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VALUE CREATION IN THE INTERFACE OF INDUSTRY AND ACADEMIA

– A Case Study on the Intellectual Capital of Technology Transfer Offices at US Universities –

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ABSTRACT: This study scrutinizes the impact of value-creating practices in university-industry technology transfer that facilitate the diffusion of knowledge generated in academic research towards its successful application by companies on markets. To be more precise, the aim is to demarcate the role that US university technology transfer offices (TTOs), one of the consequential arrangements conjured into existence by the Bayh-Dole Act of 1980, play in matching the substance of academic research and the need-driven demand of commercial markets. In the process, they implicitly, yet strategically, guarantee the sustainability of the flow of technologies out of the laboratories towards market application, as their actions and motives uphold and sustain the incentive structures of both of the universes, the academic and the commercial. This is accomplished by performing and specializing in the very functions that neither universe has been able or willing to perform in order to take a step closer towards each other. These contributions are often hard to capture in quantitative measures, which has led to common criticism about the effectiveness of TTOs. We propose such measures to be used with care in the comparative evaluation of TTO performance, but also point at and recognize their value as parameters that can be utilized to internally monitor the performance of each TTO individually over time as a tool of management. Some alternative, Intellectual Capital based measures are suggested.

KEYWORDS: University technology transfer; technology transfer office; Intellectual Capital; knowledge management; Bayh-Dole Act; government intervention; value adding functions; Value Platform

> "It is about people. If you lose sight of that, and you think you are dealing with paper, or dealing with words on a computer screen, because everything comes in as an e-mail, you have lost what you need to be focused on. It is about people. The personality of the inventor is important, it has to be managed. The personality of an entrepreneur is a part that has to be managed. The personality of co-workers has to be navigated; all that in order to get something from the lab to the market place. It is going to be people who make it happen, and people are very varied in how they approach things. The people around you, the relationships you have outside, the relationships you have inside. Those are your tools in order to take this fellow's great idea and turn it into that fellow's money-making profit.
> Match-making service is what we provide. We are not the stars, we are not making the inventions, and we are not selling the product. We are the ultimate middlemen. I think the world needs middlemen, because people are complicated creatures. Nothing will get done if everybody is myopically focused on their own "what's-right-in-front-of-me" activities.
> You cannot just focus on one piece. Somebody has to look at the whole, and look at it from the perspective of the public benefit meaning that a discovery will get out of the lab and be more than just a journal article gathering dust on the shelf. I have got to keep my eye on the end goal, and all I have to do is to move the technology ahead like a piece on the chessboard; one move at a time. If it is not moving, I have to ask myself why it is not moving. If it does move, it needs to move towards the end goal. I am the person who has my eye on the entire path. The inventors are worrying about their thing. The entrepreneurs are worrying about their thing. The department has its own angle on things. But somebody has to be there to say how this benefits the public, and how the deal will be done."
>
> *- Assistant Director of a TTO, May 2007 -*

1. Introduction

1.1. Objective – Value Creation in Technology Transfer Offices

This study scrutinizes the impact of value-creating practices in university-industry technology transfer that facilitate the diffusion of knowledge generated in academic research towards its successful application by companies on markets. To be more precise, the aim is to demarcate the role that US university technology transfer offices (TTOs), one of the consequential arrangements conjured into existence by the Bayh-Dole Act of 1980, play in matching the substance of academic research and the need-driven demand of commercial markets.

At the same time, we show how the true boundaries of TTO activities and their impact might be much broader than traditional studies focusing on revenue streams or other purely quantitative measures, such as deal flows or start-up frequencies, have assumed. We find it important to show that, even though much of the impact of TTOs might not necessarily translate into dollars earned by companies, technology transfer efforts of TTOs often benefit mankind in ways that are invaluable in many aspects. Capturing these impacts in future research will be a formidable but necessary challenge when comparing different technology transfer mechanisms.

1.2. Background – A Brief Account of the Bayh-Dole Act

Due to its direct impact on the mandates regarding university technology transfer, it is necessary to review the central stipulations of the Bayh-Dole Act as the major government intervention widely responsible for the emergence of TTOs. However, as the focus of this study will be on the micro-level analysis of the role of TTOs rather than the external impulse that gave reason to establish them in the first place, the Bayh-Dole Act is dealt with only briefly here.

The Bayh-Dole Act, also called the University and Small Business Patent Procedures Act, regulates intellectual property that arises from research funded by the federal government. The act was enacted by the United States Congress in December, 1980, providing US universities, small businesses, and non-profit organizations with the right of ownership to the inventions and other intellectual property resulting from such funding. Prior to the enactment the title belonged to the federal government, the funding agency.

To retain the title, the recipient of federal funding has to meet a set of requirements:

1. The recipient has the obligation to actively promote and facilitate the commercialization of the invention.
2. The recipient has to protect the invention by means of filing for a patent or suitable form of protection.
3. The recipient has to establish a mechanism to compensate the inventor by means of sharing the royalties arising from the application of the invention.
4. The recipient has to prefer the domestic (US) industry and small businesses when promoting the commercialization of the invention.
5. The recipient must claim title to the invention within a certain time.
6. The recipient has to inform the funding agency of inventions disclosed by researchers.
7. The recipient must grant a non-exclusive, irrevocable, non-transferable, paid-up license to practice or have practiced on its behalf throughout the world to the federal government.
8. The recipient has the obligation to utilize the residual proceedings from the commercialization of the invention for education and research.
9. The recipient must not assign the rights to the invention.

In the light of the focus, requirements one through five are especially of interest, as they have given rise to the establishment of technology transfer offices in US universities. The tasks related to fulfilling the requirements necessitate in-depth expertise in a broad set of areas including intellectual property rights, patent legislation, the very substance of science and research, administration and the commercialization of technology including marketing and strategizing. They entail reaching out beyond the boundaries of the university and actively engage in the development of the surrounding economy.

For the traditional administrative organs dealing with the university's conventional affairs the multitude of tasks and the related expertise necessary proved too extensive a burden to handle with conventional resources. There was a need for a designated unit to tackle the obligations imposed by the Bayh-Dole Act and support the university in its extended mandate that now included the commercialization of research. Hence, the TTO was born.

1.3. Limitations – A Word on the Generalizability of Implications

Before proceeding with the actual analysis a few facts must be pointed out relating to the setting in which this study was carried out. First, the results of this study are not general. They are not intended to represent the majority of US TTOs nor a model of the average university technology transfer office. Providing a general description is not the aim of the study. Rather, using a handful of the most successful cases as measured by more traditional and quantitative

measures, the intention is to approximate *the ideal* of a TTO's role in technology transfer as constructed from the underlying cases. This comes inevitably at the cost of statistical significance, because the analysis is more about making sense than making generalizations.

Second, TTOs operate in strongly local environments. Some offices in the sample are embedded in unique environments especially conducive to the transfer of technology. Thus, implications drawn from the results must be understood in their specific environmental contexts and interpreted with care in others. Care has been taken to include necessary environmental aspects in the analysis to facilitate such interpretation.

Finally, it is fully recognize that technology transfer is a complex process in which TTOs play only one of many roles. A TTO is not an isolated instance capable of providing value to the process detached from its systemic environment comprising regional entrepreneurial culture, governmental funding of research, the availability of risk financing, etc. Thus, it is paramount to recognize that the present study is an in-depth analysis of one of the central parts of the process and not of the process in its entirety. It follows that the value created by TTOs cannot be defined by measuring the overall success of technology transfer, as it is not solely attributable to the activities of TTOs alone. Instead, the focus must be on identifying the *added value* that TTOs provide to the process.

The study is structured as follows. The next section presents a brief treatment of the positioning of the analysis in the landscape of existing relevant literature followed by Section 1.5 dealing with the underlying data and methods of the study. Section 1.6 will provide a generic blueprint of the typical transfer process in order to give an initial overview of the tasks performed by the TTO. Then, reverting to Edvinsson and Malone's (1997) Value Platform Model, Section 2 constructs the theoretical framework of the study that will serve as a structural guide and point of reference against which the data and arguments are reflected. Section 3 constitutes the analytical core of the study and incorporates the results of applying the Value Platform Model to the underlying data. Section 4 concludes the study by presenting the implications of the analysis.

1.4. Related readings – A Look at the Body of Knowledge on TTO Activities

As is the case with most of interdisciplinary studies, there is plethora of existing literature from sometimes very distant fields of research among which the particular study must be positioned. In the case of this analysis relevant literature is found in the areas of knowledge management and intellectual capital (IC), on the one hand, and in the area of technology transfer, specifically technology transfer organizations, on the other. While the IC literature is mainly theoretical, the organizational research oriented literature in technology transfer provides a much broader set of empirical studies. As the relevant IC literature will be discussed in detail in conjunction with building the theoretical foundation for the analysis, it will not be mentioned here, and this overview is limited on technology transfer studies only. While the IC literature serves in the theoretical aims it is the technology transfer literature that is of interest thematically. A small selection of studies most central to the discussion of the analysis will be briefly reviewed.

Among many single studies, Chapple *et al.* (2005) analyze UK University TTOs on their performance based on the volume of annual license agreements, invention disclosures, and

total research income. They find that new licensing is positively correlated with the research intensity of regions and the presence of medical schools at the universities. These are results we can corroborate with our own later on. Furthermore, Chapple *et al.* (2005) argue that the size of the TTO, as well as the total research income of the university, affects the performance of the office, a finding that we can also support based on our data.

Siegel, Waldman and Link (2003) assess the relative productivity of US TTOs. In line with the results of this study, they find that the performance is affected by environmental and institutional factors. Based on a qualitative approach Siegel, Waldman and Link (2003) further find that cultural barriers between universities and industry as well as compensation, staffing, and reward practices also explain TTO performance to a certain extent. While their findings on the cultural, environmental, and institutional factors are supported also by our results, we will criticize the efficiency of reward and compensation schemes, as well as those indices of performance based on monetary outcomes or the sheer number of licenses or protected IPR, for example.

Observing 11 case studies of inventions made in universities, Colyvas *et al.* (2002) investigate the roles that patenting and TTOs play in transferring university inventions onto markets. They find that the transfer of embryonic inventions, in particular, benefit greatly from intellectual property protection by the TTO, while in other cases transfer would have occurred anyway. Colyvas *et al.* (2002) also provide evidence of the central significance of TTOs' marketing efforts in cases where links between the academia and the industry are weak. We will expand on the latter finding by showing how marketing efforts are used to establish a bi-directional feed-back loop that conveys information from the markets back to the inventor and *vice versa*.

Markman *et al.* (2005a) analyze which TTO structures and licensing strategies are most favorable to new venture formation, and which of these are correlated with each other. Distinguishing between for-profit TTO structures and not-for-profit structures, they find that for-profit structures are positively correlated with the formation of new ventures while not-for-profit structures relate positively to university business incubators. Similarly licensing-for-equity strategies correlate positively with new venture formation, while sponsored research licensing shows a negative correlation. A licensing-for-cash strategy reveals the least correlation with new venture formation. These results are somewhat at odds with our observations because, among the most successful TTOs, we could find no significant differences in structures or strategies as expressed in their mission statements and the ways they create value. This is possibly due to our rather small sample and the focus on top performing TTOs.

Markman *et al.* (2005b) study commercialization speeds at US universities. They find that the generation of revenue streams and spin-off ventures is positively correlated to the speed with which TTOs are able to commercialize patent-protected technologies. Central determinants of commercialization speed, in turn, include TTO resources and competency, as well as the active participation of the original inventors in the process. Complementing and supporting the findings of Markman *et al.* (2005b), we are able to provide rationales for the above-mentioned relationships. We touch explicitly on the themes of competency, resources, and the participation of inventors by empirically defining the essence of these aspects that is relevant to a TTO's success.

Parallel to Markman *et al.* (2005b), Lockett and Wright (2005) analyze the impact of university resources and capabilities on the formation of spin-out ventures. They find a positive correlation between the number of spin-out companies created and expenditure on IPR protection, business development capabilities of the particular TTOs, and the royalty regime of the university. While we deal with IPR protection only briefly, our analysis will provide rationales for the importance of business related skills in TTOs.

Jensen *et al.* (2003) observe the TTOs' practices in balancing the tensions arising due to clashing objectives of universities and their corresponding faculty. They find that TTOs adhere to the agendas of both parties and, as an agent, try to serve them as principals. As a central result, Jensen *et al.* (2003) show that a faculty's propensity to disclose an invention is dependent on its quality, the equilibrium licensing income, whether projects are sponsored research, and the inventor's rate of time preference. Our analysis provides supporting evidence by showing that TTOs indeed operate under overlapping mandates of different stakeholders. We also provide some evidence of how such mandates can be aligned. Furthermore, we will argue that a faculty's propensity to disclose an invention is greatly affected mainly by two determinants: (i) the inventor's own preferences and motivation towards commercialization and (ii) the reputation of the TTO for being competent and able to show tangible results in advancing the given inventions along the technology transfer continuum.

There is a plethora of research that is similarly relevant from the perspective of our analysis (see, e.g., O'Shea et al., 2005; Lockett et al., 2005; Clarysse et al., 2005; Degroof and Roberts, 2003; Lockett, Wright and Franklin, 2003; Di Gregorio and Shane, 2003) that we are unable to fit within the limited scope of the study. There are at least two excellent review studies that summarize the essence of scientific research on TTO activities. Von Ledebur (2008) reviews studies that pinpoint the differences in the institutional framework between Europe and USA regarding academic patenting and the organizational design of TTOs, while Rothaermel, Agung and Jiang (2007) go through over 170 studies related to university entrepreneurship in broader terms. One of their reviewed fields focuses on the productivity of TTOs.

While the above-cited literature relates to our analysis and supports the findings thereof in many ways, the present study still distinguishes itself in one central aspect from the existing landscape of literature: It is not our focus to evaluate the performance of TTOs and the drivers thereof as such. Rather, it is our intent to show *what* relevant performance is in the first place and *how* it is generated. To this end, we aim to open the "black-box", as to which TTOs are being dealt with in most other studies, and have a micro-micro-level look at the functions it provides. Understanding what TTOs do helps us to shed light on how performance should be defined, and gives us an idea of whether and how such performance can, even if possible, be measured. Only then is it sensible to draw conclusions about the effectiveness of the TTO as an institution and evaluate the government intervention underlying its emergence.

1.5. Data – Interviewing 7 Elite Technology Transfer Offices

The data utilized in the present study are taken from three separate sources between April and October 2007. The most central body of data was acquired by interviewing directors and, when the director was unavailable, high-ranking technology transfer officers at seven prominent university technology transfer offices in the United States of America. All of the included TTOs met the criteria of being among the top 20 US university TTOs when measured by the number of start-ups founded in 2005. Among many other alternative measures of technology transfer

activity[1], the number of start-ups was chosen to identify highly successful offices, because it not only mirrors activity in the TTOs themselves but also reflects the entrepreneurial environment that the offices are embedded in. As already touched on earlier, successful TTOs do not exist in a vacuum and we want to incorporate that aspect in our analyses. Table 1.1 summarizes some of the central indicators commonly used to position TTOs among each other.

Table 1.1 Outcomes of TTOs within interview-based data and AUTM data, year 2004 (AUTM, 2007).

Indicator	Sample	Total	Sample share
Number of university Technology transfer offices	7	164	4 %
Invention disclosures received	1 727	14 396	12 %
New patent applications filed	1 212	9 248	13 %
Licenses and options executed	404	3 870	10 %
Total number of active licenses and options	3 105	22 465	14 %
Licensing income received (million USD)	151	951	16 %

As Table 1.1 reveals, our sample comprises only 4% of all 164 TTOs active at different US Universities in 2004. However, those 4% were extremely efficient in generating codified knowledge as a base for commercial applications: they generated 12% of all invention disclosures and 13% of all new patent applications filed by US universities. The TTOs in the sample were also able to capture 151 million USD, roughly 16%, of the total licensing income received by all TTOs in 2004.

The interviews were conducted employing a semi-structured interview template that allowed the interviewees the freedom to answer in their own local contexts that differed from office to office in several dimensions (private vs. public university, self-sustaining vs. university financed, small vs. large office, multi-campus vs. single campus system, etc.). At the same time the template ensured that all vital aspects of the Value Platform framework were touched upon in sufficient scale and scope.

The second source of data comprised a large quantity of official and publicly distributed electronic and printed material concerning the activities of the interviewed TTOs. The function of this secondary data was, on one hand, to complement the views provided by a single person in each office and, on the other, to verify these persons' views against officially communicated ones.

The third and final source of data consists of the comprehensive AUTM's STATT (Statistics Access for Tech Transfer) database that provided time series data on 21 important variables concerning tech transfer activities in around 160 US TTOs covering a period from 1996 through 2005. The number of reported offices differed from one fiscal year to the other. The quantitative description of the US university tech transfer industry is entirely based on the STATT data.

In the course of the analysis we use direct quotes of interviewees that, for the purposes of obtaining unrestricted and in-depth comments, were promised complete anonymity. Thus, we do not attach references to any of the presented quotes at any point.

[1] In addition to a rather high number of start-ups all but one office participating in the interviews have estimated to report close to 30 million USD for the current fiscal year in royalty income, which places them in the top echelon of US TTOs in royalties. Due to reasons explained in the analytical part of the paper, we did not utilize royalty income streams as a primary selection factor for participants.

1.6. Transfer Process Blueprint – The Flow of TTO Functions in a Nutshell

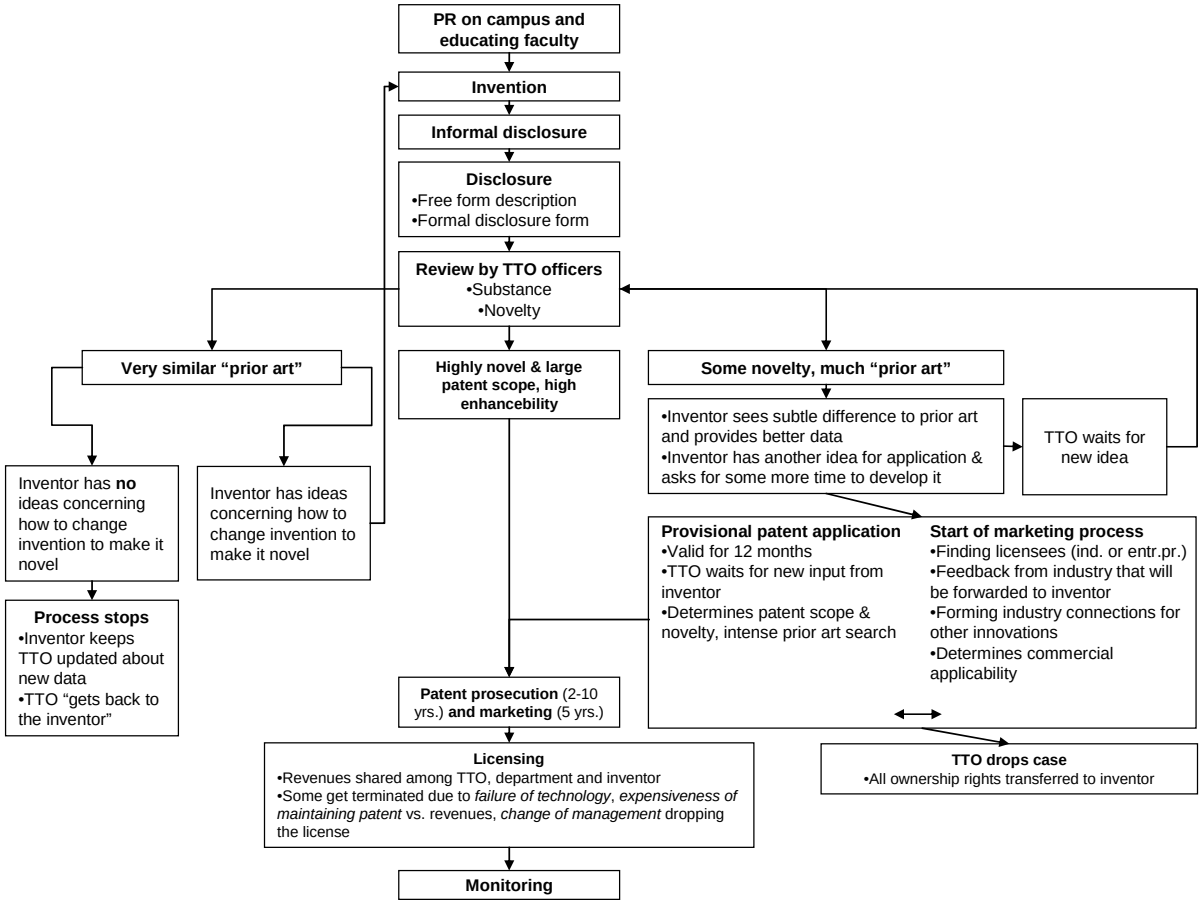

Figure 1.1 Transfer process blueprint

To position the impending analysis of particular singled-out value creating functions of a TTO in the comprehensive flow of the transfer process as a whole, we now quickly go through a structured blueprint of the process (see Figure 1.1) that each invention is bound to navigate beginning at its inception in the laboratory and ending in the hands of a licensee.

The process of technology transfer from the perspective of the TTO begins prior to the emergence of an invention. The office often activates researchers and faculty in issues of commercialization through educational events, personal laboratory visits, expert guest speakers, weekly meetings, etc. raising the propensity of inventors to disclose their achievements and input them into the transfer process by submitting an invention disclosure to the TTO. The first disclosure might be informal and it is pre-reviewed by technology transfer officers. Should the first impression seem promising, a formal disclosure is submitted to the office. It usually comprises a short and concise free-text description of the invention and a standardized form.

The disclosure initiates a rigorous technical and prior art evaluation process at the TTO. With possible help from external patent offices, technology transfer officers search the existing IPRs for potential hurdles in an attempt to determine whether the disclosed invention can be protected through IP protection. At the same time they also evaluate the technical feasibility and the potential impact factor of the invention with the prior art search being the highest

priority at this stage, however. Further action depends on the outcome of the prior art search. Outcomes can be roughly divided into three different scenarios.

First, there might be considerable existing prior art in the field that the invention is supposed to be positioned in. In such an event the inventor is given the opportunity to change major aspects of the invention in an attempt infuse a twist of novelty into it. The re-invented invention is then fed back into the process via a completely new disclosure. Should the inventor have no idea as to how to modify the invention, it is not pursued further. The inventor is free to come back once novel ideas emerge and usually keeps the office up-to-date about the latest data and developments.

Second, in the event of moderate existing prior art and, hence, some novelty inherent in the invention the inventor is asked to show how the invention can be sufficiently distinguished from existing technology. The inventor can provide proof in the form of better and more detailed data, for example, but might also have ideas concerning how to apply the invention in a way different than previously intended. The TTO waits until the inventor has modified the invention, if necessary, and initiates the next phase. This encompasses filing a provisional patent that is valid for 12 months. During that time the inventor is able to make further modifications to the invention and improve it. Simultaneously, the TTO determines the novelty of the technology by heavily intensifying the prior art search and designing the final scope of the impending final patent. Moreover, the TTO initiates an extensive marketing process that serves several vital functions: (i) finding a potential licensee for the up-coming IPR around the invention; (ii) gathering feedback on the commercial potential and applicability of the invention directly from the relevant industry. The feedback is forwarded to the inventor who, then, is able to make the appropriate modifications to the invention in an attempt to adapt it to industry requirements. (iii) Expanding the network of industry connections of the TTO that can be tapped into when marketing future inventions. Often, the inventor is said to be the best source for potential applicants of the invention.

Depending on the outcome of the final prior art search and the industry feedback, the invention is either dropped (often, then, the rights to the invention are transferred to the inventor) or its proper patent prosecution is instigated. The prosecution process can take anywhere from two to ten years after which the invention is protected. Simultaneously, the marketing efforts continue for several years or until the invention is licensed. Once licensing occurs, the ensuing royalties are shared between the inventor, the university department, and the TTO. An active license is monitored by the TTO for agreed milestones (e.g. the invention has to be commercialized within a frame of X years from the date of licensing) and possible patent/license infringements. In time, some licenses might also be terminated by the licensee, because, say, the technology simply fails in the marketplace, the patent maintenance is too expensive relative to generated revenues or for strategic reasons.

Third and lastly, the initial prior art and technical evaluations might indicate that the invention is highly novel, offers a large scope for patenting and is highly upgradable through follow-up inventions. These are the most sought after inventions. In such an event, the TTO initiates full-scale patent prosecution, marketing, and licensing efforts right away omitting the provisional patenting phase.

Before turning to a review of the theoretical backdrop of our analysis, it should be pointed out that the above description of the transfer process blueprint is very general .It does not capture the subtler or more noteworthy differences in practices across the 190+ TTOs currently active in the US. Nor does is go into the details of micro-level tasks accomplished by the office to drive

the process on. These will be the subject of analysis after we have introduced the theoretical framework next.

2. Value Platform – A Theoretical Framework Providing Structure

This section provides the theoretical framework to our analysis. Specifically, we will employ the Value Platform framework as first presented by Saint-Onge *et al*. in Edvinsson and Malone (1997). In addition to serving the central role of underlying theory, it will also determine the structural flow of the analytical part of this study due to its rather concise nature.

To rationalize our application of the Intellectual Capital (IC) and Knowledge Management (KM) based approach on understanding the determinants of success and value creation in technology transfer one has to think about its substance. This necessitates considering what technology is in the first place. As will become apparent in our interviews later on, university technology is only very rarely tangible before it is already licensed to a commercial entity for further development. During the transfer process from the scientific university lab to the commercial realm, technology is transformed from an initially very intangible state of knowledge, existing only in the mind of the inventor, to a slightly more tangible or codified form as written down in a patent or other physical epitome of intellectual property.

Thus, the fundamental task of a TTO is to understand, protect, and sell, or in other words to transfer, *knowledge* created by one party to another. This process, in turn, necessitates a vast array of specific knowledge, relationships, and support structures, as will be depicted in detail in our analysis in Section 3. What is most important to note is that there are very little, if any, tangible assets to be managed in the process. If the paper that contracts are signed on and the computer hardware that databases are maintained in are not deemed central to the process, then the process of university technology transfer leaves no physical trail to be traced. The whole process is about managing knowledge, or intellectual capital, as shall be argued later, inherent in external parties and the TTO itself. Thus, the utilization of the IC framework is a well-argued approach for analyzing the prerequisites of success in university originated technology transfer.

Edvinsson and Malone (1997) discuss the significance of IC to an organization. The essence of the discussion is the ability to give a holistic view on organizational development. Usually, IC is defined as consisting of three components, human, structural, and relational capital. IC provides a framework enabling all of these dimensions to be viewed in relation to each other. Even when two dimensions are very strong, the weak or inadequately managed third dimension of the value platform model presented in Figure 2.1 disrupts the value creation process. According to the model, it is the intersection, or put more tangibly, the dynamic interaction of all three components that forms the basis for value creation (Saint-Onge *et al*. in Edvinsson and Malone 1997). In this study our prime objective is to show what value is in the context of TTOs. Knowledge management can be seen as a force pulling distinctive components into closer interaction with each other maximizing value thereby.

The merit of the IC platform is that three central dimensions of organizational development activities are considered in a single comprehensive framework emphasizing the importance of their balanced interaction (Mouritsen *et al.* 2000).

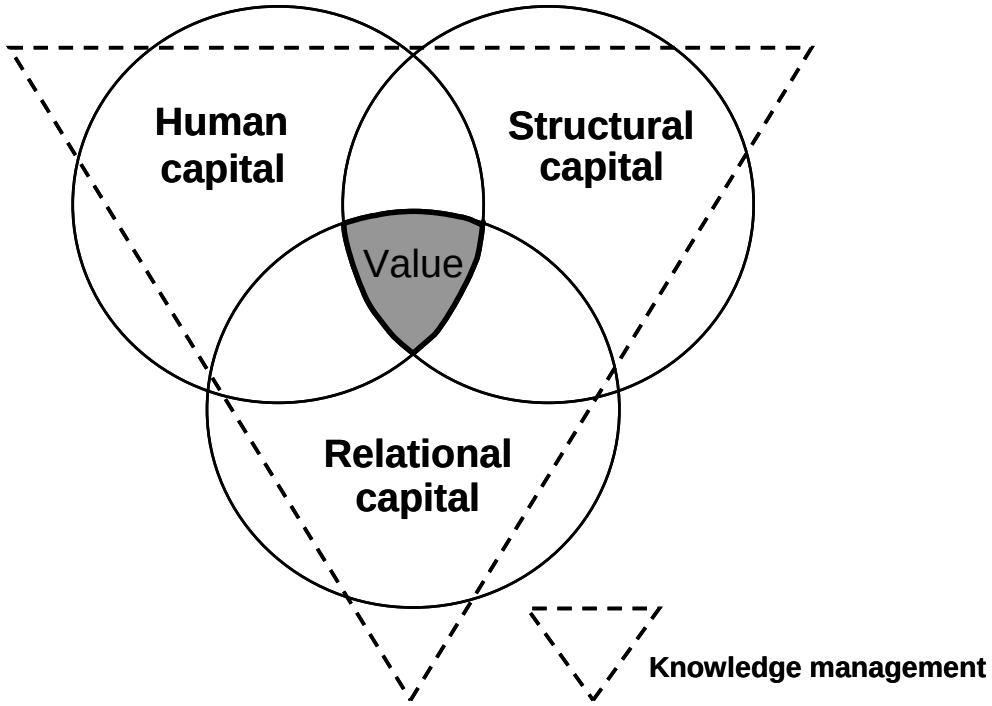

Figure 2.1 The value platform model

In the following we will shortly describe each of the three components forming the concept of IC. For further discussions, see MERITUM project (2002), Bontis (2002), and references therein.

2.1. Human Capital

Human capital is defined as an individual's *knowledge*, *experience*, *capabilities*, *skills*, *creativity,* and *innovativeness* (Edvinsson and Malone 1997). These are interconnected and collectively contribute to success in work (Ranki 1999). Sveiby (1997) uses the concept "*employee competence*", which he defines as the capacity to act in different situations to create both tangible and intangible assets.

The *ability to perceive changes* in the operational environment is also included in human capital (Edvinsson and Malone 1997). This also encompasses learning, which is the development of an individual. It is an *adaptation to a changing environment* or a *potency to change the environment*. These changes require the ability to control immediate work tasks, as well as the ability to improve operations and a readiness to develop even qualitative features of work (Salmenperä et al. 2000). *Attitudes* are related to this readiness, because they show what kind of a stance a person takes towards his or her tasks (Mayo and Lank 1994).

The fact that an organization cannot own its human capital distinguishes this component of IC from other company resources (Edvinsson and Malone 1997). Uncertainty about an employee's commitment to the organization reduces the organization's willingness to make these investments, especially if the required skills are non-specific and transferable (Albert and Bradley 1997). Yet, competent personnel are the key to a company's endeavor to realize and develop its business ideas (Hansson 2001, Sveiby 1990). Investments in personnel are as crucial for knowledge-intensive organizations as a mass producer's investment in tangible assets (Sveiby and Lloyd 1987).

2.2. Structural Capital

Structural capital includes *patents*, *concepts*, *models*, *computer* and *administrative systems*, and *organizational culture* (Sveiby 1997). Edvinsson and Malone (1997) define structural capital as the *context, empowerment of employees, structures supporting human capital, organizational capital*, *innovation capital*, and *process capital*. Empowerment of the employees is based on distributed decision-making and collaborative leadership models, aimed at inducing employees to commit to the organization and its goals. Structures that support human capital include recruiting capabilities, organizational culture, development activities, and motivating strategies. Organizational capital consists of systems and tools, enhancement of knowledge flows and organizational competence. Innovation capital includes an organization's renewal capability, results from innovativeness protected by intellectual property rights, as well as results that can be used to create new products and services and develop them quickly into applications. Process capital is practical knowledge including definitions and improvements of work and production processes (Edvinsson and Malone 1997).

An organization's knowledge base accumulates from numerous daily decisions and experiences. These are stored in *work processes*, *instructions*, *forms*, etc. resulting in organizational learning. Organizational culture can be seen as a consequence of organizational learning as it forms a shared framework for defining and solving problems. Schein (1992) associates organizational culture with leadership and defines them as different sides of the same coin.

According to Edvinsson and Malone (1997) structural capital includes all the *codified knowledge and organizational structures* a company has created utilizing its human capital, or otherwise acquired for the organization. Organizational structure, different documents, databases, and all intellectual property rights (patents, trademarks, copyrights, etc.) are included in structural capital. Unlike human capital, the company owns its structural capital and, therefore, it is also able to sell specific parts of it, such as the databases.

2.3. Relational Capital

The relational capital includes all *external relationships with customers, suppliers,* and the *organization's collaboration networks* (Edvinsson and Malone 1997, Sveiby 1997, Stewart 1998). In the context of a TTO this translates into potential licensees (industry and start-ups), faculty inventors, and collaboration with other parties important to the process of technology transfer. In the traditional knowledge management literature concepts such as *customer capital*, *networking*, and *virtual organizations* have been associated with relational capital.

Customer capital consists of the strength and loyalty of the customer relationship. In our context the customer would be the industry searching for a license or the entrepreneur willing to license a university technology to build a commercial enterprise around it. Such characteristics as *satisfaction*, *durability*, *price-sensitiveness*, and good *financial performance* of long-term customers are related to this category (Edvinsson and Malone 1997). Customer capital can be created by committing the customers to the organization's activities using time and resources. An enduring and trustful relationship between the organization and the customer is the key element. Relationships are judged based on penetration, coverage, and loyalty measured as a customer's probability of continuing the partnership (Stewart 1998).

Even in the context of technology transfer offices, maintaining long-term relationships with existing licensees is valuable in a number of ways.

Even though networking is seen as beneficial to a company, it has multifaceted effects on it. Breaking up a commitment to some relationships and building new ones can result in significant costs. On the other hand, reluctance to accept these costs reduces an organization's mobility in its relationships and may hinder its innovativeness (Håkansson and Ford 2002).
Due to the increasing need for networking, organizational boundaries lose significance. Collaboration leads to cooperative systems, such as virtual organizations lasting at least for a while. Information technology can be used to improve the functioning of the value chain both inside organizations and between them (Salmenperä *et al.* 2000).

3. The Value Creation Logic of Successful TTOs

Next, we discuss the value creation logic of successful US TTOs by showing how the interaction of the IC components described above is managed to add value to the university technology transfer. In doing so, as defined at the beginning, we aim to demarcate the role that US university technology transfer offices (TTOs) play in matching the substance of academic research and the need-driven demand of commercial markets. This, in turn, gives rise to implications of the (indirect) effects that the Bayh-Dole Act left in its wake.

As touched on earlier, success in technology transfer from the university laboratory to its ultimate application on markets of any kind cannot be attributed to the activities of TTOs alone. There are many factors external to the TTO that contribute to the diffusion of technology in society. Local, regional, and international infrastructure, IPR legislature, technology policy agendas and programs, national innovation systems, entrepreneurial culture, availability of risk financing, and the role and mission of universities in society are all major factors affecting technology transfer. To make things even more complex, they might differ significantly from region to region affecting the outcome of the transfer process even if the respective TTOs were identical copies. Thus, we cannot attribute the value created by technology transfer solely to TTOs, nor can we argue that the value created by TTOs is identical across all regions.

In the light of the above claims and our research agenda, we have to narrow our perspective on those aspects of value that *are* attributable to TTO activities. Thus, we must ask ourselves what is the *value added* provided by the offices. What are those unique services that the TTO contributes to the process of technology transfer as a whole and, thereby, furthers its progress? A structured way to approach the matter is to determine first the general mission of TTOs and then, in a second step, to dissect the mission into more tangible value adding services.

3.1. General Mission

In terms of the general mission the participating TTOs provided a rather unanimous definition. According to their views, a university TTO's mission is *to facilitate the transfer of university technology to the public sector and commercial entities, be they existing industry or*

newly formed start-ups, to be developed into products for the benefit of mankind while preserving the university's primary mission of education and research.

While being very comprehensive in nature, the general mission statement lacks the particulars necessary to make inferences about the concrete nature of a TTO's value creating activities. What it provides, however, is a valuable signpost pointing at those domains that need to be scrutinized in more depth to arrive at sufficiently detailed conclusions about a TTO's added value. Concepts like "*to facilitate*", "*for the benefit of mankind*", and "*preserving the university's primary mission*" all represent larger contexts that will be analyzed further for sources of added value.

3.2. TTO as Catalyst and Converter

Figure 3.1 depicts the TTO's role in the transfer process by utilizing the value platform of the IC framework.

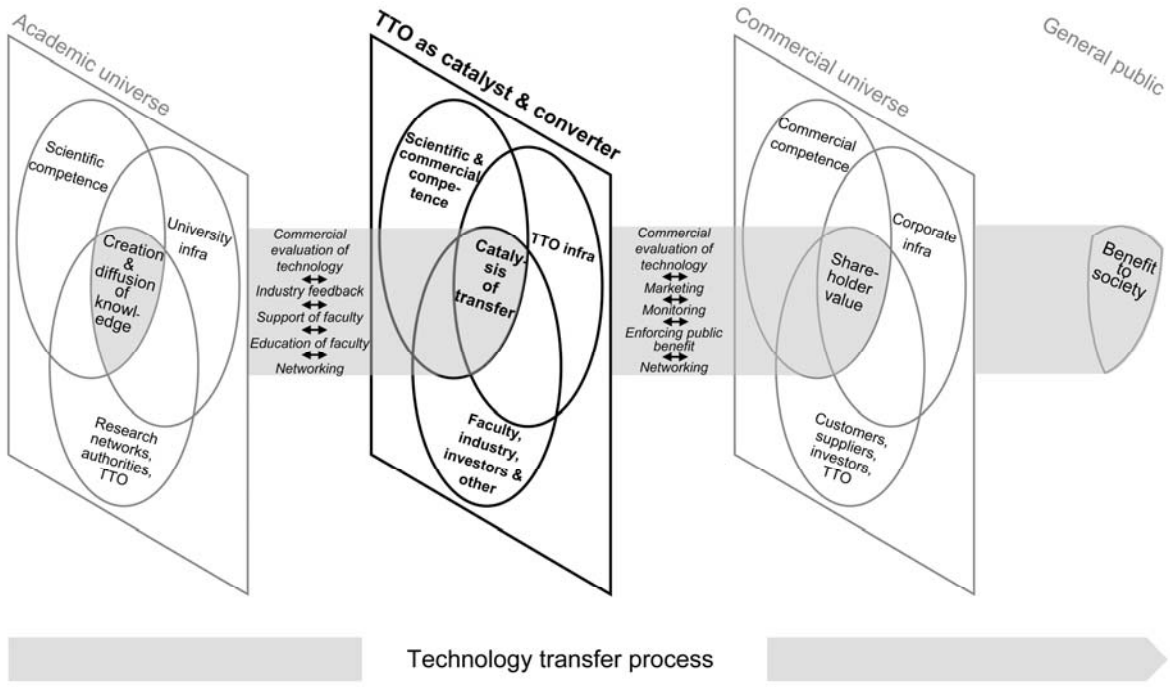

Figure 3.1 The TTO as catalyst and converter in the tech transfer process

The data reveals that the TTO performs many functions that all aim at catalyzing the process by which knowledge created in universities is converted into technological applications. In doing so, the TTO operates between two universes, the academic and the commercial, that are endowed with very distinct configurations of IC. From the perspective of knowledge management, it is these fundamental differences in the configurations, we argue, that in part open up the infamous gap between the academic and commercial universes stalling the transfer of technology. Figure 3.1 shows the rather generic value platform blueprints of the TTO, as well as both the academic and the commercial universes. The light gray beam breaching through each platform signifies the value creation process of the system as a whole, which is driven by the tangible, catalytic functions performed by the TTO in cooperation with

academic and commercial entities. The progress of the process is not to be interpreted as unidirectional or linear. On the contrary, it is a bi-directional link that allows for feedback loops between the academic and commercial universes as facilitated by the TTO.

Comparing the different value propositions that the two universes aim to implement crystallizes the essence of the challenge in bridging the gap. While the academic universe strives for the creation and free diffusion of pure knowledge as the ultimate goal, a commercial entity's priority, be it existing industry or an entrepreneurial start-up, is to provide the highest possible shareholder value to its stakeholders. This is usually achieved by exclusive ownership and strong restrictions on the diffusion of proprietary knowledge. The incentive structures of academics, on the other hand, are set up in a way that promotes the fastest possible publication of breakthrough research in order to further one's career and reap the ultimate academic merit. Simultaneously this spells doom for commercialization attempts of research, because in competitive markets only technology that provides companies with an exclusive edge over others provides the incentives to invest in research and development that will take the emerging technology to final markets.

Therein lays another challenge. The output of academic research is knowledge. Such knowledge is scientific in nature and constitutes merely very early stage technology, as it tends to lack the intention towards a market-driven and need-based application. Even at the licensing stage, university based innovations often are still starkly premature. Jensen and Thursby (1998) found in an empirical study of 62 US research universities that 50% of inventions licensed by their sample universities were only proof of concepts and another fourth were mere lab-scale prototypes. In contrast to academics, commercial entities live off meeting market needs through providing applicable technology. Thus, in order to arouse their interest in licensing a given discovery, companies need to be shown in an understandable and credible manner that the discovery can viably be developed further and reach sufficient market potential to offset the technological risk and investments inherent in such development.

Showing the potential, in turn, necessitates in-depth simultaneous understanding of applied science and markets, a clear vision of how the former can serve the latter. Moreover, it requires the capability of communicating this vision across the boundaries of the academic and commercial universes that are both characterized by strongly differing cultures, languages and mind-sets. From an IC perspective this calls for considerable overlap in at least the *human capital* and *relational capital* dimensions on both sides, which, generalizing to some degree, is rarely given. Slightly caricaturizing an everyday manifestation of the dilemma, the up to 60 slide long technical presentation of the enthusiastic scientist simply does not match the purpose of the typical elevator pitch highlighting success probabilities, return on investment rates, and market shares that investors and licensees are able to digest and require for decision making.

In terms of *relational capital* both universes tend to have fairly detached networks that provide very distinct functions. While the relational capital of academic scientists comprises research networks among fellow scientists and contacts to authorities that affect the freedom to operate in laboratories through legislation, permits, and monitoring, the commercial entity represents a nexus of contacts with customers, suppliers, and investors. Except for industrial sponsored research that is the manifestation of a long-term relationship between industry and a given university laboratory, the commercial and academic universes rarely share common relational capital that could serve as a natural channel to exchange knowledge inherent in human capital, the essence of technology.

All this being said, the value created by the TTO consists of its many functions that either dissipate the gap between the academic and commercial universes or bridge it. In essence, the core of the value created by the TTO is in the conversion of the value created by entities in the academic universe in the form of knowledge into relevant input that is fed into the value creation process of the commercial universe. The ultimate value to commercial entities and, thereby, to society does not accrue before that input is converted into applicable products or services. Below, we briefly go through each of the value adding functions of the TTO that comprise the mechanisms by which the technology transfer is catalyzed and value is converted.

To this end and for the sake of staying within reasonable thematic boundaries, a description of the functions themselves must suffice in order to establish an understanding of a TTO's implemented added value. The detailed analysis of the dynamic interaction of single components of IC is left for further research. There follows an explanation of how, in its capacity as a catalyst and converter, the TTO employs the functions to first decrease the barrier to initiate the transfer of technology on both sides of the value creation continuum depicted in Figure 3.1, and then, in subsequent stages, to sustain the process until the technology in question is diffused in a form or the other in society.

3.2.1. Value Adding Functions in the Interface of the Academic Universe

The academic universe, epitomized by the individual inventor(s) in each particular case, is initially served with catalyzing functions in the form of educational services. These aim to familiarize researchers with the concepts of protecting intellectual property and its fundamental centrality in commercializing results of research, provide guiding information about the supporting services provided by the TTO itself, offer detailed instructions and guidelines on what concrete steps to take if there is interest in commercialization, give first insights into financing entrepreneurial activities and the role of investors in start-up companies, and so forth.

> "[We] educate students and faculty on everything from IP to how you go from just thinking about research questions to how products… how to go from the laboratory to the market."
> - *Director of the TTO of a private university* -

> "We will also host events. Anybody can show up, we will have an attorney who talks about patents, we will serve you pizza and researchers will send their students, and we will do such outreach events. We will do a start-up boot camp every couple of years. We have panels of VCs and attorneys talk about this, again open to the public, anybody can attend, even people outside [the university] can attend, and we hope our faculty are motivated to come to these things. We can lead the horse to water, but it is up to them as to how they want to use their time as a […] researcher."
> - *Assistant Director of the TTO at a public university* -

> "[…] you have to get word out to faculty. Our policy is to say that they are not obligated to disclose to us. If they want to commercialize, then it has to go through us. But if they want to publish it and not look at commercialization routes for their invention they are perfectly able to do it. It is not a simple matter. But you have to get out there to faculty and try to get to department meetings […], so they will listen to you.
> Technology licensing is not often high on their list. The younger people are interested in getting tenure and that involves publications and does not involve licensing. And you also have to make sure that they have confidence in you. Otherwise, if they think you are incompetent, they are not going to give you their technologies, because they are going to think it is a waste of time.

> […] The faculty are like anything else. They are a Gausian distribution. There are those that are very highly interested in the commercial application of their technology, they want to see it out there; they want to get their financial share. We have made several millionaires from faculty. And then there is the other end who are pure academics. They want to do their research and publish and could not care less. I do not think you are going to ever make much of an impact on those that do not really care about it. I think [to] the ones that are highly motivated and are commercially motivated you have to show to them that you are capable of getting the technology [licensed].
> […] I think getting them to disclose is not the issue; showing them that you are savvy and able to license the technology [is]. There is the other zone that you have to get out there and educate them to some degree and try to get them thinking about what you are doing."
> *- Director of the TTO of a public university -*

The aim is to activate researchers and inventors to gain interest in the possibilities of commercialization and encourage disclosing their results to the office by lowering inhibitions attributable to the lack of interest in, knowledge of, and familiarity with these issues. To this end the TTO utilizes its own interdisciplinary human capital (HC) comprising scientific as well as business knowledge and its relational capital (RC) in the form of expertise from law firms, different financial institutions, and entrepreneurs. The knowledge inherent in HC and RC is channeled through the TTO's structural capital (SC) to the faculty. SC relevant to educational functions finds expression in established educational events on campus, regular laboratory rounds and related liaison activity, and business courses arranged jointly with local business schools.

> "In terms of the faculty members we did something: They had a course run by the [local] business school […]. We had an all-day course for faculty members, and they would just go over the whole thing, you know, about patents, mostly about entrepreneurship, about starting companies. We particularly invited those young, very bright, but sort of naïve and who are not really thinking about these things and are more concerned about papers and stuff like that. […] it was a great success. That's probably going to be an on-going thing. […] In physical sciences we meet once a week, […] we sit down and talk about new inventions that have come in. It is mainly marketing oriented. […] so they are very active in meeting with faculty members."
> *- Director of business development at the TTO of a private university -*

Generated value of educational functions is evident in a given faculty's increased propensity to commercialize research and could be measured by the number of disclosures per dollar of federal research funding, for example.

One of the most central functions performed by the TTO is the scientific evaluation of disclosures that are submitted by academic inventors. The evaluation determines a technology's viability to be protected and licensed. Employing their scientific expertise, licensing officers initiate a rigorous prior art search that reflects a particular invention against the existing IPR base in related fields of application.

> "The second thing we would do is an exhaustive search to find out the novelty [of the invention]. If at that stage it proves not to be novel, meaning we have found very, very similar work in public domain, then we will meet with the inventors and bring our findings to their attention and try to understand whether they can come up with ideas to circumvent the prior art. If the inventor agrees: "*Yes, this is prior art I was not familiar with*", and he really has no additional ideas as to how to change the invention to overcome the prior art, then that is the end of the case at that point. It is not novel, we really cannot protect it. […] The next category would be if the prior art search we did finds that there is some aspect of novelty, but there is considerable amount of similar work already published or patented by others that limits the scope of the commercial applicability. Then, too, our findings will be shared with the inventors and [we] try to get additional ideas from them. Sometimes they might say "Oh, but there's a subtle difference here, I can treat my research in this way and get additional or better data",

> which, then, we will wait to get from him. Or he might say that "I have some other ideas for applications, so let me do the research for an additional six months and I'll provide you with that information." In some cases we might wait. In some other cases, depending on how big the scope is, we may file what we call a provisional patent application, and that protects what we have got up until then for twelve months. […] The third category […] is the top category where it looks terrific, the invention looks terrific. It's completely novel and we will definitely pursue it, even though we have not talked to any industry, but it is perfectly novel, we can get reasonably good patent protection and scope, research is ongoing at the inventor's lab, and hopefully whatever we have can be enhanced quite a bit tomorrow. With these, we immediately decide to pursue the patent application or the patent protection, and then we will contact industry […]."
> *- Director of the TTO of a private university -*

Here, in-depth understanding of the given technology is paramount, as the decisive differences from existing and protected technologies, as well as applications thereof, can be minuscule. Again, parts of the entire IC base of the TTO are activated: The scientific knowledge of licensing officers (HC) is complemented by services from external law offices that specialize in IP protection and support in the prior art search (RC). Structural capital (SC) that supports and facilitates the evaluation process is employed in the form of accessible technology databases and regular meetings that facilitate the detection and diffusion of case-relevant knowledge among single licensing officers that then can be designated to matching cases.

> "We get 500 invention disclosures a year. So, that is 10 a week. The receptionist or sometimes […] the office manager [ponders:] "Who do you think should take this case, is it what Tom does. Or is it chemistry, it looks like chemistry. Martin does software, it looks like software", so they get distributed to the people. The clerical people are handing them to the licensing officers. And if it is not obvious, it gets fixed at the Wednesday meeting: "*No,* I *really should have that one, because* I am *working on X*" or "*I don't really know anything about this, it looks like software but it is really biology*". Then you just go round the table with 30 people, if anybody has anything to say they say it […]."
> *- Director of the TTO of a private university -*

The precise positioning of disclosed inventions within the relevant technological landscape enables the evaluation of the inventions' potential to be protected and, ultimately, to serve as a potential base for profitable business. The decision to proceed further with a given innovation is based upon this evaluation. A very limited freedom to operate in the technological dimension can be argued to entail also a limited freedom to operate in the commercial dimension, which lowers the value of an invention. Thus, the positioning of inventions constitutes a central TTO function that adds value to the process of technology transfer as a whole.

Another cornerstone of success in keeping up a steady stream of disclosures from faculty is to provide them with high quality support services in all IPR issues that relate not only to their possible ambitions as entrepreneurs in spin-off companies but to their work in academic research in its entirety. Building and sustaining a reputation of being able to solve problems quickly and reliably in all IPR related problems is key to maintaining long-term relationships with faculty that are the vital origin for emerging technology.

> "Ok, think of us as having two sets of customers. First set is the faculty. And if they are not happy, we never get to deal with the second set. And the second is the external business community. [There are] probably two, three things that keep your faculty happy. […] The first is responsiveness: Answer the phone, respond to the email and do not let them move your office from campus. It is very important that faculty can just walk in here between classes. A number of Nobel laureates have sat on that couch. So, I would absolutely insist on that. […]

> Second, smart people, bright people. The faculty are naturally trained in ten minutes, five minutes to figure out whether you are smart or not, because that is their job. And it makes a big difference even if they start with the assumption that all university administrators are idiots, if in ten minutes they can get their mind changed. So, it is important to have bright people.
> […] And then competence. Let the faculty know that you understand them, get the job done. If there is a delay, it is an intelligent delay. It is kind of like when I went to engineering school here. You might get every single problem set wrong and still get an A, if the mistakes were intelligent. If they were dumb, you got a zero. And it is that kind of… that they are dealing with competence. So, that is probably how we deal with the faculty. We understand that we put the academic priorities first, that we listen to them, that we know what we are doing. And the point comes when they come for your advice, not just to do what they want you to do, you know that you have earned their respect."
> - *Director of the TTO of a private university* -

As their foremost focus and career interests are mainly in academic objectives, the downside of not participating in commercialization efforts is in general rather low among faculty. Thus, should the TTO once suffer a blow to its reputation as a service institution, word spreads out among faculty with speed and devastating effects on disclosure rates. Repairing a once damaged reputation is cumbersome. Services requested by faculty are too numerous and situation specific to be catalogued here exhaustively. For the lesson to be learnt it is not even necessary.

To give a few examples, however, one might list the acquirement of material transfer agreements from third parties, the negotiation of sponsored research agreements in co-operation with the university's contracts office (if it is not merged with the TTO), solving infringement suspicions concerning research conducted by fellow or competing scientists, providing live support in questions concerning commercialization, and "getting the job done" fast and effectively in all cases, in which the faculty is enthusiastically engaged in promoting their research to be commercialized. Here "getting the job done" is to be understood as a reflection of the necessary emphasis on being responsive and closing deals as opposed to one on risk avoidance and detached administrative tasks in the background:

> "It can be anything from the world's most thankless task, which is incoming material transfer agreements:
> "*Get me my material*", they want.
> "*But the company wants some mortgage on your first born*", [we respond].
> "*Get me my material!*"
> "*Are you sure you want to give your first born away?*"
>
> [Other problems can include the following:]
> "*Guess what? I have this company that wants to sponsor my work in this,*" [says the faculty].
> "*Yeah, but your background patent in that is licensed to your company. How are you going to deal with that?*"
>
> It can be:
> "*My grad student thinks he is the inventor and I don't think he is.*"
>
> It can be:
> "*I'll take funding from my company and work in my lab and do such and such…*"
> "*No you can't, here's the conflict of interest rules.*"
>
> I have one now where people were sponsoring research and saying to the researchers:
> "*We want you to do it in this way*", and the researchers were saying:
> "*It won't work that way*." And they are saying:
> "*But we're paying the money*. " And the researchers are saying:
> "*But we are not a job shop*."

> […] Or I can have a professor call me up and say:
> "*This other professor at university X is infringing my work.*"
> "*What does that mean, why do you care? And I can't do anything about it and here's why.*"
>
> Solve problems, basically. Solve them and let the researchers get on with their work. We do not know what is going to happen. But we will figure it out. You cannot imagine all the stuff. You cannot tell what the problems are going to be. You cannot invent what happens."
> - *Director of the TTO of a private university* -
>
> "I think one of the key ways to fail that I have seen too many times, is that you fall into the bureaucratic mindset - you know, "My job is to move this piece of paper." That I think is the ultimate failure of a tech transfer office, whereas the ultimate success is you are a valued member of your local business community. To me those are the two ends of the spectrum. If you are just viewed as a bureaucrat, then forget it - you have failed. If you are invited to serve on panels, people are seeking you out for business opportunities within the university, then I think you have succeeded, and it is all these things working together. In the end it is your reputation, it is your ability to have repeat positive relations with the people who are going to make things happen."
> - *Assistant Director of the TTO at a public university* -

An exhaustive list of every-day services provided to faculty is not even necessary to crystallize the TTO functions' added value to the technology transfer process as a whole. By providing responsive help and support in questions and tasks that are not in the traditional sector of responsibilities and capabilities of faculty, the TTO brands itself as an easy to approach interface between the academia and the commercial world, and, thereby, further lowers the faculty's inertia to initiate and participate in the transfer of technology. Solving concrete problems for faculty is also a very tangible and pro-active contribution to clearing obstacles out of the transfer process's way.

Another value adding set of support services are linked directly to one of the central stipulations of the Bayh-Dole Act. The act requires the university to give preference to small businesses when licensing technology. This has resulted in the active promotion of university spin-off companies, in which the academic inventors are involved to varying degrees. While the TTO does not interfere with running the start-ups as businesses, it often provides valuable services to the inventors in pre-start-up stages. The degree of involvement in helping a start-up get on its feet depends very much on the case, even in our smallish sample. While some TTOs follow a *laissez-faire* strategy and leave issues of business formation entirely in the hands of the inventors or surrogate entrepreneurs, single TTOs representing another extreme may be very actively involved in organizing the establishment of the business by securing financing, constructing a management team, and establishing the organization of the start-up.

> "We do not incorporate the company for [faculty]. We tell them where to go and what people have to sign up and make the payment, and they do it by themselves. In the past, we have had some [business school] students select a few projects from here to write business plans, so they have had some interactions with groups of [business school] students and, of course, entrepreneurs, because our faculty member cannot be the CEO."
> - *Director of the TTO of a private university* -
>
> "We do not formally assist in pulling in the money. We try to make introductions and let things go where they go, because the best people to talk about the start-up are the entrepreneurs themselves. Eventually, I have to license to that start-up, so those people […] will be sitting on the other side of the table when they come to negotiate a license. I want our technologies to succeed, so making an introduction or two will help that, but I cannot get too involved, because, in the end, the start-up is not our property. The patent is our property, and that is what will be licensed to the start-up."
> - *Assistant Director of the TTO of a public university* -

> "Certainly we could put people in contact with VCs and angels, but basically it was none of our business until recently, when we started to put companies together. Then we would do it all, the first couple of steps we would do everything until a VC, an owner, would come along and incorporate. Then the responsibilities would go to that person. But certainly, for start-ups we can […] give them intelligence especially after they form. We know other IP is coming through this office that might be of use to them. […] What we want to do now is to be much more at the front end of the formation of the companies, because we get so much more of the founder's stock. We get a bigger chunk of it, and being of more service to the faculty member, and that has happened in a few instances over the past year, where we have gone to a faculty member and [seen] what the technology looked like, it was a good start-up situation, and so put together a business plan and then went out and sought entrepreneurs and money."
> *- Director of business development at the TTO of a private university -*

More subtle approaches that are closer to the average degree of involvement include support in writing a business plan or in preparing presentations to investors or entrepreneurs interested in taking the commercialization process further.

> "In two or three cases, the faculty member did everything. In almost all the other cases we played a sub-role. The role starts from helping out with making the presentation. This is something we used to do; we have not done it for the last year. We would invite a group of venture guys or angel investors and we would have five or six faculty members lined up. Each one will be making a 20-minute presentation, and those presentations are very focused on what is the significance of the science, what are the applications, where is the market, and the business preference."
> *- Director of the TTO of a private university -*

Preparing business plans and presentations necessitates a conversion of the scientific insights related to an invention into commercially selling concepts, which establishes the TTO as a converter, metaphorically speaking. Moreover, leveraging its ever growing network of diverse actors necessary in commercialization, the TTO actively introduces the inventors to potential partners in finance and management circles in an attempt to bridge the often rather wide distance between the respective networks of the academic and the partner. Bringing the inventor and the necessary partners together is essential, because the TTO cannot replace the inventor as the ultimate expert in the respective technology.

> "And to be honest, it is highly technical work. It is a wide variety of technologies that you deal with. You have to know enough detail to understand the important parts, but you cannot become the technical expert - that is the faculty member."
> *- Assistant Director of the TTO at a public university -*

> "We had some problems with people [TTO staff] with PhD degrees […], because they loved the science, and they are trained to look in great depth in a particular area. We had to let this one person go, because […] they are always over in the lab, learning in great detail about their inventions and science, they want to go to technical conferences to be on the cutting edge of the science and, as I tell our people, as long as you have the active involvement of the inventor, you do not need the depth and technical knowledge. If there are any technical questions, the inventor will respond to them."
> *- Senior Associate of the TTO of a private university -*

Since technology consists much more of the tacit knowledge inherent in the inventor than the respective patent, which basically is merely a paper document assigning rights to the use of the technology, its successful transfer inevitably necessitates the personal interaction of the inventor with those promoting the business at some stage of the process, be it as an active member of the staff or management or in a more passive role on the scientific advisory board. Thus, providing the right connections can be argued to be of great value to the outcome of the transfer. Here again, the TTO earns itself the appellation "catalyst", as it actively initiates a

reaction between two or more “reagents” that self-sustainably continues towards final commercialization.

As the last, but by far not the least, of the value adding services provided to faculty in this non-exhaustive review is the mediation and conversion of feedback from the industry to the inventor. Technology specific feedback collected from the industry in the early phases of marketing efforts is mediated back to the inventor who then can make necessary modifications to the invention. The modifications are presented to the industry again for further comments or closing a final licensing deal. This feedback loop is somewhat at odds with the traditional, linear view of technology diffusion as modeled, for example, by the Schumpeterian invention-innovation-diffusion trilogy (Schumpeter, 1939). Rather, it is evidence of the non-linear nature of the diffusion process.

For the purposes of gathering relevant feedback to a given technology the TTO must be endued with a large and diverse enough base of relational capital. Understanding the feedback and converting it from industry back to the inventor is facilitated again by the TTOs’ strongly inter-disciplinary human capital, as well as supporting structural capital in the form of contact- and cross-related, invention-specific tracking databases. The intrinsic value in this TTO function lies in the facilitation of finding or, better, affecting a match between scientific discoveries and market need based solutions.

3.2.2. Value Adding Functions in the Interface of the Commercial Universe

The commercial universe, epitomized either by individual companies or entrepreneurs looking for a technology to base a business on, is served and cooperated with by a set of functions very different from that provided to the academic universe. Although many of the functions provide output that is fed back towards the academic universe as input (e.g. the industry feedback touched on earlier), they are treated here in a more isolated manner for clarity’s sake and in an attempt to minimize repetition in the flow of the analysis.

Looking from the perspective of any newly emerging technology, marketing related activities are probably among the first that initiate contact towards the industry. While cold-calling potential customers is an indispensable and frequently used method in the attempt to make new contacts, it is not necessarily the most effective or the most popular one among the TTOs interviewed for this study. As a more focused and strategic way of marketing new technologies TTOs lean heavily on their existing relational capital and the contacts that comprise it. Surprisingly, many contacts are provided by the particular inventors.

> “So, as you have probably been told before, it is the actual investigators that have developed and disclosed the technology that are often a major player in building the network and the contact base. Not always, but they are certainly an important factor. They have their own network. That being said, we encourage them to attend conferences, people read their papers, they get contacts… So, often that is the first place you go to ask “Do you know anybody or industries, or fellow researcher that have companies that have an interest in the technology that you are doing?”, because they know the field best.”
> *- Director of the TTO of a public university -*

Established partners within the existing relational capital base of the TTO or the one of the inventor are well known and familiar, which is a valuable asset in finding a compatible customer efficiently for any given technology, as search costs are comparatively lower than in the cold-calling mode. In existing relationships, organizational procedures and guidelines are

also well known, and personal ties have already been formed, which mitigates costs related to setting up functioning communication.

If a suitable and interested customer is not to be found among the relational capital of a TTO, it can be used as an indirect link in the search. All of the actors comprising a TTO's relational capital have relational capital of their own that can be accessed through recommendations and suggestions. Existing TTO customers, for example, know their own industry's other actors fairly well and are able to pinpoint those that might be interested in the particular technology marketed by the TTO. With every new contact forged the relational capital of the TTO grows and can be efficiently leveraged in future.

As already elaborated on above, obtaining feedback that can be channeled back to the inventor also constitutes a major objective of marketing. Each time a contact (RC) provides relevant feedback (HC) of any kind on the marketed technology it is recorded in the case specific tracking database (SC) and forwarded later to the inventor who then can utilize it to modify or develop his invention further. The feedback provides a mechanism that facilitates the matching of scientific endeavors with market needs:

> "The marketing process is not only to find an interested party who will take a license, but also to get feedback from the private sector: "*This is what we have, tell us what advantage you see of this technology, and if you do not see any interest from your company for this technology, do you know others, who may be doing something similar that they might have an interest in?*" It is really to get their feedback as well as to find out if they are interested. Their feedback does not always help us. By that I mean, we always share all the feedback that we gather with the inventors. If the feedback is negative, then many times our inventors do not want to accept it, or do not want to believe it, but in the process, though, inventors may come up with a different way of doing things, or may come up with a different idea that they did not think about before. It helps both parties quite a bit. And because we have this dialogue, we can come back to the same people within the same industries with other ideas, because during this first dialogue they might be saying: "*But in the event you have something along those lines, contact us*". That is how the networking gets expanded, and the feedback we collect is also very useful for our inventors."
> *- Director of the TTO of a private university -*

In summary, one might say that transaction costs in general are lower and the probability of finding a matching customer is higher when existing relational capital is leveraged in the marketing of technologies. Marketing efforts and the maintenance of the feedback loop requires the exploitation of a TTOs entire IC base. The relational capital base serves as a channel through which the TTO can leverage its human capital and bring it to bear efficiently. Again, interdisciplinary human capital fusing scientific and commercial expertise in single individuals is key in identifying potential customers. Identification is based on the evaluation of compatibility of the marketed technology with customers' existing technology bases and the technology's suitability to the customers' business logics.

Thus, the licensing officer responsible for a case has to possess the necessary science- and business-related skills to be able to make such an evaluation. Moreover, the interdisciplinary knowledge is needed to, first, convert the mainly technical specifications of the marketed technology, as provided by the inventor, into marketing jargon emphasizing the business solutions the technology is able to support, and, second, to convert the feedback provided by the market contacts back into technical specifications that the invention would have to meet before a customer is truly interested in licensing it.

> "I need to be able to not become glassy-eyed when I talk to my inventors and they discuss their invention, because it is all going over my head. I need to be able to grasp to the essentials and be able to articulate those to a potential licensee. Otherwise I am not helping my inventor. They are doing much of the work, so I need to be able to save them time that way. I translate the hardcore technical document that the inventor provides. It gives all the details. But it is all the details; it is not a concise, digested presentation of the features and benefits. Can I give an elevator speech, the usual venture capital-style elevator speech, on this technology? I must be able to do that. Technical background helps me do that, especially in a way that does not put additional burden back onto the inventor."
> *- Assistant Director of the TTO at a public university -*

Structural capital in the form of databases keeping track of case specific details in terms of contacts, recommendations, dialogues, requests, demanded specifications, etc. and regular TTO internal meetings through which relevant human capital is allocated to cases supports the marketing functions.

> "And then we have this rather extensive database system that has been carefully evolved over several years that contains… there is a contacts list, I think we have over 5000 people on the contacts list, companies or whatever. […] If you want to go and search for by company or by keyword, technology keyword etc., [you can do that] both for companies and individual contacts. Each docket, each invention has its own file docket, where all the information is inputted, and as I said, that is being made accessible to the inventors, they can check if they have any questions about their invention that what is happening to them."
> *- Senior Associate of the TTO of a private university -*

In terms of value creation, these functions actively contribute to establishing the vital bi-directional bridge to the commercial universe through which technology is diffused, and encourage the active involvement of the industry in the transfer process.

While marketing is an active function aiming at tying the commercial universe to the transfer process, TTO-managed electronic technology databases, also called technology portals, displaying all technologies available for licensing at a given university provide an easy to approach public interface that, while being a more passive mechanism, nevertheless is applied as a major channel in outreach activities by all the offices interviewed. Provided with summarized descriptions and all relevant information, each technology is accessible to the public through the Internet. For companies on the search for new solutions and technological opportunities such an interface is of value, as it decreases search costs significantly. Being a complementary mechanism to marketing, a well-maintained IPR database maximizes the visibility of available technologies and enhances the probability of licensing thereby.

> "There is a database in our central office where a company […] can go in and inquire about technologies, or inquire about research capabilities and enter their interests. […] that inquiry is sent to someone who then will contact researchers working in that area and ask if they are interested in performing research."
> *- Director of the TTO of a public university -*

The interface also provides a number of positive externalities that favorably and indirectly affect the technology transfer. To mention one illuminating example, an exhaustive and easy to access technology portal serves as an indicator for the types of research conducted in the laboratories of the respective university. It is a major facilitator in attracting industrial sponsored research funding to the university, because single research groups are, thereby, easily found and approached by companies looking for academic research alliances.

In establishing and maintaining such a database, employing the IC of a TTO in its entirety is necessary again. In this case, the role of well-functioning structural capital in the form of database structures is emphasized, while interdisciplinary human capital is essential for extracting and converting the essence of each invention into content inserted into and displayed through the databases. Relational capital is implicitly involved, as the whole system is built for the purpose of attracting, serving, and connecting to new and existing partners.

Once marketing as well as other outreach activities have fulfilled their purpose and an interested customer is found, the TTO and the licensee-to-be negotiate a license. At this stage value is added by the TTO mainly by two means.

First, by applying the human capital in the form of experience and skills in negotiating contract terms, on one hand, and utilizing the results of both the scientific and commercial evaluations of the technology to be licensed, on the other, the licensing officer can ensure that the terms of licensing and the entailing compensation paid by the licensee correspond to the real value of the technology with a higher probability, than if negotiations were lead by the original inventor.

In the light of pure economics, one might argue that, in the short-term, licensing negotiations is a zero sum game with the total social benefit being constant independently of its allocation between the licensee, the university, the TTO, and the inventor. In the long run, however, licensing deals unfavorable to the inventors diminish incentives to disclose and participate in commercialization in the first place. Thus, the value inherent in the TTO's negotiation function finds expression not only in a relatively superior influx of royalties, but also more importantly in sustaining the fundamental prerequisite of technology transfer, the constant inflow of new technology from the academic laboratories to the TTO.

> "But you also have to have negotiating skills. You really have to be able to see the other side … it is negotiating that is more like diplomatic negotiation than negotiating the price of a car, because you are going to be living together for a long time. It is not some zero sum game of how much I am paying for a used car There are a lot of things you need, they need, and it is two different cultures that you have to explain to each other. This is why the industrial experience benefits us so much, because we are hiring people who are bilingual in the languages of academia and industry. They have an academic background and they understand how industry thinks. […] They have to feel that even though you are on the university's side and are negotiating for the university's benefit, but that you are fair, that you can creatively solve problems for both sides […]. You do not have to win in a negotiation. But instead see the victory in getting a fair deal done."
> *- Director of the TTO of a private university -*

The second value providing function in the licensing phase of the transfer process has to be reviewed in the light of the TTO's stated mission, which emphasizes the importance of public benefit as the objective of university technology transfer. As will be elaborated on shortly, purely profit maximizing objectives are hard to justify in university technology transfer. They are just one aspect of the entire mission and, as such, are pursued mainly to complement research funding up-holding the universities' academic mission. What was stated as more important, regardless of whether the university in question was public or private, was that the given technology was put to use in society in the first place. Though being a rather broad agenda, making an effort to see a technology developed and diffused entails a number of very concrete measures:

A fair number of these measures is laid down in the form of stipulations for TTOs in a public initiative publication authored and signed already by 12 major US university TTOs: *In the Public Interest: Nine Points to Consider in Licensing University Technology* (available at www.autm.net, last accessed on December 13th, 2007). Among other things, the stipulations prompt TTOs to design license agreements in a way that allows the office to "reserve the right to practice licensed inventions and to allow other non-profit and governmental organizations to do so" (p. 2) so that performing and publishing research related to the field of the invention is not constricted unnecessarily.

Moreover, license agreements that provide the licensee with exclusive rights to an invention are encouraged to include clauses that demand the development and use of the underlying invention by setting milestones to be met or including the obligation to give sublicenses to third parties that aim to fulfill unmet market or public health needs. In general, exclusive rights should be reserved for cases in which "significant investment of time and resources in a technology" are required to develop and widely implement it. Inventions in the area of research tools, in particular, should be kept widely accessible. Again, exclusive licensing is discouraged due to their potential negative impacts on unanticipated uses, further research, future commercialization efforts and markets.

Also the unnecessary licensing of "future improvements" of existing licensed inventions is to be considered carefully in order to avoid tying the inventor's research program to the licensee. This could strongly restrict the inventor's ability to obtain industrial and other research funding and to collaborate with colleagues working for other companies.

According to the stipulations, special attention is to be paid to licensing to "patent aggregators". Aggregators operating according to the "value added" model gather coherent and comprehensive IPR portfolios from multiple sources around single technologies. In doing so, they are in the position to provide themselves or secondary licensees with great freedom to operate. As universities are not able to assemble such portfolios, "value adding" aggregators are argued to "serve an important translational function in the successful development of new technologies and so exert a positive force toward commercialization". In contrast, aggregators operating under the "patent troll" model are the pitfalls to be avoided at all cost. Trolls strive to obtain rights that slash widely across entire technological fields without intending to develop the respective technologies themselves but to strongly limit the freedom to operate of other actors. Under the possession of trolls, technologies and their development are kept inert as they play only a strategic role in the troll's actions. Anyone aspiring to operate in the technological vicinity of a troll is forced to sublicense from it.

A last stipulation reviewed here comprises the inclusion of provisions into agreements that attend to special societal needs such as therapeutic, diagnostic and agricultural needs of the developing world or patient population too small to be of interest to commercial ventures. Basically, these provisions aim at ensuring that these markets have access to relevant technology at low or no cost. As an illustrative example, one of the TTOs interviewed not only donated the rights to one of its therapeutics technologies addressing an orphan population of patients to the respective central association for the underlying disease, but it actually provided financing out of its own proprietary funds to develop a prototype of the therapeutic instrument that was later used in the treatment of the disease.

In a cynical world, in which the "educational industry" has become ever more competitive and incentive driven, one might wonder where the motivation for universities lies to diffuse

technology at all cost. This is a question that this study is unable to answer definitely based on empirical evidence. The Bayh-Dole Act provides only an ambiguous answer, as it only requires the active facilitation of commercialization of inventions and the preference for domestic and small industry, not their diffusion at any cost.

According to our underlying data, it is simply the task of an educational research institution to create and diffuse knowledge as well as to deploy inventions thereof to society with profits and costs not being the priority. But when resources for the primary functions of research and education are limited as they always are, why should universities allocate them to a function that does not necessarily provide any additional resources but might even produce losses? How does a single university's research and education benefit from dissipating its seed if the fruit is enjoyed by others? The question is of special interest in a setting where public and private universities co-exist with each other having different incentive structures.

It is our view and argument that for a university's reputation as well as its impact in the academic world and, thereby, its capability to attract faculty and students of high quality, profits and other monetary indices are rather irrelevant, as they do not convey signals of academic merit or the standard of research and education. Rather, being able to point out the number and, especially, the impact of technologies that have emerged out of a given university make a decisive difference. Take Yahoo! as an illustration. Being conceived by two Stanford University students in their spare time, the company has soared among the most popular brands and services for a great number of years. As the students only used their own resources, Stanford University had no rights to the algorithms used in running the portal. Nonetheless, Yahoo! has benefited Stanford greatly, as the credit for developing the necessary capabilities and the students' entrepreneurial drive are credited to the university and its progressive education.

We argue that breakthrough technologies with impact, not the revenues created by them, are important signals carrying information about a university's standard and quality and provide, thereby, an important edge in the competition for key faculty, students, and a rank among top universities. As stated by one of the interviewees:

> "When I was at school [X], there was a number of potential faculty that were looking at positions at the medical school that actually came in and interviewed the licensing office as part of their own due diligence for accepting a position."
> *- Director of the TTO of a public university -*

Thus, one could argue, universities have also strong internal and strategic incentives to maintain TTO operations with the ultimate goal to diffuse technology as broadly as possible.

As a last value adding TTO function reviewed here, monitoring closed licensing agreements is an essential requirement, as the strength of the protection of IP is equal to the credibility of its prosecution. While clauses included in license agreements for ensuring a fast and broad application of the technology have effect only if met, the prosecution of infringements and non-compliance is still not a straightforward issue. Prosecution is not recommended if no direct benefit is to be expected in the light of furthering the transfer process, because involvement in lawsuits never reflects well on any of the parties involved. Prosecution might do more harm than good in the long run in cases where an infringer is a great contributor of industrial sponsorships to the particular university's research.

> "[…] he had this idea, he said: "[With] *the semi-conductor* [industry] *we are having great difficulties licensing, and companies are very persistent and don't want to have licenses. So why don't we pool our inventions in that area, and then hire a law firm to enforce these patents* […] *and threaten to sue if they don' t* [license]." And I said: "*That's the worst idea I have ever heard in my entire life, because these are companies that are bringing in tens of millions of dollars into the interdisciplinary research center* […]." It is a good example. You need to look at it in the context of the university rather than just the office itself and what is going to get the most money to the office."
> *- Senior Associate of the TTO of a private university -*

Concluding the analysis of the value creating functions of TTOs, three issues have to be addressed before continuing with the brief discussion of monetary indices of value creation.

First, in reality TTOs perform a plethora of functions that add value in many different forms in many different contexts. For the sake of conciseness, the discussion of functions in this section has been limited to those that are the most focal from the perspective of technology transfer. Some examples of functions not elaborated on in this paper include the support that a TTO often provides internally to other university departments, such as procurement or contracts offices in all IPR related issues, or the indirect effect that the sheer presence of a TTO of renown has on a university's ability to recruit better faculty.

> "We have a good relationship with the office of contracts and grants, because it is right upstairs and handles the intake of research. The great proposals go to them, they send them off and they manage the whole proposal and research contract aspect, both with the government, and with the private industry. Those often have intellectual property terms, certain commitments for licensing, and so we get involved with that if they are unusual. We have a good relationship with them, we are support to them.
>
> Similarly for our purchasing department. Purchasing will buy things, let us say they are going to in-license some software. The software maker says: "*Okay, I'm going to give you a 90% discount, but I want some feedback*." If they do not work the description of *feedback* correctly, it could get to the realm of patents and things like that. So, they sometimes pull us in. Not as often as the research contracts folks, but they will pull us in if intellectual properties are an issue with their purchasing agreements.
>
> Another example is if there is a drive by researchers to get a new institute on campus. We are going to pull in some money, set up a new institute. They will pull us in to talk about intellectual property and how that would relate especially to industry sponsors. So internally, yeah, there is a lot of interaction that occurs. We work with the campus Counsel's office quite a bit. In our world litigation occurs. Litigation tends to have a 4 to 5 million dollar price tag. So that is a big impact on the money. So in those types of things the chancellor would be interested, the budget office would be interested, because that is a significant amount of spending."
> *- Assistant Director of the TTO of a public university -*

Yet other positive effects of TTO activities are touched on in the following:

> "The real value that I think we create is the new relationships that result from this activity, from which can come consulting opportunities for faculty, sometimes, or students. Hiring graduating students, sometimes they want to hire their co-inventors in particular. They sometimes provide sponsored research support, or sometimes start-ups and small companies will have the inventors on their boards and scientific advisory boards for which they get some kind of compensation. Sometimes we even see donations [from well-served inventors that have done well in commercialization]."
> *- Senior Associate of the TTO of a private university -*

Second, procedures and ways of working described in this section represented generalizations. Individual TTOs may vary in many aspects in their actions. Those functions in the above treatment that, on a general level, coincided by and large over all interviewed TTOs are included. Thus, deductions should be made with care and awareness of the underlying generalizations.

Lastly, the explicit treatment of IPR protection via patenting, securing copyrights or registering trademarks as a TTO function has been purposefully omitted. This is not to say that it is not of importance as a value creating function of a TTO. On the contrary, it is probably the most central of functions. Without formally and legally securing the rights to an invention there is nothing to transfer. Thus, IPR protection is a prerequisite to any kind of transfer of technology; it is an axiomatic step in the process. Having said this, an in-depth elaboration of IPR protection is unnecessary and does not provide much new insight or contribution. It is a mechanical task. Suffice it to say that the TTOs interviewed for this study, without exception, revert to specialized external law firms in drafting and prosecuting patents and the other forms of IPR protection once the prior art search and the commercial evaluation of the invention approve protection. In doing so, the law firms cooperate with the inventors directly to capture the essence of the invention and the novel aspects thereof.

Before engaging in the discussion of implications, a brief treatment of monetary indices that have served as more traditional measures of value in literature must be added. Monetary indices are the platform, based on which much public and academic criticism has been voiced against the real impacts of the Bayh-Dole Act. In the light of such criticism, the relevance of these indices has emerged as a rather strong discourse from the data, and, thus, they deserve a separate treatment of their own. The omission of monetary measures of added value from the discussion, especially when assessing the impacts of government interventions that are commonly evaluated based on macro-economic, quantitative indices, would leave a void in the coherence of the analysis.

3.3. Measuring Value – Monetary Indicators vs. IC Metrics

3.3.1. The Relevance of Monetary Indicators as Proxies for Value

It is interesting to note that, against the expectations of the layman, in the general mission statements of TTOs income accruing to universities through licensing royalties or equity were never ranked to be a high priority. In some cases generating licensing income was mentioned as one of a number of aims of the TTO in officially published sources such as the offices' Internet sites or promotional print material. In the course of the interviews, however, income generation was systematically de-emphasized in relation to aims treated earlier.

It is surprising at first, because revenue streams are probably the most tangible and quantifiable dimension of value, since they concretely measure the volume and outcome of economic activity in so many other contexts. Ultimately, however, the reasons for not focusing on revenue streams as a measure of created value are manifold and evident:

> "Well, I think the monetary thing is a canard. First of all, statistically you have to get lucky before you make a lot of money. Secondly, most people think that they can play and get lucky. If you could do that, it would be much easier to buy a lottery ticket than to do the kind of work we do. As you look across the country, there are a few universities that have won the lottery

> once in a while and made a significant difference in the fortunes of the university for a while; but not very many. So, there are so many false expectations about the money […]. If you set up an organization with unreachable financial goals, and with the thought that you are going to run it primarily with financial benefit when that is not how it works, everyone is doomed to unhappiness. […] This year the gross income, and people always forget that gross is not net, is going to be high, about $60 million. Almost 40% of it is due to one invention, but at least it is 40%, not 80%, as it is in so many universities that get lucky. And it is continuing royalty income rather than a single piece of equity. So it is nice to have. Gross income, when we pay inventors, pay co-owners, pay expenses and pay for patents, if we calculate what is going to the general fund and the departments together, it will be about 25 million. Which is nice, but […] our budget is over a billion dollars in research; our university is about a 1.3 billion dollar operation, so 25 million is 2%. It is nice, because it is discretionary funds, but it is not going to change the economics of this institution."
> - *Director of the TTO of a private university* -

> "You will see that any office bringing in more than 10 million, 96% to 98% is due to one or two, and the rest of them, collectively, would be the other hundred or two hundred [cumulative] deals […]."
> - *Director of the TTO of a private university* -

> "[…] when we had our venture appreciation party a year or so ago where ventures generating over five million dollars were recognized, there were 12 of them, and we had to confess that out of the 12, six of them we did not think worth anything when they were first disclosed to us. […] That is the problem. Everyone in this office has been through this. Things we said: "*Oh, this is the greatest invention ever, it can't possibly fail. This is really…*" and it has gone nowhere. And there have been other things, we have just shaken our heads and said "*What's this?*" and then it ends up for whatever reason being very significant. It is hard to say. But it is as I said, we need the portfolio, we have over 400 things, anyone of which… let us say 4 of those are over a million [annually] […]. It is just too many unknowns and typically it is a long development cycle, so…"
> - *Senior Associate of the TTO at a private university* -

Pure revenue streams seem to be an unreliable measure of value creation, as the commercial success of a technology is unpredictable before its market introduction. The implication is that creating significant revenues is a numbers game, a matter of "getting lucky". Doing things right does not guarantee commercial success due to the technological and market uncertainties inherent in early stage technologies that universities mostly license. In this respect, revenues do not measure value created by TTOs reliably, because the ultimate commercial success of a certain technology is not necessarily a function of TTO activities but of the commercial potential of the technology itself, its viability on commercial markets and the actions of the entities commercializing it.

Another reason to dismiss revenues as the dominant driver behind TTO actions is the fact that they often pale in significance when set in relation with overall budgets dedicated to research at universities. The contribution to research budgets is marginal, even when annual TTO revenues are among the highest in the country. Thus, maximizing profits by focusing only on those transfer transactions that are expected to reap the highest payoff might compromise the transfer of technologies that could potentially show great social or human impact when put to use. These impacts will be dealt with shortly.

There are still other reasons not to place major importance on revenue streams or other purely quantitative measures as indicators of value creation:

> "You cannot focus too much on revenue for a lot of reasons. A deal that brings in a hundred dollars may be very meaningful to the faculty member who submitted that disclosure and just went through the process. Whereas the home run that is pulling in millions of dollars royalties

> a quarter, that is going to get a lot of attention. But they are the home runs; you cannot always count on them. So, for a well-balanced office you hope for that home run, but if it does not show up, there are a lot of other things you can point at to show that you are a successful office. […] And your top one or two [inventions] are probably going to be 50%-80% [of gross royalty income]. It is a home run game. But, to make the faculty happy, if you only focus on the home runs and only serve the people who might give you those home runs, you are only serving a very small percentage of the faculty, and the rest will be pretty unhappy and the popular perception is then that you are not running a good office."
> *- Assistant Director of the TTO at a public university -*

To run a TTO in a "well-balanced" way a revenue generating license constitutes a valuable resource. As part of the income is retained by the TTO as discretionary funds, royalty and equity income provides the TTO with more autonomy and a greater freedom to operate financially, because resources do not have to be applied for through the rigid and bureaucratic channels of the university's administration. Nevertheless, it is merely seen as a resource from that perspective, not an objective *per se*.

On the other hand, a license, regardless of whether it actually generates revenue, can constitute value from the perspective of the faculty, as it motivates the faculty's research and provides a sensation of success. This value is immeasurable in monetary terms, as it affects the faculty's propensity to disclose future research and generate potential marketable technologies. These, in turn, constitute sources of monetary return that cannot be anticipated in the present. Thus, focusing only on revenue as a proxy for value is a short-sighted strategy. Serving only those few faculty members responsible for potential home run technologies leaves the majority of faculty dissatisfied with the offices services. The problem is that it is this dissatisfied majority of inventors that constitutes the base for future home run technologies. Therefore, equal service to all faculty members is the key for the longevity of a successful office from the perspective of sustainable tech transfer:

> "Everybody gets a basic level of service when they submit the disclosure. So if you disclose an invention, we are going to come up with a non-confidential description, put it on the website, we are going to market it and we are going to see if it has traction. Maybe [it generates] low dollars and maybe high dollars, but we are going to do the same basic service for everyone."
> *- Assistant Director of the TTO at a public university -*

Furthermore, depending on whether a university is public or private, focusing on revenues might reverberate negatively in the local community and damage the university's relationship with its surrounding social environment:

> "We are [a] public university. So if we focused on gross revenue, it will be too easy for those 38% of [local] licensees to say "*Hey wait a minute, we are working. All that money is coming out of our pocket* [through royalties and taxes]. *You're not helping the* [local] *economy; you're just a cash register for the university*." So we don't really emphasize that number."
> *- Assistant Director of the TTO at a public university -*

In other words, publicly financed universities with an implicit societal mission to strengthen local economies are constrained in measuring their success in terms of revenue, as maximizing the university's profits is in strong contrast to (i) the taxpayers' perceived right to benefit from the technology largely generated based on their taxes and (ii) the paying licensees' expectations that their royalties will be pumped back into the local economy in one form or other. Of course, private university TTOs do not have these constraints to the same extent.

Other reasons that render purely quantitative comparisons of TTO activity less valuable include the fact that the amount of research conducted at a given university is affected by the amount of governmental research funding provided to it (see also Chapple *et al.* 2005). This in turn translates into differences in the number of invention disclosures that constitutes the pool of technologies available for transfer. Furthermore, the field of technology that an invention is made in correlates with the amount of potential revenues that it is able to generate. As universities differ in their research foci, there are systematical differences in licensing revenues to be expected:

> "These are deals that involve financial transactions across all three ways of intellectual property protection: patent, copyright and trademark. The numbers are tied very much to the economy, they are tied to federal government funding of research. […] If you look at the AUTM statistics, if you get two million in research funding [you can] expect one disclosure, so we get around 700 million in research funding, we should have about 350 disclosures. I think last year we had, let us see, 345.
> Some universities bias themselves. They just set up their systems so they get lots of disclosures. Others work the other way. I would be a little concerned if you are getting too few disclosures, because you are either missing the diamond in the rough, or it is possible your faculty has lost confidence in your office. We have seen that in a couple of cases where, not here, but the disclosure numbers fall off the cliff and it is because the faculty have […] said we are not going to work with the tech transfer office anymore.
> […]Also when you break down the numbers, […] the revenues will be dominated by therapeutics. […] So in a certain sense it is not fair to judge an office on numbers alone, it is one part of the entire picture."
> - *Assistant Director of the TTO of a public university* -

Although not a measure of commercial success, the number of disclosures is an indicator, if controlled for the effects of research funding, of whether the TTO is able to create value for faculty. Mistrust in and dissatisfaction with the office will have a negative impact on the number of disclosures. That being said, disclosures can be used in a controlled environment to proxy and monitor the value generated to faculty. It is important to note that such monitoring is valuable only in the context of a single office for the purposes of charting its development over time. Comparisons between offices are less valuable due to the differences in external influences as discussed above.

Comparing measures of quantifiable value, for example, the number of licensing deals made, across universities is difficult for two additional reasons. Firstly, some technologies are more suitable for non-exclusive licenses than others. This is especially relevant in the case of platform technologies that are very broadly utilized among the appropriate industries. Licensing platform technologies increases the number of licenses by a TTO manifold in comparison to non-platform technologies with very narrow application opportunities. Thus, depending on the research foci of universities, the types of technology emerging from research have a great impact on the number of potential licenses. Secondly, some technologies also require the bundling of single inventions to comprise a sensible and protectable whole. Bundling is an arbitrary decision, however, and should be made with the goal of optimal transfer in mind, not to increase deal flow. TTO's with internal incentive structures based on deal flow have the motivation to license technology in sub-optimally small pieces in an attempt to increase deal flow:

> "[License] deal flow has always been in the 20-22 range, and part of it is because […], with one exception, we have not had a type of software for instance that [University X] has that is not exclusively licensed to a very large number of companies, or like [University Y] has had a cell line in biological research that is so valuable to a large number of biotech companies that

> virtually every single company took a license to that cell line. We have not had any sort of proprietary materials or proprietary software like that.
> The other thing is [how] we count our deals. Each licensed deal is counted as one even though each one may have anywhere from half a dozen inventions to as many as 48 inventions. But we will count that as one deal and not six or 48. And we do not count as deals where a company has sponsored a research project, and in that agreement we have entered license terms. Then, when an invention is disclosed [from that project], we inform the company, and the company is very interested in the patent rights. [In such a case] there will be no separate license deal, however, because most of the terms are already part of the research agreement, and we do not count those research agreements as license deals, because we are not entering to a separate new license deal.
> […] So, I know that different universities have very, very different criteria for doing this counting and even though we are reflected as a low number of deal flow in terms of licenses, I do not want to change it. There is a set of criteria that was established and we will follow that set."
> *- Director of the TTO of a private university -*

Having said this, the benefits of revenue streams generated through licensing also have to be acknowledged. It is merely their role as indicator of success and variable of comparison between TTOs that has to be scrutinized critically. To begin with, licensing income enhances the flexibility of the TTO to react quickly to emerging situations and apply its discretionary assets without having to apply for resources through the university's bureaucracy. As we have shown earlier, there are a multitude of TTO activities that do not necessarily relate to promoting the licensing process of technologies directly, but are valuable in the light of public benefit and nurture the conduciveness of the surrounding environment to successful technology transfer. As opportunities to enhance this conduciveness are unpredictable, additional flexibility in terms of resources enabling to react to the opportunities is a valuable asset.

> "Structurally we are just a department of the university that reports up the academic ladder, the research ladder. But I do not have to ask for money, because we earn enough to support our operations; this increases our autonomy. We are largely autonomous and expect to stay that way by respecting policy and behaving ourselves. Which is, you know, do the *right* thing, not necessarily the most profitable, and, do not get into ethical trouble."
> *- Director of the TTO of a private university -*

Second, potential licensing revenues not only motivate the researcher pursuing personal wealth to push forward and commercialize his work, in other words, to initiate the transfer process in the first place, but it is also an additional resource, though a small one, to the department that receives its share according to the royalty sharing policies of each university. One could argue that in the case of the wealth-seeking researcher it is the sheer possibility, the anticipation of winning in the game of commercialization that serves as the true motivator rather than the exact probability of it, as the latter seems to be rather insignificant. Finally, despite its unreliable and invalid nature as a proxy for success in the light of the broader mission of TTOs, it is nevertheless an indicator closely monitored and taken as a signal of performance by the environment:

> "I do not know if you have looked at AUTM Surveys, we are in the top 15-20 institutions in the country. Last [year] we did 30 million and this year we will do about 40 million dollars. So from that point of view we do well with the metrics for money. […] I would not consider money an official metric, that is one of the unofficial ones, but people pay attention to you. If you make money, people are happy; at least here. So we do make money, we are well known, we are well respected in the community."
> *- Director of the TTO of a public university -*

In the end, however, focusing solely on metrics that attempt to measure commercial success does not capture the full spectrum of value generated by a TTO. Many dimensions of a TTO's mission and, thus, value creation do not materialize in the form of commercial indicators. As an illustrative example, those offices also responsible for attracting industrial sponsored research need an array of additional metrics to monitor performance over time:

> "Well, of course metrics like that have a place. But if you are looking at the office [as a whole][2], certainly license revenue is not an adequate metric for [the office's] success. The number of licenses is not an adequate metric. They are a piece of the picture, but I think one needs to look at how much emphasis to put on those metrics, not *whether* you look at them, but is that *all* you look at? We are the research arm and the licensing arm. […] Another metric we would use, is how many dollars go directly to research on the campus, in research groups, how much new research has been brought in? That is the metric. How many new faculties are being engaged to participate in this research? How many student PhDs are coming out of this research? Those are all metrics, too."
> *- Director of the TTO of a public university -*

In summary one could argue that, in the context of university technology transfer offices, indicators of performance, such as number of patents, agreements, licenses, etc., do not constitute value as such. They are mere proxies and are affected by external circumstances such as the nature of technology, the economic growth cycle, and governmental research funding. The real added value generated by TTOs is only partially and indirectly manifest in these proxies. Rather, value is added through those activities of the office that have an impact on the propensity and willingness of inventors to commercialize inventions, favor long-term public benefits that are not necessarily commercially viable in the short-term, strengthen the entire system of the technology transfer community including entrepreneurs, financiers, support organizations etc. by serving as a nexus of contacts and providing "match making" services, advising researchers in protecting IPR, and so forth. These activities are seldom quantifiable and have to be considered as investments into future technology transfer, because they strengthen the necessary infrastructure.

As such, indices based on annual deal or revenue flow cannot capture the value provided by a TTO, because it will manifest itself in periods still to come and are hardly attributable to any single action taken by a TTO. Another difficulty with measuring the added value provided by TTOs is that it is tough to assess how much less commercialized or otherwise diffused technology would emerge out of universities if TTOs or equivalent instances did not exist in the first place. How easily would a university inventor approach a patent office or a VC if it was not for the contacts of the TTO or the educational services that lower the psychological hurdle of scientists to approach the realm of commercialization? If one could measure the differences, one would be much closer to capturing the real added value provided by TTOs.

Quantitative indicators can be utilized to monitor different stages of the transfer process within a single TTO, however, as they confer information on the performance of different TTO functions and relationships as compared to prior periods. Therefore, they are important tools in self-evaluating the value creation process of any given office, but should not be sole measures of value creation.

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[2] The original name of the office has been omitted for reasons of anonymity. In this particular case the office also handles industrial research agreements.

3.3.2. Measuring Impact, not Income – Alternative Approaches

In the name of constructive criticism it is required to propose alternative measurement practices to those rejected above. Furthermore, these alternative practices must be based on the utilized Value Platform framework to have a coherent argumentative foundation in the analysis presented in this study.

The Value Platform framework proposes that value is created through the strategic, holistic, and multi-lateral interaction of human, structural, and relational capital inherent in an organization. As a prerequisite, such interaction presumes the existence of all three components in any given organization aiming to create value. This implies that the lack of or weakness in any one of the components impedes the value creation process. Thus, this study proposes to build measures that proxy the existence and nature of human, structural, and relational capital in TTOs that is relevant to their performance. This enables the assessment of a given TTO's capability to perform value creating functions in the first place. Due to space limitations, the propositions made below are intended to be exemplary only and aim at showing the direction in which to continue when building a more exhaustive array of indicators.

One of the most central functions performed by TTOs was argued to be the conversion of scientific knowledge and ideas into information digestible by the industry and *vice versa*. A key element of human capital in performing the conversion was shown to be the fusion of a solidly scientific background and extensive experience in commercial activities in a single person, one of important criteria in the recruitment of licensing officers. The fusion of such knowledge outside the individual is challenging, because it is deeply tacit and can only partly be codified into communicable form. Without interdisciplinary professionals the knowledge gap between the academic and commercial universes would only be internalized into the TTO. Thus, in a first step, a relevant measure of human capital would quantify or otherwise approximate both aspects of knowledge, scientific and commercial. The choice, whether the actual proxies are years of experience, fields of expertise, or levels of education, depends on the particular research setting and the availability of data. Then, in a second step, the measure would indicate whether both aspects are inherent in a single individual. Such a two-step approach can be integrated into a single factor score based indicator using factor analyses, for example (Tahvanainen and Hermans 2005; Hermans and Kauranen 2005).

Relevant structural capital is difficult to identify. Databases, organizational strategies, or training programs as such are not necessarily relevant for value creation if they do not support the interaction of human and relational capital. The identification is a matter of context-specific, careful analysis and, thus, is qualitatively achievable as shown in this very study. A real challenge is to build quantitative measures of SC. How would one measure the degree of openness of organizational culture, the quality and content of training programs, or the impact of networking events in a way that can be standardized over different organizations in a given sample? And yet, these are the aspects of SC that do matter if one aims at explaining the value creation process of an organization, since they constitute the systemic environment and its mechanisms in which university technology transfer is being conducted.

One possible approach to operationalizing SC in a justifiable manner would be to measure the tangible results achieved by employing different SC rather than to measure SC as such. For example, open organizational culture, active educational efforts aiming at activating researchers to think outside the context of purely academic research, building trust and reputation through the display of competence, and delineating strategies that have the protection of the researchers' incentives as their core all have the purpose of stimulating and

motivating faculty to disclose their scientific work and, thereby, to initiate the first phase of technology transfer. A tangible result of such stimulation could be a rise in the proportion of research disclosed to the TTO. Controlling for the effects of scientific discipline and field of research, one could measure the ratio of disclosures and scientific articles in a given university as the proxy of relevant SC put into action, for example. It is evident again how context-specific a single measure must be.

Measuring relational capital is equally challenging. While the plain determination of whether a TTO has established contacts to faculty, industry, financiers, regulatory bodies, etc. is easily proxied using dummy type of variables, the nature, strength, and function of these contacts is not captured by such indicators. Slightly better measures would include the share of faculty that the TTO maintains active contact to, the average frequency of having contact to faculty, the share of companies in case-relevant industries that the TTO keeps contact with, binary indicators that proxy whether the TTO mediates advice, insights and knowledge gained from these external parties to each other and so forth. As single indicators do not provide much insight about the necessary dynamics between the parties, one can use factor analysis to merge separate indicators into a single measure that proxies the simultaneous existence of contacts to diverse parties. Another fruitful approach to measuring the relevance and importance of TTOs in a network is to determine their embeddedness in the multilateral relationships formed between the different actors utilizing suitable methods of network analysis as already widely applied in related literature (see e.g. Powell 1996). Resulting parameters such as *network centrality* and *network density* can be applied as quantitative measures for a variety of purposes depending on the focus of a given study.

Once all three components of IC are quantified, it is fairly simple to assess, whether a given TTO, among a larger sample of peers, is endowed with a well-balanced IC base that is argued to be a prerequisite to creating value (Hussi and Ahonen 2002). A well-balanced IC base is one that is not lacking or weak in any of its three separate components. Using factor analysis, it is possible to categorize TTOs into those that have a well-balanced IC base and those that are deficient in one or several. Factor scores indicating to what extent a given TTO is a representative of any of the categories can then be used in quantitative analyses as independent variables to explain any given outcome of interest.

Having said that, one attractive avenue for future research would be to investigate whether TTO performance as measured by the monetary indicators criticized above can be related to the respective IC bases of offices. The question is interesting because there is a discrepancy between the stated mission priorities of TTOs interviewed in this study and their financial performance. If social welfare and societal impact are clearly given priority over monetary results, why is it then that these TTOs excel in monetary terms at the same time? Does giving priority to societal impact entail financial success, and, if so, what is the role of IC in enabling such an impact?

4. Conclusions

This analysis set out to examine one of the central manifestations that government intervention in the form of the Bayh-Dole Act gave birth to – the university technology transfer office. To better understand the potential and tangible leverage that such legislation can have on the economy and society in broader terms, we were specifically interested in how

a selection of the most successful offices at US universities contributes to the advancement of technological progress and, thereby, carry out the agenda drafted in the Bayh-Dole Act.

Although the establishment of TTOs was not specifically mandated in the Act, it was a natural consequence of the stipulations therein. For the traditional administrative organs dealing with the university's conventional affairs the multitude of tasks and the related expertise necessary proved a burden too extensive to handle with conventional resources. There was a need for a designated unit that could tackle the obligations imposed by the Bayh-Dole Act and could support the university in its extended mandate that now included the commercialization of research.

The true motivation for the enactment of Bayh-Dole originated in the need to standardize the plethora of different and diverging guidelines and legislation governing the ownership of intellectual property arising from federally funded research in different US states. The consequences were far broader than the sole simplification and streamlining of legislation. Among other things out of the focus of this analysis, the Act basically enforced the emergence of an additional and strategically dedicated mechanism to complement the existing mechanisms of university technology transfer (including education, publication, sponsored research, seminars, consulting, joint R&D, academic entrepreneurship, etc.). The emphasis here is on the word "complement", because it is by no means a replacement or an alternative to the afore-listed mechanisms. The TTO is a support organization providing value adding services that close the rifts and gaps between the academic and commercial universes still left open by these conventional methods of knowledge diffusion.

In so doing, the TTO is driven by two major factors: The mandates stipulated by the Bayh-Dole Act and the primary mandates and interests of universities, namely education and research. Thus, in their mission statements TTOs combine both the mandates of the Bayh-Dole Act with those of the universities' to, firstly, guarantee the competitiveness of the particular universities in the academic universe by protecting interests of their most precious stakeholders, the researchers, and secondly, to adhere to the legislative mandates by protecting IPR and promoting it to commercial use.

In the process, they implicitly, if not strategically, guarantee the sustainability of the flow of technologies out of the laboratories towards market application, as their actions and motives uphold and sustain the incentive structures of both of the universes, the academic and the commercial. This is accomplished by performing and specializing in the very functions that neither universe has been able or willing to perform in order to take a step closer towards each other.

To perform these functions a TTO needs to be run holistically. By leveraging the internal human capital comprising general scientific and commercial expertise, communication skills, social capabilities, and experience with IPR legislation, TTOs convert academic knowledge provided by inventors into language appropriable by the industry and *vice versa*. Thereby, the TTO facilitates the matching of commercially driven needs of the industry with solutions emerging from academic research. Additionally to its own resources, the TTO exploits also its position in a network of complementary actors, its relational capital, including patent offices, law firms, entrepreneurs and industrial contacts, investors, etc. to promote the commercialization of a given invention. Furthermore, the exploitation of human and relational capital demands supportive structures, i.e. structural capital. Such structures include databases documenting the progression of single cases, alerting of vital deadlines, and warehousing contact information, as well as commercialization-related educational programs and events

hosted by the TTO, an open organizational culture encouraging the diffusion of expertise within the office, and internal training programs for employees.

By showing how human, structural, and relational capital are managed in a sample of the most successful TTOs in the USA the study implicitly presents a model of management, the principles of which can be applied at university TTOs world-wide. While specific practices and functions might strongly depend on the local, regional, or national contexts, the governing principles implied by the application of the Value Platform Model are rather universal.

Furthermore, by analyzing the interaction of IC components empirically, a contribution was made to the literature of knowledge management and IC that is lacking a rich empirical tradition. The utilization of the Value Platform Model was shown to be a structured and comprehensive framework to analyze the key success factors of organizational practices and understand the underlying dynamics of single resources. Thus, the framework, having been mainly the subject of theoretical debate, has been shown to be highly applicable to empirical research. However, it is emphasized that such application is only feasible under considerable context-specificity – an aspect that is at the same time one of the central strengths of the framework.

The contributions of TTOs are often hard to capture in quantitative measures, which has led to common criticism about the effectiveness of TTOs. Such measures should be used with care in the comparative evaluation of TTO performance. At the same time, one must also recognize their value as parameters that can be utilized to internally monitor the performance of each TTO individually over time. In an attempt to enable more comparative research, the study proposed an exemplary set of alternative metrics to be used. Such metrics should be grounded in the IC base of TTOs, as it determines their ability to perform the value creating functions necessary to bridge the gap between academia and the industry.

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