.; Nelson, R. R. (eds.): *The Oxford Handbook of Innovation*. Oxford University Press, New York, pp. 487-513.

Vinig, T.; Van Rijsbergen, P. (2009): Determinants of University Technology Transfer: Comparative Study of US, Europe and Australian Universities. Working Paper, Amsterdam.

Wright, M.; Clarysse, B.; Lockett, A.; Knockaert, M. (2008): Mid-range Universities' Linkages with Industry: Knowledge Types and the Role of Intermediaries. In: *Research Policy*, Vol. 37, No. 8, pp. 1205-1223.

Youtie, J.; Shapira, P. (2008): Building an Innovation Hub. A Case Study of the Transformation of University Roles in Regional Technological and Economic Development. In: *Research Policy,* Vol. 37, No. 8, pp. 1180-1204.

Zademach, H.-M.; Rimkus, M. (2009): Herausforderung Wissenstransfer in Clustern - Neues Wissen vom Biotechnologiestandort Martinsried. In: *Zeitschrift für betriebswirtschaftliche Forschung,* Vol. 61, No. 6, pp. 416-438.

Zucker, L. G.; Darby, M. R.; Armstrong, J. (2000): University Science, Venture Capital, and the Performance of US Biotechnology Firms. Working paper, Los Angeles.

Erklärung

Ich erkläre hiermit, dass ich diese Bachelorarbeit selbstständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt, nur die angegebenen Quellen benutzt und die den Quellen wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe.

Die Arbeit hat in gleicher oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegen.

Berlin, den _____