ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

Keskusteluaiheita – Discussion papers

1236

Antti-Jussi Tahvanainen* – Raine Hermans**

MAKING SENSE OF THE TTO PRODUCTION FUNCTION: UNIVERSITY TECHNOLOGY TRANSFER OFFICES AS PROCESS CATALYSTS, KNOWLEDGE CONVERTERS AND IMPACT AMPLIFIERS

* Helsinki University of Technology, Department of Industrial Engineering and Management, PL 5500, 02015 TKK, Finland / The Research Institute of the Finnish Economy (ETLA), Lönnrotinkatu 4B, 00120 Helsinki, Finland. E-mail: antti.tahvanainen@etla.fi

** Helsinki School of Economics, PL 1210, 00101 Helsinki, Finland.
E-mail: raine.hermans@aalto.fi

Corresponding author: Antti-Jussi Tahvanainen, The Research Institute of the Finnish Economy, Lönnrotinkatu 4B, 00120 Helsinki, Finland. Phone: +358 44 535 1797. Fax: +358 9 601753.
E-mail: antti.tahvanainen@etla.fi.

ISSN 0781-6847 11.01.2011

TAHVANAINEN, Antti-Jussi – **HERMANS**, Raine, **MAKING SENSE OF THE TTO PRODUCTION FUNCTION: UNIVERSITY TECHNOLOGY TRANSFER OFFICES AS PROCESS CATALYSTS, KNOWLEDGE CONVERTERS AND IMPACT AMPLIFIERS** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2011, 40 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; No. 1236).

ABSTRACT: This inductive case study of 7 US university technology transfer offices (TTOs) examines the value added that TTOs contribute to university-industry technology transfer (UITT[1]). We therefore (i) characterize a set of central organizational TTO practices, (ii) describe how TTOs systemically manage intangible resources to generate these practices, and (iii) describe the conceptual mechanisms through which the practices add value to UITT. The results form an inductive framework that establishes the TTO as (i) a *process catalyst* that lowers the threshold of UITT stakeholders to engage in technology transfer and to maintain its sustainability, (ii) a *knowledge converter* that enables congruence between university technology and market needs, and (iii) an *impact amplifier* that alleviates problems related to the opportunistic incentive structures of UITT stakeholders and maximizes societal impact. The study thus provides new insights into the internal logic of the TTO production function by qualitatively expanding and refining our understanding of the value added generated by TTOs and by helping to comprehend the relationship between inputs and outputs that underlie it.

KEYWORDS: University-industry technology transfer; technology transfer office; organizational practices; Intellectual Capital; knowledge management

JEL: O31, O32, O33

[1] University-industry technology transfer

"A 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. […] Somebody has to look at the whole, and look at it from the perspective of the public benefit […] 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. We will help connect the dots […]."

1. Introduction

With the evolution of globalization and the emergence of the "second unbundling" (Baldwin, 2006), i.e., the global competition between any given stage of a firm's production and the offshoring of individual tasks within those stages, even firm functions that add substantial value, such as R&D, have undergone divisions. The appropriate parts of these functions are offshored to countries with lower costs, better market proximity, or superior knowledge.

For highly developed, high-cost countries that rely on superior innovation capabilities for their global competitive advantage these developments pose a serious challenge because quickly developing, low-cost countries such as China and India are advancing in the race for knowledge and innovation. Companies from around the world have already offshored parts of their R&D activities to these countries. In light of the challenge to preserve competitive advantage, "incumbent" countries need to maintain cutting-edge knowledge bases as growth plates for high value-added innovation to retain and attract economic activity.

However, the maintenance of such knowledge bases, which has traditionally been the task of academic institutions such as universities, is not sufficient. These bases must be accessible to firms to be attractive. Accessibility has thus far presented a major obstacle to UITT. As Siegel, Waldman and Link (2003) state, "universities in the US have been criticized in some circles for being more adept at developing new technologies than moving them into private sector applications (p. 27)." Similar conclusions have also been reached in much smaller and more peripheral countries, which are even more dependent on progressive innovation capabilities. Finland, for example, seems to struggle with commercializing its otherwise rather competitive academic research achievements (Ali-Yrkkö et al., 2004).

A well-studied institutional response to this challenge is the university technology transfer office (TTO). Mandated mainly by the Bayh-Dole Act of 1980, US universities have established TTOs and charged them with facilitating the diffusion of university-generated technology toward its industrial or societal use through licensing. Since their emergence, TTOs have been the subject of many studies. Most of these studies have scrutinized their effectiveness in enhancing university-industry technology transfer (UITT) (Siegel and Phan, 2005).

Studies have established that an array of institutional, environmental and organizational factors determine TTO effectiveness (e.g., Siegel, Waldman and Link, 2003; Mustar et al., 2006, and Chapple et al., 2005). The impact of these factors is commonly analyzed using a "TTO production function." Factors of interest are fed into the function as inputs and related to certain output measures using quantitative statistical methods. The question of how the inputs are transformed into outputs, i.e., the logic of the production function itself, has largely remained a black box, however.

The most recent contributions to the TTO literature have examined the impact of organizational factors in general and organizational practices in particular on TTO performance. Because practices are difficult to capture quantitatively, these studies have reverted to more qualitative approaches. They have shown that practices can indeed affect TTO effectiveness as measured by conventional measures such as the number of annual licensing deals or

royalty turnover (e.g., Siegel, Waldman and Link, 2003). Also, practices that cannot be captured with conventional metrics have been recently examined in studies investigating the broader societal impacts of TTOs (e.g., Siegel et al., 2004, and Sorensen and Chambers, 2008).

However, both lines of research still largely fail to provide deeper understanding on the conceptual mechanisms of TTO practices and how these facilitate the process. These studies typically fail to provide a "value generation logic" for TTO practices beyond an exploratory intuition and the general statement that they are important to the process. We know even less about how TTOs manage and apply their resources, especially intangible ones, to generate value-adding practices. The production function thus remains opaque.

Given the above shortcomings, this inductive case study of 7 university TTOs contributes to the TTO literature by looking into the black box that has thus far obscured an understanding of the value-adding mechanisms of TTOs. We (i) identify a set of central organizational practices through which TTOs facilitate UITT, (ii) show how TTOs manage their intellectual capital resources, i.e., human, structural, and relational capital, to generate these practices, and (iii) describe the conceptual mechanisms through which the practices add value to UITT and facilitate its process. The results form an inductive framework, which establishes the TTO as (i) a process catalyst that lowers the threshold of UITT stakeholders to engage in technology transfer, (ii) a knowledge converter that enables congruence between university technology and market needs, and (iii) an impact amplifier that alleviates problems related to the opportunistic incentive structures of UITT stakeholders and that maximizes societal impact.

In this manner, the study provides valuable new insights into the internal logic of the TTO production function. A qualitative intuition for the logic expands and refines our understanding of TTO effectiveness and helps us understand the relationship between the inputs and outputs that determine it. The study thus reinforces the foundation for the development and adjustment of measures used in the assessment of TTO effectiveness in future research.

The study is structured as follows. The next section examines the existing literature on TTOs and positions the present study within it. Section 3 presents the data and the applied methodology. Section 4 introduces Edvinsson and Malone's (1997) Value Platform Model, which is a tool used in the initial structuring of the data and which allows the systematic depiction of how intangible resources are managed to generate TTO practices in the analysis proper in Section 5. Section 5 constitutes the analytical core of this paper. It presents the results of the study in the form of an inductive framework that depicts three TTO mechanisms (catalyst, converter, and amplifier) through which TTOs generate value added for UITT. Section 6 concludes the study with a discussion of the findings and their implications. Appendix 8.1 contains a brief descriptive disquisition of the systemic flow of the licensing process as it emerged from the data and the interview protocol.

2. Literature review

The contributions of this study must be framed by extant previous research on TTOs and their effectiveness in mediating the flow of resources and information (Siegel and Phan, 2005) between academia, industry, and other actors that participate in UITT.

The need for TTOs as "boundary spanners" presupposes the existence of gaps, barriers, inhibitors, structural holes (Burt, 1992), or other boundaries between actors that inhibit the efficient flow of technology. Barriers that have been identified include differences in incentive structures, objectives and cultures among scientists, TTOs, and companies

(Lee, 1996; Link and Siegel, 2003; Siegel, Waldman and Link, 2003; Siegel et al., 2004; Siegel and Phan, 2005), information asymmetries between actors (Jensen and Thursby, 2001), uncertainty regarding the technological and commercial potential of inventions (Macho-Stadler, Pérez-Castrillo and Veugelers, 2007), and the diversity of universities' research missions (Rahm, Bozeman and Crow, 1988). Finally, in a more generic context, Bozeman's (2000) Contingent Effectiveness Model of technology transfer attributes the ineffectiveness of the transfer process to incongruence in the "characteristics" of the "dimensions" that constitute his model: the transfer agent, object, media, and recipient, as well as the demand environment.

Due to the inhibiting effects of inter-actor boundaries in UITT, the effectiveness of TTOs in facilitating the UITT process by "spanning" these boundaries has been an object of intense study. Studies on this topic relate institutional, organizational, and/or individual drivers to select transfer process output proxies (licensing deals, filed patents, number of university start-ups, research funding, invention disclosures, licensing revenues, etc.) to determine the effectiveness of TTOs (Friedman and Silberman, 2003; Lach and Schankerman, 2004; Rogers, Yin and Hoffman, 2000; Thursby and Kemp, 2002. For comprehensive reviews cf. Phan and Siegel, 2006; Mustar et al., 2006; Siegel and Phan, 2005; Bozeman, 2000). For instance, Siegel, Waldman and Link (2003) establish a production function for US TTOs and find that, after controlling for a number of environmental factors, their performance is affected by the number of inventions disclosed to the office, the size of the TTO staff, and the amount of legal expenditures on internal and external legal consultation by the office.

Markman et al. (2005a) analyze which TTO structures and licensing strategies are most favorable to new venture formation and which of these are correlated, and 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 with the speed with which TTOs are able to commercialize patent-protected technologies. Central determinants of commercialization speed include TTO resources and competency and the active participation of the original inventors in the process. Lockett and Wright (2005) back up these findings by establishing a positive correlation between the number of spin-off companies created and the expenditure on IPR protection, the business development capabilities of TTOs, and the royalty regime of the university. The positive effects of business competency among other determinants such as previous success in UITT, faculty quality, and federal funding on start-up formation have been further verified by O'Shea et al. (2005) and Di Gregorio and Shane (2003).

Despite this work, the qualitative link between inputs and outputs, i.e., resources, capabilities, and effectiveness, remains at least somewhat obscured by a black box because the above analyses do not directly address the practices that a TTO performs to transform inputs into outputs. Some approaches have begun to dismantle the black box by exploring the roles of organizational practices in TTO performance more directly. Bercovitz et al. (2001) relate organizational structures, i.e., the degree of centralization of UITT-related units at three universities, to a number of performance indicators and find that structure indeed matters. Scrutinizing organizational practices, Colyvas et al. (2002) provide evidence of the significance of TTOs' marketing efforts in cases where links between academia and the industry are weak. Jensen, Thursby, and Thursby (2003) observe TTOs' practices in balancing the tensions that arise from the clashing objectives of universities and their faculty. They find that TTOs adhere to the agendas of both parties and, as agents, try to serve these agendas in a manner that maximizes utility. The authors 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. Debackere and Veugelers (2005) show how a decentralized management style, in contrast to the

style applied by a more traditional university administration, would provide the TTO with more leeway to address the diverse needs of its heterogeneous stakeholders.

Three recent contributions are tightly focused on organizational practices and their impact on TTO performance. Swamidass and Vulasa (2009) examine the effects of scarce staffing resources and inventions-processing capacity in 99 US TTOs. Based on multiple regression analyses, they show that, when short on staff and budget, TTOs reduce their marketing efforts in favor of securing proper IP protection, which is argued to have a negative impact on the UITT process as a whole. A deficiency in the appropriate competencies would lead to problems in identifying markets for inventions and in the translation of the technology into a form that can be appropriated by industry. In the current paper, we will provide an inductive argument that supports Swamidass and Vulasa's (2009) finding.

Sorensen and Chambers (2008) examine TTOs' ability to facilitate access to knowledge protected by faculty and university IP, which the authors propose is the ultimate benchmark of TTO performance. In line with our own findings, the authors claim that such an access metric is based on nonmonetary indicators and takes into account practices that are not captured by conventional measures of performance. According to the authors, practices that "drive value in UITT" but that cannot be directly measured based on monetary indicators could be captured through, for example, citation analyses, indicators related to alliance management, counting research and humanitarian use exceptions, as well as the identification of practices related to open source business modeling, patent pooling and bundling, exclusivity shifting, and regional economic development through capacity building. As we shall corroborate, Sorensen and Chambers (2008) conclude that TTOs "may actually make less money by adopting a nonmonetary benefit strategy, but less money through royalty revenue is not necessarily less societal value (p.535)."

Finally, based on a qualitative exploratory approach, Siegel et al. (2004) establish that the different objectives of and cultural barriers between universities and industry, as well as inadequate compensation, staffing, and reward practices, explain poor TTO performance to a certain extent. These findings are much in line with those of Clarke (1998) and Roberts (1991), who claim that the existence of an entrepreneurial culture and certain social norms such as the unspoken acceptance of entrepreneurial activities can be prerequisites of successful entrepreneurship at universities. Siegel et al. (2004) conclude that certain organizational practices, such as incentive schemes favoring scientists, the integration of technology transfer into promotion and tenure schemes, the inclusion of informal technology transfer into TTO objectives, and increases in overall TTO resources, could potentially enhance UITT effectiveness.

Despite recognizing the central role of practices in TTO performance, however, the above studies provide few in-depth insights into the value generation logic, that is, into the internal logic of the TTO production function. Regarding staffing practices, for instance, Siegel et al. (2004) state that "it appears that the marketing aspect of the TTO is often given short shrift (p. 134)." In an earlier study based on the same data, Siegel, Waldman and Link (2003) argue that "a lack of requisite business skills and expertise could have a significant deleterious effect on TTO productivity (p.43)." However, the authors do not explain explicitly why "deleterious effects" arise, what role "requisite business skills" play in the value generation logic of TTOs, or how such a lack in skills disrupts a given TTO practice or value generation mechanism. As another example, Siegel et al. (2004) also state that "knowledge transfer appears to work in both directions" and that "interacting with firms enables them [scientists] to conduct "better" basic research (p. 131)." However, they do not identify the mechanisms and practices through which TTOs help establish bi-directional interactions, the resources that are necessary to

generate such practices, or the value that is added in the broader context of UITT, beyond micro-level benefits such as the refinement of experiments and new perspectives on problems.

Likewise, Sorensen and Chambers (2008) laudably begin a discussion on the societal mission of TTOs and advocate the development of metrics that capture related outcomes. However, they fail to provide (i) arguments about why such objectives should be preferable over (or at least complementary to) more conventional ones and (ii) examples of practices through which TTOs might fulfill societal objectives.

The study presented here will build upon the work of Siegel, Waldman and Link (2003), Siegel et al. (2004) and Sorensen and Chamber (2008) by inductively analyzing the value adding practices of TTOs at the interface of industry and academia to reveal the TTO production function logic. The study thus informs existing theory by answering the aforementioned questions inductively rather than by creating an entirely new theory.

For more readings on the issue of UITT, there are at least two excellent review studies in addition to those of Siegel and Phan (2005) and Phan and Siegel (2006). 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, and Rothaermel, Agung, and Jiang (2007) review over 170 studies related to university entrepreneurship in broader terms. One of the fields of study they review focuses specifically on the productivity of TTOs.

3. Data and methodological approach

3.1. Data

The data utilized in the present study were 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 7 US university technology transfer offices at Stanford University, Massachusetts Institute of Technology, Northwestern University, Harvard University, UC Berkeley, UC San Diego, and University of Massachusetts. All of the included TTOs were among the top 20 in the US as measured by the number of start-ups founded in 2005, which served as the primary criterion for being considered for the study. The final choice of cases was further refined by recommendations from TTO practitioners who were active in AUTM, The Association of University Technology Managers. However, our intention was not to capture the best performing TTOs but those that could provide us with a rich description of practices and underlying resources based on a long track record of experience with both success and failure.

Because this is a case study, TTOs in the sample are not intended to represent the average or the majority of US TTOs. Instead, using a handful of select cases, our intention is to approximate a model of a TTO as constructed from the underlying data. In building a conceptual framework of value-adding TTO practices, we do not attempt to establish a 1:1 model of the entire population of US-based TTOs but to learn from TTOs with profound experience and to organize individual practices into a coherent framework. It is important to emphasize this point because normative claims or arguments for the generalizability of results beyond the sample would strongly undermine the validity of our research design.

Among many alternative measures of technology transfer activity,[2] the number of start-ups was chosen to identify experienced offices because it not only mirrors activity in the TTOs but also reflects the entrepreneurial environment in which the offices are embedded. TTOs do not exist in a vacuum, and we wanted to incorporate their context into our analyses. Table 1 summarizes a number of other indicators that are commonly used to determine the relative position of TTOs.

Table 1 *Positioning of sample TTOs in total population, 2004 figures (Source: AUTM STATT, 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 reveals, our sample comprises 4% of all 164 TTOs active at different US Universities in 2004. The TTOs in our sample were particularly efficient at generating codified knowledge as a foundation for commercial applications such that they generated 12% of all invention disclosures and 13% of all new patent applications filed by US universities. Furthermore, the TTOs in the sample accounted for 151 million USD, or roughly 16%of the total licensing income received by all TTOs in 2004. The ratios serve to further corroborate our assumption that the TTOs in our sample had experience with at least some successful UITT transactions in the past.

The interviews were conducted using a semi-structured interview template that allowed interviewees the freedom to respond in their local contexts, which differed among offices along 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 our analytical framework were addressed in sufficient scale and scope. We obtained roughly 20 hours of recorded data from the interviews, which were then transcribed for further analysis.

The second data source comprised a large quantity of official and publicly distributed electronic and printed material on the activities of the TTOs in the sample. The function of this secondary data was to complement the views of interviewees (especially in cases where interviewees explicitly referred to these secondary data) and to verify these views against officially communicated policy, i.e., to triangulate the views provided in the interviews.

Our third and final data source was the AUTM STATT (Statistics Access for Tech Transfer) database that provided time series data on 21 important variables regarding the technology transfer activities of US TTOs covering a period from 1996 through 2005. Table 1 is entirely based on the STATT data. In addition to demarcating our sample, the STATT data were mainly used to verify the numeric information provided in the interviews.

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

3.2. Methodology

3.2.1. Approach

Regarding methodology, the present study applies content analytical techniques to probe the underlying data using ATLAS.ti text analysis software. The content analytical approach employed in this study is inductive in nature. The analysis is not concerned with ontological issues regarding the phenomena that emerge from the data. Their truthful existence is presupposed and remains unchallenged. Rather, it arranges these phenomena into a framework that reveals their systemic role in generating value added in the UITT process. This implies that we regard the interview data as rich descriptions of reality.

The inductive nature of the study further implies that we draw our conclusions primarily from the data. With the exception of the literature that underlies the discussion and the construction of the Value Platform Model (Section 4), which serves as a structural frame for reporting our results, pre-existing views from literature play only a minor role in the interpretation of the data, as the following description of the analytical process will show. The process itself is strongly guided by the template presented by Eisenhardt (1989). To show parallels to findings reported in other literature, to position our work among existing literature, and to anchor and verify our own interpretations against the established body of knowledge, however, references to studies that are relevant to our findings are included in the argument in Section 5.

3.2.2. Initial objective

The process originally began with the intermediate objective of mapping components of Intellectual Capital (IC) that are relevant to TTOs for the purpose of building measurable metrics for large-scale quantitative analyses. In later studies, these indicators were to be applied in analyses that would assess the impact of different configurations of IC in TTOs on UITT outcomes. However, the objective shifted and expanded radically shortly after we initiated coding of the data. We will discuss this in more detail shortly.

3.2.3. Interview protocol

The original objective necessitated the systematic collection of specific data that describe the IC components that are prevalent in TTOs in detail. This implied the use of a priori defined constructs (Eisenhardt, 1989), i.e., the inclusion of the fixed set of IC components identified in the knowledge management literature (primarily Edvinsson and Malone, 1997), in our interview protocol. The mapped components included human, relational and structural capital, each of which was discussed with interviewees after providing them with generic, noncontext-specific definitions of the constructs. Regarding the validity of our claims related to the inductive nature of the study, it is paramount to point out that the underlying IC framework (Value Platform), which will be introduced in more detail in Section 4, was not presented to or discussed with the interviewees in any form. In fact, the naming of IC components was deliberately reformulated to prevent any accidental recognition of the framework by interviewees. Human capital was the sole exception because it is a widespread and common concept that does not exclusively refer to the Value Platform framework. The applied protocol template is attached in Appendix 8.2. In addition to the three IC components, we further asked the interviewees to provide us with (i) depictions of occurrences when they felt their respective TTO had achieved success, and (ii) a walk-through of the process of technology transfer from the perspective of the TTO.

3.2.4. Case selection

Once the protocol was established, we proceeded with the selection of appropriate cases. This selection was not random, but followed the tenet of Eisenhardt (1989) to choose cases such "in which the process of interest is transparently observable." Given our initial objective to map IC components for later quantitative uses, it was crucial to select cases that yielded as broad a spectrum of IC component descriptions as possible. Hence, following the IC framework, according to which experienced and successful organizations are endowed with a balanced and more complete set of IC components than less experienced and successful ones, we focused on a set of comparatively experienced TTOs. The purpose was to avoid analyzing the IC bases of TTOs that we would a priori expect to be more deficient in some aspects of IC. To cover IC relevant across different TTO types, we included public and private TTOs and economically dependent and independent TTOs in the sample. The recommendations from TTO practitioners active in AUTM were helpful in identifying potential target that matched these criteria. Given the number and choices of participating TTOs, the presence of multiple cases in each category allowed the findings to be replicated within categories in the analysis in Section 5.

There is a central caveat regarding the selection of cases. Given the research question addressed by this study, we recognize that to make any normative claims based on the findings, i.e., to state that the sample TTOs fare better than others because of the practices they perform, we would have to incorporate TTOs that are far less successful into the sample and utilize comparative techniques to pinpoint differences in their respective practices. Thus, we emphasize that we do not provide normative implications but instead examine the role of TTO practices in creating value added for UITT and how the TTOs in our sample manage and apply IC to generate these practices. In this context, "value added" is not to be understood as a comparative concept like the difference in monetary indicators of effectiveness or productivity between "successful" and "less successful" TTOs. Rather, it refers to the concept of enabling and triggering the process of UITT to advance from one phase to another. According to this concept, a TTO provides value added not by performing better than other TTOs but by performing necessary functions that other stakeholders of UITT (e.g., inventors, universities, financiers, industry, entrepreneurs, etc.) are not able or willing to perform to overcome the gap between academia and industry. We do not need to contrast high performers to low performers to understand the role of practices in providing value added as defined above because we are not interested in the factors underlying the differences in TTO performance but in what performance is and how it is generated.

3.2.5. Data collection

All interviews were conducted with both investigators present and making independent notes in addition to full audio recordings. Extensive discussions between investigators after each interview introduced overlap between data collection and preliminary theme-searching data analysis, which led to some minor and subtle adjustments to the interview protocol between interviews. These took the form of follow-up questions in cases where respondents did not touch on newly emerging themes independently (e.g., the role of monetary objectives). Protocol alterations were made to probe and confirm themes that emerged from prior cases. As a result, toward the end of the iterative data collection process of alternating team discussions and interviews, we had a collection of loosely connected themes at our disposal, and we were thus able to preliminarily identify potential inter-case similarities. Central emerging themes included, among others, the need for inter-institutional human capital in bridging knowledge gaps, the importance of customer orientation in dealing with faculty, the role of feedback loops in marketing, and the systematic downplay of

purely monetary objectives. Although we had not yet established the interplay of themes or their relative positioning in a coherent framework, we developed an early sense of the potential of the data to answer questions beyond the mere mapping of the IC components that are relevant to TTOs.

3.2.6. Within-case analysis – A shift in objectives

Once the interviews were transcribed and, together with the secondary data material, inputted into the text analysis software tool, we proceeded with the first rounds of coding by flagging references to IC components as established in the original research design. IC components were identified according to the guidelines of the IC measurement literature (see, e.g., Bontis, 2001, for a review on IC measurement models) and the categorization implied by the Value Platform Model introduced in Section 4. The coding was performed for each case separately and gave primary emphasis to the interview-based data. Secondary data were used mainly for triangulation and validation purposes.

It became evident early on that the interviewees were not able to define the IC components without reference to the contexts in which they were applied, i.e., to the practices performed by the TTOs. Because these practices constituted the dominant themes that emerged in every case, we saw the opportunity to shift our research question away from building indicators of IC components and toward understanding how IC is applied to generate practices in TTOs and how these practices add value to the UITT process.

In the following analytic iterations, we coded the practices thematically for each case separately. Each of the resulting categories of practices (e.g., education, feedback looping, and problem assistance) consolidated a number of different practices with common objectives or functions.

Having shifted our level of analysis from IC components to practices, we further recognized that several different IC components were defined by interviewees when describing their role in generating the same practices. Thus, several different components seemed to be simultaneously at play in the generation of any given practice. Therefore, we were able to capture the dynamic interplay of IC components underlying the generation of TTO practices.

This inductively derived finding is particularly interesting from a conceptual perspective because the dynamic interaction of IC components as the prerequisite to value generation is incidentally also the central tenet of the Value Platform Model (VPM). It encouraged us to return to and utilize VPM to structure our report of the results in Section 5.

3.2.7. Inter-case analysis

In the subsequent inter-case analysis, we compared the presence of practice categories, and not necessarily of specific practices, across cases. Specific practices within practice categories might have differed among TTOs, but we required them to serve the same or similar function in facilitating UITT. Along this line of interpretation, specific practices represented different aspects of the same constructs, i.e., practice categories. Identifying practice categories that were common to all sample TTOs was important to facilitate separating these constructs from specific TTOs or types of TTO (private vs. public, and economically dependent vs. independent) to link them to general value-adding mechanisms. Thus, in a final round of analytical iteration, we further abstracted away from practice categories to code them according to their role in furthering UITT. This resulted in the constructs that were labeled "catalyst," "converter," and "amplifier" to describe the conceptual mechanisms through which TTOs add value to UITT.

To introduce more plasticity to our own interpretations, we present a fair number of direct quotes from interviewees who, for the purposes of obtaining responses that were uninhibited by political, diplomatic, personal, or other concerns, were promised complete anonymity.

4. Value Platform

4.1. Rationale for utilizing VPM

To present the relevant resources commanded by TTOs and to show how these resources are put into action to generate organizational practices in a cohesive manner, we integrate these aspects into a single comprehensive framework. To this end, when reporting the results in Section 5, we will employ the Value Platform Model (VPM) first presented by Saint-Onge et al. in Edvinsson and Malone (1997). It should be noted that VPM is a pre-existing concept that is not the result of our own interpretation of the data. It originally served as a structural foundation in the data collection phase that was intended to map intellectual capital components that were relevant to TTOs. The model was not used to interpret the data beyond identifying these components. The identification of practices, their value-adding functions, and the interplay of IC components necessary to generate the practices are the result of inductive analysis.

To rationalize the application of an intellectual capital (IC) and knowledge management based approach, one must consider the characteristics of the object of UITT (Bozman, 2000). Thus, it is relevant to ask: what is technology?

University technology is only rarely tangible before being licensed to a third party for further development (Jensen and Thursby, 2001). In UITT, technology goes from an initially very intangible state, existing only in the domain of the inventor's knowledge, to a slightly more tangible or codified form, such as a patent, proof of concept or a prototype. Thus, the fundamental task of a TTO is to understand, protect, and transfer knowledge created by one actor to another. This process necessitates a vast array of specific expertise, relationships, and support structures, as will be shown in our analysis.

It is important to note that there are very few, if any, tangible assets to be managed. UITT leaves virtually no physical trail. The process involves the management of knowledge or intellectual capital inherent in external parties and the TTO. Thus, utilizing the IC framework that deals explicitly with the management of intangible assets is an appropriate approach to analyzing the prerequisites of TTO practices in UITT.

4.2. VPM in a nutshell

Edvinsson and Malone (1997) discuss the significance of IC to an organization. IC consists of three components – human, structural, and relational capital. The component designations used differ from the original designations to capture broader contexts (see e.g., Tahvanainen and Hermans, 2005). IC provides a framework that enables the examination of components in relation to each other. According to the framework's central tenet, even one weak or inadequately managed component of the Value Platform Model (presented in Figure 1) may disrupt an organization's value creation process even when the remaining two components are strong. The model further claims that the dynamic interaction of all three components is the prerequisite for creating value (Saint-Onge et al. in Edvinsson and Malone 1997). In this generic context, knowledge management is the strategic management of the synergetic interaction of the components in a way that maximizes value. The merit of the Value Platform is its comprehensiveness

in capturing the systemic interplay of three central dimensions of organizational development in a single framework (Mouritsen et al. 2000).

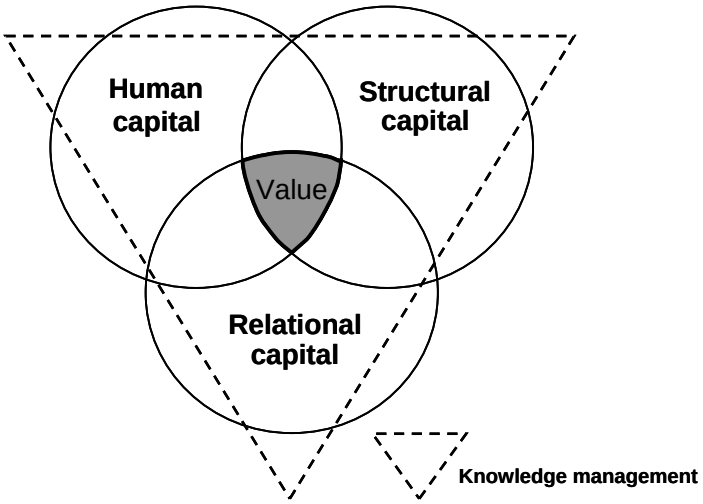

Fig. 1 *The value platform model*

In the following section, we will briefly describe each of the three components of the concept of IC and introduce their TTO equivalents as identified in our data for their use in the analysis in Section 5. For further discussions on the role of IC in knowledge management, see e.g., MERITUM project (2002) and Bontis (2002).

4.2.1. Human capital

Human capital (HC) is defined as an individual's knowledge, experience, capabilities, skills, creativity, and innovativeness (Edvinsson and Malone, 1997). These are interconnected and collectively contribute to workplace success (Ranki, 1999). Sveiby (1997) adds the concept employee competence to this list, 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 HC (Edvinsson and Malone 1997).

The fact that an organization cannot own its HC distinguishes this component of IC from other resources (Edvinsson and Malone, 1997). Despite this fact, competent personnel are fundamental to an organization's ability to realize and develop its ideas (Hansson, 2001). Investments in personnel are as crucial for knowledge-intensive organizations as a mass producer's investment in tangible assets (Sveiby and Lloyd, 1987).

In the TTO context, we identified several key dimensions of HC that are crucial to TTOs' organizational capabilities: For technology transfer officers, a technical background and a PhD facilitate communication with faculty. A technical background is also necessary to understand the disclosed technologies well enough to protect and market them. Furthermore, industrial experience is a prerequisite to understanding industry needs, its incentive structures and its value-creation logics. This understanding is vital to interpreting how an invention complies with value-creation logics and adds value to a potential licensee's business model. Although both types of expertise are necessary and valuable in their own right, it is their fusion in a single individual (the licensing officer) that bridges the gap between the academic and commercial universes. According to our data, the typical licensing officer, who is often responsible for processing a single invention from its initial disclosure to its post-licensing phases (cradle-to-grave principle), had both a solid scientific background, which was usually formalized through an advanced degree in a particular science,

and long-term experience in industry or start-ups (usually ten or more years). A failure to employ officers with such an interdisciplinary background would internalize the gap between academia and industry.

Another central aspect of HC is robust negotiation skills because operating at the interface of actors with very different incentive structures and objectives necessitates the re-alignment of interests, the re-definition of objectives, and the negotiation of viable compromises. Strong communication skills are also paramount in this respect. Solid experience in legal issues, particularly in the field of intellectual property, was another prerequisite demanded from a competent licensing officer. These competencies were rarely required for the purposes of drafting patent applications because this task is often outsourced to law firms. Instead, they were necessary to conduct a proper prior art search and to check a given invention against existing IPRs. Finally, robust organizational and management skills were identified as important to run a TTO efficiently. Organizational skills expand the capacity of the office to deal with the increasing volume of work implied by the 340+ invention disclosures received by the bigger TTOs. Because there is no natural upper limit to the total volume of potential technologies to be transferred, organizational skills can represent a bottleneck that limits annual deal flow. Experience and a sufficiently large support staff alleviate the related problems.

4.2.2. Structural capital

Structural capital (SC) includes patents, concepts, models, administrative systems, and organizational culture (Sveiby 1997). Edvinsson and Malone (1997) define SC as the context, empowerment of employees, and structures supporting human capital, organizational capital, innovation capital, and process capital:

Structures that support human capital include recruiting capabilities, organizational culture, development activities, and motivating strategies. Organizational capital consists of systems and tools, the enhancement of knowledge flows, and organizational competence. Innovation capital includes an organization's renewal capability, results from innovativeness protected by intellectual property rights, and 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. Among others, these are stored in work processes, instructions, and forms, and they result in organizational learning. Organizational culture can be understood as a result of organizational learning because 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) SC further includes all of the codified knowledge and organizational structures an organization has created from its HC or otherwise acquired for the organization. Organizational structure, various documents and databases, and all IPR (patents, trademarks, copyrights, etc.) are included in SC. Unlike HC, the company owns its SC and, therefore, it is also able to sell specific parts of it, such as the databases.

According to our findings, SC in the TTO context includes: team-work based problem solving and the allocation of cases according to matching expertise; TTO internal job circulation for reasons of motivation and organizational learning; the empowerment of licensing officers with autonomous decisions rights regarding entire cases, tracking docket databases, industry out-reach events, formal and informal university and TTO policies; an open-door culture that encourages licensing officers to share HC unrestrictedly within the TTO and across TTOs; monitoring routines; and recreation programs to nurture familiar organizational culture; entrepreneurship contests.

Providing licensing officers with autonomy regarding decision-making rights enables the efficient and unrestricted application of their HC. Structural capital in the form of written policy and unwritten rules is therefore required to keep autonomous decisions within acceptable boundaries. Such rules and policies are internalized through learning, which is facilitated through an open-door culture. Often, such a culture did not emerge accidentally, but is strategically enforced and demanded of the personnel. Given officer's liberties and the emphasis on interaction between them, clear boundaries are necessary to uphold efficiency and to avoid "committee meetings."

4.2.3. Relational capital

Relational capital (RC) 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, university administration, corporate liaisons offices, surrogate entrepreneurs, financiers, intermediaries, entrepreneurship associations and centers, governmental agencies, and collaboration with other parties that are important to the process of UITT. In the traditional knowledge management literature, concepts such as customer capital, networking, and virtual organizations have been associated with relational capital. In this respect, we observe a broader stakeholder base than Siegel et al. (2004), who limit their analyses to university scientists, university technology managers and administrators, and firms/entrepreneurs.

Customer capital consists of the strength and loyalty of the customer relationship. In our context, the most important customer is the faculty inventor, but the industry searching for a license and the entrepreneur willing to license a university technology to build a commercial enterprise around it are also customers. An enduring and trusting relationship between the organization and the customer is crucial to the sustainability of UITT. In a more commercial context, relationships are judged based on penetration, coverage, and loyalty, which are measured as a customer's probability of continuing the partnership (Stewart, 1998). However, even in the context of TTOs, maintaining long-term relationships with inventors and existing licensees is valuable.

The following analysis discusses the value creation logic of sample TTOs by showing how the interaction of IC components is managed to perform organizational practices that add value to UITT.

5. Analysis and results

The TTO operates between two universes: the academic universe and the commercial universe. As reviewed earlier, extant literature has verified the existence of a gap between the two obstructing the process of UITT (Rahm, Bozeman and Crow, 1988; Lee, 1996; Link and Siegel, 2003; Siegel, Waldman and Link, 2003; Siegel et al., 2004; Siegel and Phan, 2005; Jensen and Thursby, 2001; Macho-Stadler, Pérez-Castrillo and Veugelers, 2007). The value created by the TTO, then, is inherent in its many practices, which either dissipate the gap or bridge it. In essence, this implies the conversion of the value created by the academic universe in the form of knowledge into relevant input, which is fed into the value creation process of the commercial universe. The ultimate value to commercial entities and to society does not accrue before that input is converted into applicable products or services unless the created knowledge itself is valuable and can be used for normative purposes, for example.

Below, we characterize each of the value-adding, "boundary-spanning" practices of the TTO as they emerged from our data. We show how, in its capacity as a process catalyst, knowledge converter, and impact amplifier, the TTO employs these practices to (i) decrease the barrier to initiate and sustain the transfer of technology on both sides of the value creation continuum, (ii) effect a match between the supply of knowledge created in the academic laboratory and market-based industry demand, and (iii) maximize the overall societal impact of university technologies by favoring breadth of use over short-term financial objectives.

5.1. TTOs as process catalysts

As UITT catalysts, TTOs are not unlike chemical catalysts that decrease the amount of energy needed to initiate and maintain chemical processes and enable reactions between reagents that would otherwise be blocked or slowed by kinetic barriers. TTOs were found to lower inhibitions, counteract fears and correct prejudices of academic scientists and potential industrial partners that had arisen due to a lack of knowledge and experience, uncertainty, misinformation, and cultural legacies in both the academic and commercial realms. TTOs dismantle these barriers by: performing educational and emancipatory practices; providing guidance for commercialization attempts; solving administrative, IPR-related and other problems that inventors are helpless to solve; strengthening the system of the technology transfer community including entrepreneurs, financiers, and support organizations by serving as a nexus of contacts and, in some cases, by being actively involved in designing business plans; attracting funding; and assembling management teams for university start-ups. In the following section, we review a number of identified catalytic practices and show how they are generated.

Molding academic culture - The academic universe, which is epitomized by the individual inventor, involves catalyzing practices that take the form of educational services. Among other goals, these aim to: familiarize researchers with the concepts of protecting intellectual property and its fundamental centrality in commercializing the results of research; to provide guiding information about the support services provided by the TTO; to build confidence in the TTO's capabilities; to offer detailed instructions and guidelines on the concrete steps to take if there is interest in commercialization; to provide initial insights into alternative methods of financing entrepreneurial activity, and to explain the role of investors in start-up companies.

> "[We] educate students and faculty on everything from IP to how you go from just thinking about research questions to how to go from the laboratory to the market."

> "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."
> "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. […] I think getting them to disclose is not the issue; showing them that you are savvy and able to license the technology [is]. […] You have to get out there and educate them to some degree and try to get them thinking about what you are doing."

According to Markman, Gianiodis and Phan (2006) inventor-related obstructions such as resistance or indifference to commercialization are the main impediments to the UITT process. As a catalyst, the TTO aims to activate researchers

and inventors to gain interest in the possibilities of commercialization and to encourage them to disclose their results to the office by lowering inhibitions and fears and by mitigating prejudices that are attributable to a lack of interest in, knowledge of, and familiarity with these issues. By dismantling inhibitions, discomfort, and prejudices, TTOs mold academic culture toward being more conducive to commercialization and the application of research results, which has been identified as a key driver affecting the willingness of academic scientists to engage in commercial activities (Bercovitz and Feldman, 2008). To this end, the TTO utilizes its own interdisciplinary HC, which comprises both scientific and business knowledge. Further, applied RC is in the form of expertise from law firms, financial institutions, and experienced entrepreneurs. The knowledge that is inherent in HC and contracted through RC is channeled through the TTO's SC to the faculty. SC relevant to molding the academic culture finds expression in established educational events and programs on campus, regular laboratory rounds and related liaison activity, and business courses that are arranged jointly with local business schools.

> "They had a course run by the [local] business school […].They would just go over the whole thing 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. […] it was a great success. […] In physical sciences we meet once a week, […] and talk about new inventions that have come in. It is mainly marketing oriented. […] so we are very active in meeting with faculty members."

Thursby and Thursby (2002) attribute the rise in UITT to a greater willingness of university researchers to patent. Based on the above discussion, we argue that the value added of the educational and emancipatory practices provided by TTOs is evident in a given faculty member's increased propensity to commercialize research. Therefore, this value added is at least a partial contributor to the phenomenon evidenced by Thursby and Thursby (2002). Although Thursby and Thursby measure the increase in UITT based on the number of licensing deals and patents, we favor the number of disclosures per dollar of federal research funding as a primary indicator of researchers' willingness to engage in UITT. The number of disclosures is more neutral to technological, environmental, economic and other factors that are external to the researcher's initial willingness to participate in UITT.

Problem assistance and service - Another cornerstone of maintaining a steady stream of disclosures is to provide faculty with high-quality support services concerning all issues, which not only include their ambitions as entrepreneurs but their work in academic research. Building and sustaining a reputation of being able to solve problems quickly and reliably in all aspects regarding commercialization is key to maintaining long-term relationships with faculty, who are the vital origin of emerging technology.

> "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. […]
> Second, smart people, bright people. The faculty are naturally trained to figure out in five minutes 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. […] 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. […] We understand that we put the academic priorities first, that we listen to them, that we know what we are doing. And when the point comes they come for your advice, not just to do what they want you to do, then you know that you have earned their respect."

Because their primary focus and career interests are mainly academic, the opportunity costs of not participating in UITT are generally low among faculty. Thus, if the TTO were to suffer a blow to its reputation as a service provider, word would likely spread among faculty with devastating effects on disclosure rates. A damaged reputation is difficult to repair as many of the interviewees emphasized.

The services requested by faculty members are too numerous and situation-specific to be exhaustively catalogued here. To provide a few examples, however, one might list: the acquisition of material transfer agreements from third parties; the negotiation of sponsored research agreements in cooperation with the university's contracts office (if it is not integrated into the TTO); solving faculty's infringement suspicions regarding research conducted by fellow or competing scientists; providing live support for questions concerning commercialization; solving conflicts of interest between financiers, the faculty, and the university, and "getting the job done" quickly and effectively. "Getting the job done" is to be understood as an emphasis on being responsive and closing deals as opposed to risk avoidance and administrative back-office tasks.

> "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."

> "I think one of the key ways to fail that I have seen too many times, is that you fall into the bureaucratic mindset. […] 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. […] 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."

Solving a wide variety of problems necessitates the context-specific interplay of different aspects of IC. While tackling prior art-related questions, for instance, is dependent on licensing officers' technical and IPR-related expertise (HC), consultations with external law offices, other university administrative departments (RC), database inquiries, internal procedural guidelines, and university IP policies (SC), settling infringement disputes, as another example, draws on an entirely different set of IC. Here, negotiation and communication skills, diplomacy, and other social aspects of HC come to the fore in an attempt to uphold the involved faculty's motivation to participate in UITT despite the obvious inconveniences involved.

By providing responsive help and support concerning questions and tasks that are not in the traditional domain of the responsibilities and capabilities of faculty members, the TTO brands itself as an easy-to-approach interface between academia and the commercial world. It lowers the faculty's inertia to engage in further commercialization and thereby catalyzes the initial phases of the UITT process. Furthermore, solving specific problems for faculty effectively removes tangible obstacles that inhibit the UITT process and thereby facilitates its sustainability.

Start-up support - The Bayh-Dole Act requires universities to give preference to small businesses when licensing technology. This has resulted in the active promotion of university spin-offs that involve the academic inventors to varying degrees. Although the TTO does not interfere with running the start-up as a business, it often provides valuable services to the inventors in the pre-start-up stage. The degree of involvement depends on the TTO and its policies. Some TTOs follow a laissez-faire strategy and leave issues of business formation entirely in the hands of the inventors or surrogate entrepreneurs.

> "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."

> "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. […] 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."

Offices that represent the other extreme are actively involved in securing financing, building management teams, establishing the organization of the start-up and feeding it a complementary IP.

> "[…] 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. […] 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 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."

More subtle approaches that are closer to the average degree of involvement include support in writing business plans or in preparing presentations to investors or entrepreneurs who are interested in taking the commercialization process further. The lack of these services has been identified as constituting one of several nonnegligible bottlenecks in UITT (Swamidass and Vulasa, 2008).

> "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. […] 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."

Preparing business plans and presentations necessitates a conversion of purely technical features and scientific insights related to an invention into commercially saleable concepts and viable business models. In addition to the catalytic function, it establishes the TTO as a converter of knowledge between academia and industry. Converting knowledge is probably the most significant practice a TTO performs to add value to UITT because it bridges the gap between the fundamentally different human capital of the academia and the industry. This fundamental difference is a major factor behind the incongruence of university technology and market needs. We shall return to the subject later, in Section 5.2.

To effect the conversion, HC in the form of the interdisciplinary expertise of the individual licensing officer, which combines solid scientific understanding and business sense, is a prerequisite. RC is involved in the process such that business plans and presentations are developed in cooperation with contacts in industry and finance or with the help of local centers for entrepreneurship and business schools, for example. The organization of business plan contests refereed by guests from industry is one example of the involvement of SC in the process.

Furthermore, leveraging its network of actors in industry, government, and finance (RC), the TTO actively introduces inventors to potential partners in an attempt to bridge the usually wide gap between the respective networks. Bringing the actors together is essential to the success of UITT because the TTO cannot replace the inventor, who is the ultimate expert in relation to the respective technologies. Because technology largely consists of a tacit component

proprietary to and inherent in the inventor, its successful transfer inevitably necessitates the personal interaction of the inventor with the individuals who promote the business, whether as an active member of the staff or management or, in a more passive role, as a member of the scientific advisory board (see Nonaka and Takeuchi, 1995, for the transfer of tacit knowledge in organizations). The active participation of the inventor has been argued to increase the probability of transfer success (Jensen and Thursby, 2001) and speed (Markman et al., 2005b). Therefore, providing the right connections can be argued to add value to UITT. Here, the TTO functions as a catalyst that actively initiates the reaction between two or more reagents that self-sustainably propel the process toward the final commercialization of an invention.

Figure 2 below summarizes the above findings and conceptualizes the catalytic practices according to Edvinsson and Malone's (1997) Value Platform Model, which was discussed earlier. We apply the model here to emphasize the importance of the synergetic interaction of TTO resources in the generation of practices as identified by the interviewees. Again, we must emphasize that the model was not used to interpret the data, i.e., to identify practices, and that it has been used in this paper only because it tightly conforms the manner in which the interviewees depicted resource interaction.

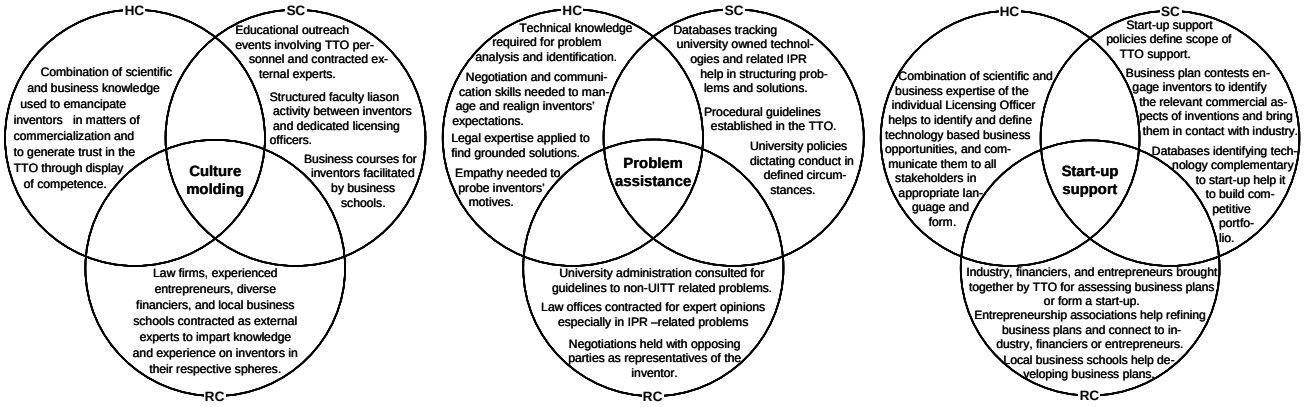

Fig. 2 *Practices of the TTO as a process catalyst*

5.2. TTOs as knowledge converters

In their role as knowledge converters, TTOs add value to UITT by affecting the congruence between the features of scientific discoveries and specific market needs (i.e., customer preferences, profit requirements and business models). To do so, TTOs open and maintain a bi-directional feedback loop between the academic and commercial universes. TTOs convey invention-specific responses that are gathered from industry through marketing and other related outreach practices (conventions, business plan competitions, etc.) to the academic inventor who is then able to incorporate the insights and specifications into the invention and increase its commercial value. In the following section, we will present a selection of identified conversion practices and the underlying interaction of IC resources.

Technical assessment *- One of the central functions performed by the TTO is the technical evaluation of invention disclosures. The evaluation determines a technology's viability to be protected and licensed and whether the office will pursue the respective UITT process further. Licensing officers use their scientific expertise to initiate a rigorous prior art search. During the search, measuring the features of a given invention against the existing technological landscape and the related IPR protection requires the ability to grasp the essence of the prospective technology. One must be*

able to perceive and understand the essential differences and similarities to existing technologies to be able to make comparisons. In fact, one must be able to identify the boundaries of the relevant technological field against which the prospective technology is measured. Here, an in-depth understanding of the particularities of the given technology is paramount because the decisive differences between existing and protected technologies, as well as between the applications of these, can be minuscule. Again, parts of the IC base of the TTO are activated: A robust technical background (HC) is argued to provide the foundation for understanding technologies, identifying their key features, and determining whether these are relevant to a given case.

> "I would much rather have somebody with a very strong technical background […], because the heavy work, the most time-consuming work, is done at the front-end, where you're understanding what the technology is, you're doing very extensive prior act search to make sure this is a novel idea."

HC in the form of the licensing officers' scientific knowledge and experience in IP legislation is complemented by RC in the form of services from external law offices that specialize in IP protection and support in the prior art search. In addition, the expertise of the inventor, which is brought to bear through intensive cooperation during the search, is crucial to the outcome because the relatively generic technical knowledge of licensing officers can never substitute for the knowledge of the inventor, who is the ultimate expert on the technical dimensions of his invention.

> "And to be honest, it's highly technical work. It's a wide variety of technologies that you deal with. You have to know enough detail to understand the important parts, but you can't become the technical expert, that's the faculty member."

SC that supports and facilitates the evaluation process comprises the comprehensive technology and IP databases that are maintained by most of the offices, as well as regular internal meetings and more informal knowledge sharing that facilitate the identification and diffusion of case-relevant knowledge among licensing officers. The allocation of cases in accordance with their respective fields of expertise makes efficient use of the entire stock of available HC in the office and enhances its effectiveness at the same time. A culture of open interaction and the frequent strategic absence of incentive structures and compensation schemes that are tied to monetary or other performance-related indicators promote the uninhibited and comprehensive application of the office's HC because competition among officers is reduced to a minimum.

> "We get 500 invention disclosures a year. So, that is 10 a week. […] 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. […] 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 […]."

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 foundation for profitable business. Limited freedom to operate in the technological dimension entails equally limited freedom to operate in the commercial dimension, which lowers the value of an invention. Thus, by screening out unviable technologies, TTOs add value to the UITT process (i) by reducing the total flow of technology to inventions that have an obvious potential to survive IP protection, (ii) by sparing the university redundant costs that are related to IP prosecution and marketing, and (iii) by

sparing the inventor unnecessary strain and disappointment related to unfulfilled hopes of commercial success. Regarding the first two aspects, screening is of utmost importance when considering the efficiency of the UITT process. Regarding the last aspect, the early assessment of technical potential is crucial to the successful management of inventors' expectations and to sustaining their continued motivation toward the commercialization of research, which is a prerequisite of sustainable UITT.

> "The biggest challenge we have is managing expectations that every innovation made should be a very successful proposition, and that every innovation is worth half a million to five million dollars to the industry. That is quite common and I guess it is expected, because if you are the inventor, and you have been doing research in the field for a decade, or five decades, and you bump into this great idea. Emotionally, psychologically, you are very attached to it."

Search practices - From the perspective of any given invention, marketing activities are the first to initiate contact with industry. Efficient marketing requires the identification of the industrial actors that the invention might potentially provide benefits to. 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 method among the TTOs in the sample. As a more focused and strategic way of marketing new technologies, TTOs lean heavily on the existing RC and its contacts. A proper search for suitable industrial partners considerably lowers transaction costs in the subsequent intense marketing phase, which allows a focused allocation of resources. The search process itself can be burdensome, however, because the mere identification of potential licensees requires interaction with each prospect.

> "It starts as a kind of dating service: "*Are you interested in blondes, are you interested in brunettes? Well, I got one who is blond but she is 6'3'', do you mind if they are tall?*" So I describe a little bit what [the technology] is about and why it is interesting and then send them off to talk with the professor. And if they get further interested, then they come in, and we will send them a term sheet or a draft license agreement, and then we start talking."

Frequently, initial contacts are also provided by the inventors because they have personal experience in the industry and are familiar with contacts through prior industrial-sponsored research projects or conferences, for instance (cf. also Thursby, Jensen and Thursby, 2001).

> "It is the actual inventors 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."

To implement an effective search, licensing officers must have the appropriate technical and industrial expertise (HC) to analyze the technology bases of potential licensees for sufficient compatibility with the invention. The officer needs to be able to convert technical specificities into industrial solutions and to identify their potential as parts of larger and systemic existing solutions. Locating companies with the right technological base is insufficient, however, because the success of establishing durable communication links to these organizations and transmitting the intended information depends on locating the appropriate individuals and on the licensing officers' ability to elucidate the key features of an

invention. The importance of individual-level contact is also recognized by Siegel et al. (2004). Technical expertise facilitates the identification of these individuals because it enables licensing officers to communicate with industrial partners on a sufficiently deep level.

> "I [prefer] somebody with a strong technical background. [They are able to] identify companies, who are in the field, identify individuals within those companies, who we should be in touch with. […] These are very raw ideas that we are trying to find partners for, these are not ideas or prototype products that really need to be polished and packaged and managed to customers. These are ideas that nobody knows whether there is a market, whether there is anybody to pay anything to buy these things, or what type of products might come out of these ideas, even that is not known."

Established partners who belong to the existing RC of the TTO and the inventor are well known and familiar, which is a valuable asset in finding a compatible customer, because search costs are comparatively lower than in the cold-calling mode. In existing relationships, organizational procedures and norms (SC) are also well known, and personal ties have already been formed, which mitigate the costs of establishing functioning and trustful communication. If a suitable and interested customer is not to be found in the RC of a TTO, existing contacts are exploited as indirect links in the search. The actors who compose a TTO's RC are embedded in networks that can be accessed through recommendations and suggestions. With every new contact, the RC of the office grows and can be leveraged in future. Because it searches industry for potential licensing partners, the TTO excuses the inventor from this strenuous and time-consuming task. Because it has a comparative advantage over the inventor, the office: experiences greater outreach due to its broad RC base; is better able to identify potential partners through its interdisciplinary HC, which is not limited to a given field of science or business; and has more monetary and structural resources (databases, personnel, etc.) to use in the search. TTO search practices thus add value to UITT by increasing search effectiveness (if not efficiency) and the probability of finding suitable licensing partners.

Feedback looping - After potential licensees are identified in the initial search, rigorous marketing ensues. As discussed earlier, a major objective of TTO marketing practices involves obtaining feedback from industry. The office mediates invention-specific feedback, which is collected from the industry in the early phases of marketing a particular invention to the academic inventor. Based on that feedback, she can make necessary modifications to the invention to raise its commercial applicability and value. The modifications are then presented to the industry for additional comments or to close a licensing deal. Feedback sharing between industry and inventors constitutes 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 in this technology, and if you do not see any interest from your company, do you know others, who may be doing something similar and might have an interest?*" 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 network expands."

Again, the interdisciplinary HC, which fuses scientific and business savvy into one individual licensing officer, is paramount to converting the mainly technical specifications of a marketed invention as provided by the inventor into marketing jargon that highlights the business solutions the technology is able to support. Further, the interdisciplinary HC is necessary to incorporate feedback provided by the industry into technical specifications that the invention will 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 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."

For the purposes of gathering relevant feedback on a given technology, the TTO must be have a large and diverse base of industrial RC because finding actors who are capable of providing relevant feedback with regard to a specific technology is not a trivial task. In the form of docket databases that track case-specific details (contacts, recommendations, dialogues, requests, demanded specifications, agreements etc.) that help codify the evolution of inventions through the iterative feedback loop between the inventor and industry, databases with information on industry contacts who mitigate the search costs related to identifying potential sources of feedback, regular TTO internal meetings, and an organizational culture that nurtures knowledge sharing. Through knowledge sharing, the relevant HC is allocated to cases within the office, which underlies efficient marketing practices. The allocation of the relevant HC to cases is of special importance because the effectiveness of the knowledge conversion depends heavily on the licensing officers' ability to link technological features to business solutions and vice versa.

Regarding value creation, feedback looping actively helps establish the vital bi-directional bridge to the commercial universe through which knowledge is diffused and encourages the active involvement of industry in the transfer process. O'Gorman, Byrne, and Pandya (2008) argue that "the principal benefit of the TTO is in the domain of putting external resource providers in contact with scientists committed to commercialization." In so doing, they can "help individuals or organizations with resources learn of new knowledge developed by scientists." We find that TTOs have an even more pivotal role: As a knowledge converter, the intrinsic value of TTOs lies in their affect on the congruence between features of scientific discoveries and specific market needs by maintaining the bi-directional iterative feedback loop between the academic and commercial universes. This notion extends on Siegel et al's (2004) discourse on the bi-directional interaction between academia and industry by showing how it benefits UITT and society in a much broader sense than a single researcher's ability to conduct "better research."

Figure 3 summarizes the findings and conceptualizes the interaction of the IC resources that are required to generate the respective practices.

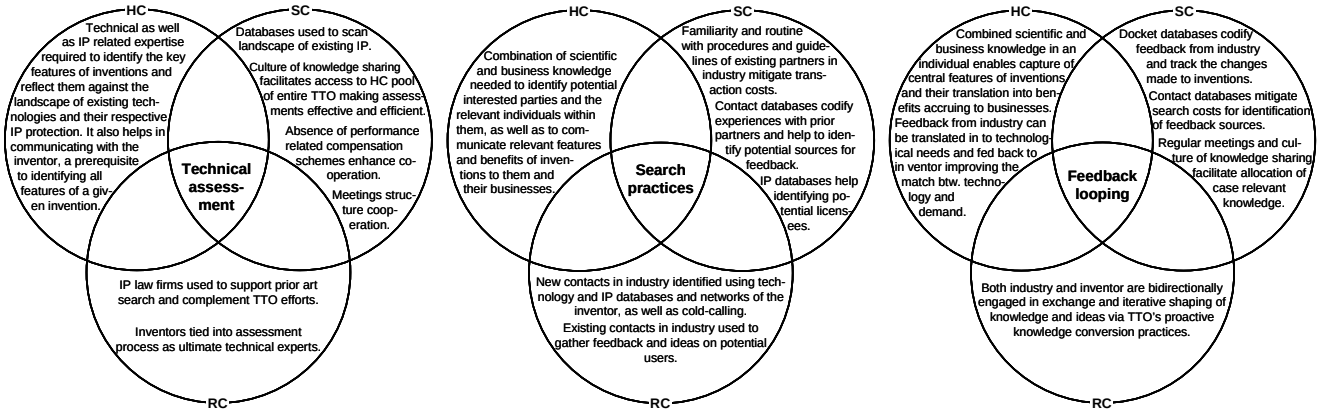

Fig. 3 *Practices of the TTO as a knowledge converter*

5.3. TTOs as impact amplifiers

Unlike previous studies (e.g., Siegel, Waldman and Link, 2003, and Siegel et al., 2004), we found that the maximization of monetary returns and other volume-related indicators such as deal flow were de-prioritized as indicators that were monitored to track TTO performance. Aside from one of the universities we studied, the interviewees clearly distanced themselves from return-driven TTO policies for a number of reasons that are discussed in greater below. Instead, there is a clear emphasis on maximizing the greater societal impact of university technologies and supporting the university in its primary tasks of education and research. Thus, most of the TTOs involved in this study were geared toward maximizing the breadth and speed of application of university technology.

The reasons not to adopt revenue stream-focused strategies alone are manifold. First, pure revenue streams seem to be an unreliable measure of value creation because creating significant revenues is viewed as a numbers game, or a matter of "getting lucky," and not as the main function of TTO activities. "Doing things right", as an interviewee stated, does not guarantee commercial success due to the technological and market uncertainties inherent in early-stage technologies that are independent of TTO actions (see also Macho-Stadler, Pérez-Castrillo and Veugelers, 2007). Further, licensing revenue generation is dependent on the commercialization abilities of the licensee.

> "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."

Second, maximizing profits by focusing only on transfer transactions that are expected to reap the highest payoff might compromise the transfer of technologies that could potentially have great societal or human impacts. Third, when only the few inventors who are accountable for potential blockbuster technologies are served, the majority of the faculty will be dissatisfied with the office's services. The problem is that this dissatisfied majority of inventors constitute a potential source for future blockbuster technologies.

> "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. […] 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. […] Everybody gets a basic level of service when they submit the disclosure. Maybe [it generates] low dollars and maybe high dollars, but we are going to do the same basic service for everyone."

Fourth, publicly financed universities, which have an implicit societal mission to strengthen local economies, are constrained in measuring their success in terms of revenue. The goal of maximizing the university's profits stands in strong contrast to (i) the taxpayers' perceived right to benefit from technologies that are largely generated based on taxes they paid and (ii) the expectations of paying licensees that their royalties will be injected into the local economy in one form or another. Obviously, private university TTOs do not have these same constraints.

> "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*."

Finally, some technologies require the bundling of single inventions to comprise an economically viable 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. TTOs 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.

> "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. When an invention is disclosed [from such a project], there will be no separate license deal, however, because most of the terms are already part of the research agreement […]. So, I know that different universities have very, very different criteria for doing this counting and even though we are regarded as a low number of deal flow in terms of licenses, I do not want to change it."

How, then, do TTOs maximize the breadth of application that some interviewees seemed to prefer over others? We found this process to be less about concrete action than about a philosophy of picking the option among a set of alternatives, which most likely results in the application of a technology. This does not necessarily have to coincide with the most lucrative option in terms of possible economic returns.

> "I look at the resources put on the table, and by resources I don't mean just the financial capital, but the human capital, the understanding of that human capital in the technology, and whose proposal really indicates the fastest [track from] the development phase through to the product […]. Even if a large corporation offers me a huge amount of upfront fee that a start-up company cannot, I still would not go to that one million, if it's a huge amount as much as one million, if it looks like the start-up company would really aggressively develop it and take it to market. So, [the question is] really, what makes sense for that particular technology, for that particular market, and who are offering the most resources to develop it."

Applying such a philosophy is a balancing act between the diverging objectives of intrinsically opportunistic UITT actors and upholding incentives structures for all involved parties. As an impact amplifier, the TTO mitigates the detrimental effects that the opportunistic incentive structures of the diverse stakeholders might have on UITT. Left to determine an equilibrium outcome for UITT on its own, the system of opportunistic actors might converge toward suboptimal solutions at the cost of the diffusion of technology and the benefit to society. We provide support for this argument in the following section.

Maximizing diffusion *– Regardless of whether the university in question is public or private, interviewees insisted that putting a technology to use in society is regarded as more important than its licensing terms or the monetary benefit that accrues to the office or the respective university. Maximizing technology diffusion and public benefit more broadly involves various concrete measures.*

A fair number of these measures were outlined in the form of stipulations in a public initiative publication (December 2009) signed by 51 US university TTO,s including all but one that participated in this study: In the Public Interest: Nine Points to Consider in Licensing University Technology (available at http://www.autm.net/White_Papers/ 2188.htm, last accessed on September 28th, 2009).

Among other things, the stipulations prompt TTOs to design license agreements in a manner that allows the office to "reserve the right to practice licensed inventions and to allow other nonprofit and governmental organizations to do so" 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 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 a "significant investment of time and resources in a technology" is 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 its potential negative impacts on unanticipated uses, further research, future commercialization efforts and markets.

Further, the unnecessary licensing of "future improvements" of existing licensed inventions should be considered carefully 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, who operate according to the "value added" model, gather coherent and comprehensive IPR portfolios from multiple sources around single technologies. Thus, they are in a position to provide themselves or secondary licensees with great freedom to operate. Because universities are not able to assemble such portfolios, the stipulations of the initiative publication argue that "value adding" aggregators "serve an important translational function in the successful development of new technologies and so exert a positive force toward commercialization," In contrast, aggregators that operate under the "patent troll" model represent pitfalls to be avoided. Trolls strive to obtain broad rights that apply across technological fields. Their intention is not to develop the technologies but to strongly limit other actors' freedom to operate.

Finally, agreements should include provisions that attend to special societal needs such as the therapeutic, diagnostic, and agricultural needs of the developing world or of patient populations that are too small to be of interest to commercial ventures. These provisions would be designed to ensure that orphan markets have access to relevant

technologies at little to no cost. To provide an illustrative example, in addition to donating the rights to a therapeutic technology that addressed an orphan population to the central association corresponding to the underlying disease, one of the sampled TTOs offered its own proprietary funds to develop a prototype of the therapeutic instrument that was later used to treat the disease.

The principles outlined above, which guide licensing officers in their decisions and negotiations, form an integral component of a TTO's SC. In conjunction with other written and unwritten guidelines, they serve two primary purposes. First, the principles set tangible boundaries for the autonomy of licensing officers, which ensures that the correct decisions are made regarding which organizations to partner with and what outcomes to favor to achieve intended goals. Setting well-defined boundaries provides officers with greater autonomy in applying their expertise in an environment that is too dynamic for rigid hierarchies in decision-making.

> "You need clear policies, no exceptions, so everything doesn't deteriorate into a committee meeting. [Establish] clear boundaries and then give people autonomy within the boundaries. It is the ideal way of doing things anyway. The place can be called controlled chaos. The new president who is not from [this university's] culture is trying to bring the chaos under control. We are not sure if that is a good idea. It is a long, long history of letting smart people do the right thing, and they figure it out."

Second, the principles integrate the generic TTO mission to benefit mankind while preserving the university's primary mission of education and research into licensing officers' daily decision-making. The systematic absence of performance-related compensation schemes for licensing officers is a structural solution that further precludes opportunistic decision-making by officers that could lead to suboptimal deal structures, for instance, piece-meal licensing, that counteract the impact-amplifying effects of the principles discussed above.

To apply the above policies in choosing licensees and structuring deals, the licensing officer must have diplomatic negotiation and communication abilities (HC) because many of the stipulations impose restrictions on the preferred solutions of other actors such as industrial for-profit licensees.

> "You also have to have negotiating skills. You really have to be able to see the other side. It is more diplomatic negotiation than negotiating the price of a car, because you are going to be living together for a long time. 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 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."

The licensing officers are entirely responsible for generating incentives for involved parties that guarantee the sustainability of the UITT process. Thus, their ability to argue the benefits of proposed solutions to the industrial partners net of the imposed restrictions is critical. In turn, this ability requires considerable understanding of the licensees' business models, technological portfolios and markets. Again, technological expertise and business acumen prove to be central aspects of the prerequisite HC. Establishing the "rules of the game" and thereby gaining credibility with industry is achieved though the common commitment of the larger TTO community (RC) to the rules. Active relationships with other TTOs are a vital part of the RC of the sampled TTOs. The relationships to other TTOs were systematically characterized as cooperative and noncompetitive. The emergence of such an initiative as the Nine

Points to Consider in Licensing University Technology is a tangible artifact that attests to a shared view of which objectives TTOs should emphasize. Finally, society's perception of the university's role and the expectations implied by that role represent another important stakeholder in the determination of the principles a TTO must take into account when developing its decision-making protocols.

Monitoring infringement and noncompliance of deals *- The last value adding practice that will be discussed in this study is the monitoring of closed licensing agreements. This practice is essential to the longevity of UITT because the strength of IP protection is equal to the credibility of its prosecution. Even though clauses included in license agreements to ensure the rapid and broad application of a technology only take effect if they are enforced, the determination of the true advantages of infringement and noncompliance prosecution is not straightforward. Prosecution is not recommended if no direct benefit to the transfer process can be expected because involvement in lawsuits seldom reflects well on any of the involved parties. Prosecution might do more harm than good in the long run, especially in cases where an infringer is a great contributor of industrial sponsorships to the university's research endeavors.*

> "[…] 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."

Monitoring practices add value to the UITT process in two ways. First, they add credibility to the enforcement of IP protection regarding university technology. An academic inventor not only lacks the means and expertise to search for possible cases of infringement but also lacks the appropriate resources to follow up on any infringements that are detected. The TTO, which is supported by the university's infrastructure and resources, is a much more credible opponent. Therefore, one aspect of the value added by monitoring practices is the difference in the volume of infringements and cases of noncompliance from a scenario in which the inventor is responsible for the enforcement of IP.

The second aspect of value added is inherent in the TTO's ability to respect the university's societal mission when enforcing IP. Because licensing officers seldom directly benefit from an increase in licensing income or other comparable metrics due to the absence of performance-related compensation schemes (only one office included in this study employed deal volume-related compensation to licensing officers), the stipulations and principles discussed earlier weigh heavily in decisions regarding whether and how enforcement action should be taken. Maximizing the breadth of use and speed of diffusion, considering a deal's impact on the university's ability to conduct further research on the technology in question, and protecting the university's dual reputation as an academic institution and as a partner in industrial cooperation are just some of the priorities considered when choosing an IP enforcement action. The incentive structures of all parties involved in UITT, including the inventors, the licensees, the universities and the greater public, must be respected to ensure the longevity of the process. As on interviewee stated, although single actors tend to be "myopically focused on their own what's-right-in-front-of-me," TTOs are able "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."

Effective monitoring and follow-up action engages a TTO's entire IC base. While the code of conduct that emphasizes the long-run sustainability of UITT and maximizes diffusion is an artifact of SC, HC is required in the form of technical and legal expertise to detect infringements and assess their severity. Negotiation skills are also necessary to solve conflicts diplomatically without breaking the UITT continuum. Further, external law firms, which provide expert legal support, are a central example of the involvement of RC.

Figure 4 summarizes the findings and conceptualizes the interaction of IC resources required for the generation of the respective practices.

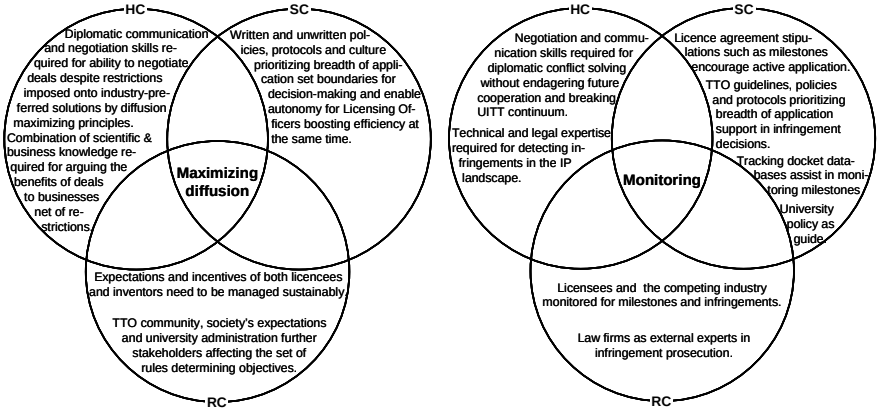

Fig. 4 *Practices of the TTO as an impact amplifier*

6. Discussion and conclusions

In this inductive study of 7 US university technology transfer offices (TTOs), we set out to identify the added value of the practices that TTOs perform to bridge the infamous gap between academia and industry in university technology transfer (UITT). To this end, we inductively characterized various core practices and some of the respective resources underlying these practices. We were able to establish three central concepts for the value added that the offices provide by considering the TTO as: (i) a process catalyst, (ii) a knowledge converter, and (iii) an impact amplifier.

As process catalysts, TTOs lower the threshold to participate in and sustain the process of UITT on both sides of the transfer continuum, that of academia and of industry. These thresholds are caused by various factors, including lack of experience with commercialization, cultural barriers, IPR issues, economic, professional and other uncertainty, misinformation, and prejudices. TTOs lower thresholds by educating and emancipating researchers, giving them personal guidance in commercialization, settling disputes, solving problems that inventors cannot solve, serving as a nexus of contacts, and, depending on university policy, designing business plans, attracting funding, and assembling management teams for university start-ups.

As knowledge converters, TTOs open and maintain a bi-directional iterative feedback loop between the academic and commercial universes by bringing technology-specific responses gathered from industry through searches, marketing and other related outreach practices (conventions, business plan competitions, etc.) to the academic inventor who can incorporate these insights and specifications into the invention to increase its commercial value. Changes to the invention are then presented to the industry for iteration. Through search practices and feedback looping, the office

facilitates congruence between the features of scientific discoveries and specific market needs (i.e., customer preferences, profit requirements and business models). The tangible value that these practices add is related to the TTO's ability to convert the essence of an invention's technical features and the respective industry feedback into concepts and propositions that can be appropriated by industry and the academic inventor, respectively.

As an impact amplifier, the TTO mitigates the detrimental effects that the opportunistic incentive structures of diverse UITT stakeholders might have on the scale, scope and speed of the technology transfer. It thereby amplifies the impact a given technology will have on society and the environment. Left to determine an equilibrium outcome on its own, the system of opportunistic actors with divergent objectives regarding UITT might converge toward suboptimal solutions on the cost of the diffusion of technology and the societal impact. For instance, licenses to inefficiently small parts of technology could be granted; IPR could be licensed to patent trolls that only use patents to strategically block competition; infringements could be prosecuted without considering long-term detrimental effects to the university; licenses could be structured in ways that impede further academic research related to the underlying technology; the breadth of use might be endangered by exclusive licenses; and improvements to existing technologies might be obstructed if ex post additions to licensed technologies are included in licensing contracts. To prevent value-destroying opportunistic behavior, the TTOs in our sample apply a set of principles and stipulations that favor breadth of use over purely monetary objectives when managing stakeholder expectations, considering potential licensees, structuring licensing deals, and monitoring infringements.

The TTOs' motives as an impact amplifier necessitate further discussion. In a cynical world where the "educational industry" is increasingly competitive and incentive-driven, one must inquire as to the origin of universities' motivation to diffuse technology at all costs and to favor technological impact over income. If resources for universities' primary functions of research and education are limited, why should universities allocate them to a function that does not necessarily provide any additional resources and might even incur losses? How do a university's research and education missions benefit from the distribution of technology? Despite the empirical evidence gathered by this study, these questions cannot be conclusively answered. However, we argue that profits and other monetary indices are comparatively of little importance to a university's reputation, its impact in the academic world, and its capability to attract high caliber faculty and students. They do not necessarily convey signals of academic merit or a high standard of research and education. In contrast, the number and impact of technologies that have emerged from a given university are important markers of that university's academic achievements.

We provide the case of Yahoo! as an illustrative example. Although it was conceived by two Stanford University students in their spare time, the company has been one of the most popular Internet services for many years. Because the students used their own resources, Stanford University has no rights to the algorithms used to run the Internet portal. Nevertheless, Yahoo! has benefited Stanford greatly because the credit for developing the students' abilities and entrepreneurial drive are credited to the university and its progressive education.

We argue that the societal impact and application of breakthrough technologies, rather than their revenues, are important signals of a university's standards and quality of education and research. This signal provides universities with an important edge in the competition for key faculty, ambitious students, and a rank among top universities.

> "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."

Thus, we argue that universities have strong internal and strategic incentives to maintain TTO operations with the ultimate objective to diffuse technology as broadly as possible.

In addition to establishing the TTO as a process catalyst, a knowledge converter, and an impact amplifier, the study showed how the scrutinized TTOs manage key resources and, more specifically, their Intellectual Capital (human, structural, and relational capital), to generate organizational practices that underlie the three constructs of value added. Perhaps the most crucial of the identified resources was the amalgamation of solid technical expertise and extensive industrial experience in the individual licensing officer. The fusion of capabilities from both the academic and the industrial universes was a prerequisite to most of the value adding practices analyzed in the study. However, such boundary-spanning human capital is effectively applied only if it is supported by practice-specific structural and relational capital.

The study's inductive approach to linking resources to practices and practices to value creation enabled us to contribute to the existing literature on TTOs. Much of the existing body of knowledge focuses on estimating the so-called TTO production function. Identified inputs to UITT are estimated against a variety of performance measures in the TTO context (Friedman and Silberman, 2003; Lach and Schankerman, 2004; Thursby and Kemp, 2002). While the mechanisms through which inputs are transformed into performance are based on intuitions, logics and arguments derived from previous (mostly quantitative) literature in these studies, the extant approaches typically fail to provide first-hand evidence and an explicit, in-depth understanding of the inner workings of the production function. The questions of "why" and especially "how" have received little attention because previous studies have focused on finding statistical explanatory power between a set of variables. More recent contributions to the literature have taken up the challenge to examine the role of organizational practices in the generation of TTO performance (e.g., Siegel, Waldman, and Link, 2003, Siegel et al., 2004, and Sorensen and Chambers, 2008) and made initial steps toward generating qualitative explanations of the production function. However, even these attempts have made few conceptual connections between resources and practices and their role in generating value to UITT. It is claimed that data indicate that certain resources are vital to performance, but little is said about the intuition behind this connection, i.e., about how a particular resource enables a specific practice and thereby affects a certain aspect of value generation.

Therein lies the contribution of the present study. We illuminate one corner of the black box that has thus far obscured the TTO production function to (i) show the dynamic interaction of the central resources that underly the generation of key organizational practices, (ii) identify and characterize those practices and demonstrate their centrality to the role of TTOs in UITT, and (iii) argue how these practices add value to the UITT process. Providing the internal intuition for the process starting with resources and concluding with the value added enables one to explain why the lack or mismanagement of certain key resources can be considered detrimental to UITT, which processes it might obstruct, and what kind of value might be forgone.

We further contribute to the empirically weak literature on Intellectual Capital by qualitatively analyzing the interaction of IC components in empirical cases. The categorization of resources implied by the Value Platform Model of IC was shown to be a well-suited approach to capture resources that are quantitatively difficult to measure and link to organizational practices. Having previously been the subject of theoretical debate, the framework was shown to be highly applicable in empirical research. However, it is emphasized that such application is only feasible under considerable context specificity. This aspect is one of the framework's central strengths.

Regarding managerial implications, in showing how the three components of intellectual capital are managed to generate value-adding practices, the study implicitly presented a model of TTO management, the basic principles of which are applicable to TTOs worldwide. While specific practices and functions may strongly depend on local, regional, or national contexts, the governing principles implied by the case study are universal. Among others, these include employing interdisciplinary licensing officers endowed with both technical expertise and personal industry experience, abandoning purely profit-maximizing objectives, and focusing on serving the faculty as a cherished customer and valuable resource.

A few caveats must be issued regarding the study setting. First, the results are not generalizable. They are not intended to represent the average university technology transfer office because providing a general description of TTOs not the aim of the study. Instead, using a handful of select experienced cases, the intention is to understand the TTO's role in the technology transfer process and how the office adds value to this process as constructed from the underlying cases. Thus, deductions should be made with care and awareness of the underlying generalizations.

Second, given the focus on 7 relatively successful TTOs, we cannot derive normative implications based on the results, i.e., we cannot claim that by strictly following the example of the TTOs in our sample, other TTOs will achieve comparable success. To make such claims we would have had to (i) include a number of less successful offices in the sample and (ii) apply comparative techniques to discern practices that have a decisive impact on TTO performance. Our focus is on making sense and providing an understanding of the TTO production function and the value added by the underlying organizational practices. We do not claim to measure the production function or to compare value added among the sample TTOs.

Third, in line with the above caveats, it must be recognized that TTOs operate in strongly local environments. Some offices in the sample are embedded in unique environments that are especially conducive to the transfer of technology. Thus, implications drawn from the results must be applied with care in contexts that are less favorable to UITT.

Fourth, it is fully recognized that UITT is a complex process in which TTOs play only one of many roles. A TTO is not an isolated entity that is capable of providing value to the process detached from its systemic environment comprising the regional entrepreneurial culture, government interventions, the structure and dynamics of national innovation systems, the availability of risk financing, and other contextual factors. 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 as a whole. We emphasize this throughout the study by concentrating on the value added of TTO practices.

Fifth, despite the prevalence of the term "process" in the terminology of this study, we primarily investigate constructs (intellectual capital, practices, and TTOs as catalysts, converters, and amplifiers). We do not claim to construct a process flow, but use the framework of UITT to position individual practices and to illustrate their value. The existence of the process as such is assumed a priori based on its established treatment in the existing body of knowledge. Phan and Siegel (2006), for example, discuss the flow of certain resources such as money, intellectual property and information in the technology tranfer process.

Finally, the practices reported in this study are not exhaustive. Many others arising from the data could be argued to add value to the process of UITT as well. Due to space and scope restrictions, and for the sake of coherence, only the practices that were most prevalent in each of the interviews are reported.

To conclude the study, some valuable avenues for future research should be discussed. Because the focus of this study was to establish a conceptual framework that identifies the value-adding TTO practices of a small set of experienced offices and to place them into a coherent context, more rigorous empirical testing could not be incorporated into the

limited space available. There is a clear need to follow up our efforts with a survey of a larger sample of TTOs to verify our conclusions and interpretations regarding their role in UITTand the variety of practices they perform and, most importantly, to explore how widespread such practices are among TTOs. In a large-scale setting, one could also test whether these practices have a statistically significant impact on UITT outcomes. Another potentially fruitful approach to the phenomenon would be to apply comparison and contrasting techniques to highlight the variation in practices to provide greater insight into the challenges facing the UITT process and to discuss the range of behaviors and practices employed by TTOs.

7. Acknowledgements

The authors express their gratitude to the participants of the Scancor seminar at Stanford University in June 2007 for insightful and valuable comments regarding research design and implementation.
We gratefully acknowledge the funding by the Foundation for Economic Education, Finland, the Academy of Finland, the Instrumentarium Science Foundation, the Jenny and Antti Wihuri Foundation, the Finnish Cultural Foundation, and the Yrjö Aitto Foundation [3].
Special thanks go to the anonymous interviewees at the seven technology transfer offices in our sample for providing us with the vital empirical evidence for this study, and to the Research Institute of the Finnish Economy for providing research facilities.
Lastly, we want to thank Dr. Tomi Hussi for his valuable comments on the Intellectual Capital framework..

8. References

Ali-Yrkkö, J., Hermans, R., Hyytinen, A., Lindström, M., Paija, L., Pajarinen, M. and Ylä-Anttila, P., 2004. Finland and Europe in the international division of labor – An analysis of the competitiveness of industrial sectors and clusters. In Finnish. Prime Minister's Office 20/2004, Helsinki, 124 pp.

Baldwin, R., 2006. Globalization – The great unbundlings. Prime Minister's Office. Economic Council of Finland, Helsinki, 50 pp.

Bercovitz, J. and Feldman, M., 2008. Academic Entrepreneurs: Organizational change at the individual level. Organization Science, 19(1): 69-89.

Bercovitz, J., Feldman, M., Feller, I. and Burton, R., 2001. Organizational structure as a determinant of academic patent and licensing behavior: An exploratory study of Duke, Johns Hopkins, and Pennsylvania Universities. Journal of Technology Transfer, 26(1-2): 21-35.

[3] The funding sources had no involvement in study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

Bontis, N., 2001. Assessing knowledge assets: a review of the models used to measure intellectual capital. International Journal of Management Reviews, 3(1): 41-60.

Bontis, N., 2002. Managing organisational knowledge by diagnosing intellectual capital: Framing and advancing the state of the field. In: Bontis, N. (Ed.), World Congress on Intellectual Capital Readings, MINT Research Center, McMaster University.

Bozeman, B., 2000. Technology transfer and public policy: a review of research and theory. Research Policy, 29(4-5): 627-655.

Burt, R.S., 1992. Structural holes. Harvard University Press, Cambridge, Mass.

Chapple, W., Lockett, A., Siegel, D.S. and Wright, M., 2005. Assessing the relative performance of U.K. University technology transfer offices: parametric and non-parametric evidence. Research Policy, 34(3): 369-384.

Clarke, B.R., 1998. Creating entrepreneurial universities. Organizational pathways of transformation. IAU Press, New York, 180 pp.

Clarysse, B., Wright, M., Lockett, A., Van de Velde, E. and Vohora, A. 2005. Spinning out new ventures: A typology of incubation strategies from European research institutions. Journal of Business Venturing, 20(2): 183-216.

Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R.R. and Rosenberg, N., 2002. How do University inventions get into practice? Management Science, 48(1): 61-72.
Debackere, K. and Veugelers, R., 2005. The role of academic technology transfer organizations in improving industry science links. Research Policy, 34(3): 321-342.

Di Gregorio, D. and Shane, S., 2003. Why do some universities generate more start-ups than others? Research Policy, 32(2): 209-227.

Edvinsson, L. and Malone, M.S. (1997). Intellectual capital: Realising your company's true value by finding its hidden brainpower. Harper Business, New York, 240 pp.

Eisenhardt, K.M., 1989. Building theories from case study research. Academy of Management Review, 14(4): 532-550.

Friedman, J. and Silberman, J. (2003). University technology transfer: Do incentives, management, and location matter? Journal of Technology Transfer, 28(1): 81-85.

Hansson, B., 2001. Essays on Human Capital investments. Stockholm University, Stockholm.

Hermans, R. and Kauranen, I., 2005. Value Creation Potential of Intellectual Capital in Biotechnology - Empirical Evidence from Finland. R&D Management, 35(2): 171-185.

Hermans, R., Löffler, A. and Stern, S., 2008. Biotechnology. In: Macher, J.T., & Mowery, D.C. (Eds.), Innovation in global industries – U.S. firms competing in a new world. The National Academies Press, Washington, D.C.

Hussi, T. and Ahonen, G., 2002. Managing intangible assets – A question of integration and delicate balance. Journal of Intellectual Capital, 3(3): 277-286.

Jensen, R. and Thursby, M., 2001. Proofs and Prototypes for Sale: The Licensing of University Inventions. American Economic Review, 91(1): 240 -259.

*Jensen, R.A., Thursby, J.G. and Thursby, M.C., 2003. Disclosure and licensing of university inventions: 'The best we can do with the S**T we get to work with'. International Journal of Industrial Organization, 21(9): 1271-1300.*

Lach, S. and Schankerman, M., 2004. Royalty sharing and technology licensing in universities. Journal of the European Economic Association, 2(2-3): 252-264.

Lee, Y.S., 1996. "Technology transfer" and the research university: a search for boundaries of university-industry collaboration. Resesarch Policy, 25(6): 843-863.

Link, A.N. and Siegel, D.S., 2003. Generating Science-Based Growth: An Econometric Analysis of the Impact of Organizational Incentives on University_industry Technology Transfer. European Journal of Finance, 11(3): 169-181.

Lockett, A. and Wright, M., 2005. Resources, capabilities, risk capital and the creation of university spin-out companies. Research Policy, 34(7): 1043-1057.

Macho-Stadler, I., Pérez-Castrillo, D. and Veugelers, R., 2007. Licensing of University Inventions : The Role of a Technology Transfer Office. International Journal of Industrial Organization, 25(3): 483-510.

Markman, G., Gianiodis, P. and Phan, P., 2006. An agency theoretic study of the relationship between knowledge agents and university technology transfer offices. Rensselaer Polytechnic Working Paper, Troy, NY.

Markman, G.D., Phan, P.H., Balkin, D.B. and Gianiodis, P.T., 2005a. Entrepreneuship and university-based technology transfer. Journal of Business Venturing, 20(2): 241-263.

Markman, G.D., Gianiodis, P.T., Phan, P.H. and Balkin, D.B., 2005b. Innovation speed: Transferring university technology to market. Research Policy, 34(7): 1058-1075.

MERITUM project, 2002. Guidelines for managing and reporting on intangibles (Intellectual Capital Report). Fundación Airtel Movil, Madrid.

Mouritsen, J., Bukh, P.N.D., Thorsgaard Larsen, H., Hansen, G., Stakeman, B., Jeppesen, G., Rezai, D., Andersen, B., Kirkegaard Rasmussen, S. and Holm Nielsen, L., 2000. A guideline for intellectual capital statements – a key to knowledge management. Danish Agency for Trade and Industry, Copenhagen.

Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B. and Moray, N., 2006: Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy. Research Policy, 35(2): 289-308.

Nonaka, I. and Takeuchi, H., 1995. The knowledge creating company: How Japanese companies create the dynamics of innovation. Oxford University Press, New York, 304 pp.

O'Gorman, C., Byrne, O. and Pandya, D. 2008. How scientists commercialise new knowledge via entrepreneurship. The Journal of Technology Transfer, 33(1): 23-43.

O'Shea, R.P., Allen, T. J., Chevalier, A. and Roche, F. 2005. Entrepreneurial orientation, technology transfer and spin-off performance of U.S. universities. Research Policy, 34(7): 994-1009.

Phan, P.H. and Siegel, D.S. 2006. The effectiveness of university technology transfer. Foundations and Trends in Entrepreneurship, 2(2): 77-144.

Powell, W. W., 1996. Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. Administrative Science Quarterly, 41(1): 116-45.
Rahm, D., Bozeman, B. and Crow, M., 1988. Domestic technology transfer and competitiveness: an empirical assessment of roles of university and government laboratories. Public administration review, 48(6): 969-978.

Ranki, A., 1999. Vastaako henkilöstön osaaminen yrityksen tarpeita? [Do personnel competencies meet the organizational needs?] (In Finnish). Kauppakaari, Helsinki.

Roberts, E., 1991. Entrepreneurs in high technology: Lessons from MIT and beyond. Oxford University Press, USA, 400 pp.

Rogers, E.M., Yin, Y. and Hoffmann, J. (2000). Assessing the effectiveness of technology transfer offices at U.S. research universities. The Journal of the Association of University Technology Managers, 12: 47-80.

Rothaermel, F. T., Agung, S. D. and Jianf, L., 2007. University Entrepreneurship: A taxonomy of the literature. Industrial and Corporate Change, 16(4): 691-791.

Schein, E.H., 1992. Organizational culture and leadership. Jossey-Bass Publishers, San Francisco, CA, 448 pp.

Siegel, D. S. and Phan, P.H., 2005. Analyzing the Effectiveness of University Technology Transfer: Implications for Entrepreneurship Education. In: Libecap, G.D. (Ed.): University Entrepreneurship and Technology Transfer: Process, Design, and Intellectual Property. Advances in the Study of Entrepreneurship, Innovation and Economic Growth, 16: 1-38.

Siegel, D.S., Waldman, D., Atwater, L.E. and Link, A., 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. Journal of Engineering and Technology Management, 21 (1-2): 115-142.

Siegel, D.S., Waldman, D. and Link, A., 2003. Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. Research Policy, 32(1): 27-48.

Siegel, D.S., Wright, M., Chapple, W., and Lockett, A., 2008. Assessing the relative performance of university technology transfer in the U.S. and U.K.: A stochastic distance function approach. Economics of Innovation and New Technology, 17(7): 719-731.

Sorensen, J.A.T. and Chambers, D.A., 2008. Evaluating academic technology transfer performance by how well access to knowledge is facilitated—defining an access metric. The Journal of Technology Transfer, 23(5): 534-547.

Stewart, T.A., 1998. Intellectual capital. The new wealth of organisations. Nicholas Brealey Publishing Limited, London, UK, 320 pp.

Sveiby, K.-E., 1997. The new organizational wealth. Managing and measuring knowledge-based assets. Berret-Koehler Publishers, Inc, San Francisco, CA, 275 pp.
Sveiby, K.-E. and Lloyd, T., 1987. Managing know-how. Bloomsbury Publishing Limited, London,UK.

Swamidass, P.M. and Vulasa, V., 2009. Why university inventions rarely produce income? Bottlenecks in university technology transfer. The Journal of Technology Transfer, 34(4): 343-363.

Tahvanainen, A.-J. and Hermans, R. (2005). Funding intellectual-capital-abundant technology development: empirical evidence from the Finnish biotechnology business. Knowledge Management Research & Practice, 3(2): 69-86.

Thursby, J.G., Jensen, R. and Thursby, M.C., 2001. Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities. The Journal of Technology Transfer, 26(1-2): 59-72.

Thursby, J.G. and Kemp, S., 2002. Growth and productive efficiency of university intellectual property licensing. Research Policy, 31(1): 109-124.

Thursby, J.G. and Thursby, M.C., 2002. Who is Selling the Ivory Tower? Sources of Growth in University Licensing. Management Science, 48(1): 90-104.

Von Ledebur, S., 2008. Technology transfer offices and university patenting – a review. Jena Economic Research Papers, No. 33-2008, Friedrich Schiller University, Jena.

9. Appendix

9.1. Transfer process

For the purpose of providing a descriptive reference of the UITT process for the analysis proper, Figure A.1 presents a systemic flow of the licensing process as it emerged from the data. It should be pointed out that the model is generic and, thus, is not an attempt to capture differences in practices across the 190+ TTOs currently active in the US. Nor does it go into the details of micro-level practices performed by the office to drive on the process. These are the subject of Section 5 where we construct the conceptual framework of TTO practices adding value to UITT.

The process of UITT 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, regular department meetings, etc. raising the propensity of inventors to submit 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.

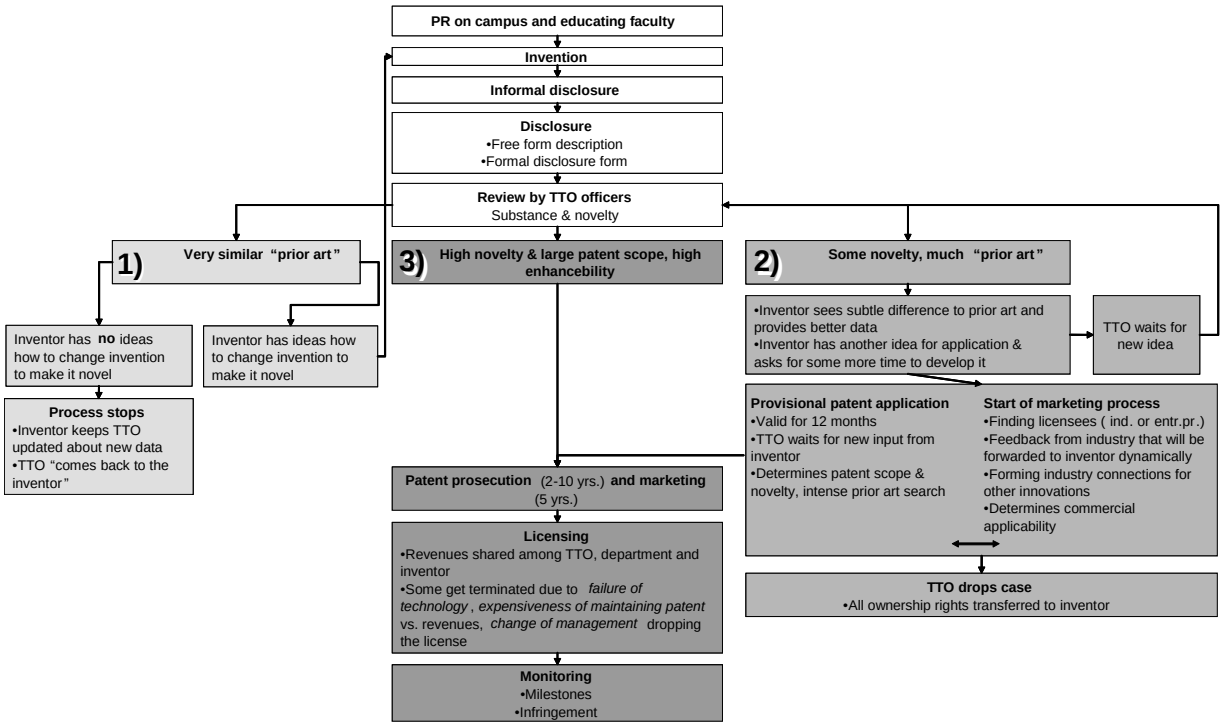

Fig. A.1 *Transfer process blueprint*

The disclosure initiates a rigorous prior art search and a technical evaluation process. With help from external patent offices, technology transfer officers search the existing IPR landscape for potential hurdles in an attempt to determine whether the disclosed invention can be protected through IP protection. At the same time they evaluate the technical feasibility and the potential impact factor of the invention. 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 to 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 not know how to modify the invention, it is not pursued further. The inventor is free to report 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 required to show how the invention distinguishes itself sufficiently from existing technology. The inventor can provide proof in the form of better and more detailed data, for example, but might also have ideas as to how to apply the invention in a way different than previously intended. The TTO stands by until the inventor has modified the invention, if necessary, and then initiates the next phase. This includes filing a provisional patent that is valid for 12 months. During that time the inventor can make further modifications to the invention and improve it. Simultaneously, the TTO determines the novelty of the technology by intensifying the prior art search and designing the final scope of the impending patent. Moreover, the TTO initiates an extensive marketing process that serves several vital functions: (i) finding a potential licensee for the up-coming IPR; (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; and finally, (iii) expanding the network of industry connections of the TTO that can be tapped into when marketing future inventions. Depending on the outcome of the final prior art search and the industry feedback, the promotion of the invention is either terminated (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. 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 period of X years beginning from the date of licensing) and possible patent/license infringements. Occasionally, 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 search and technical evaluation 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 immediately initiates full-scale patent prosecution, marketing, and licensing efforts omitting the provisional patenting phase.

9.2. Interview template

Q1: From the perspective of the Technology Transfer Office (TTO), and from its perspective alone, what is the mission of the office, both officially and unofficially? In other words, which different instances would you say the office does achieve success?" (Alternatives for the term mission: strategic objectives, value proposition)

> !!! The interviewer should emphasize that the question is *purposefully ambiguous* with regard to third parties, for example, that the terms *success* or *value* might relate to or be defined by, because their type and nature, too, are of interest to the study and, thus, shouldn't be predetermined by the researcher !!!

Allocated time: 10min.

Cumulative time: 10min.

Q2: "Could you elaborate in detail, even on individual level, on the human capital employed by the TTO that is instrumental in achieving the objectives you just defined in the prior question?"

"Human capital encompasses specific skills, experiences, education, knowledge and other intangible assets inherent in an individual employed by the TTO. It does not include these aspects inherent in individuals outside the office that still might be associated with the office in some respect. This type of human capital will be dealt with later on during the interview."

Allocated time: 15min.

Cumulative time: 25min.

Q3: "Could you elaborate on and characterize in detail, even on individual level, those relationships of the TTO personnel to external instances that are instrumental in achieving the objectives or fulfill the TTO's mission as you defined in the beginning of the interview? We are just as interested in informal ties to, e.g., acquaintances of any kind, friends, ex-colleagues, family, etc., as we are interested in formal relationships corroborated through, e.g., contracts or long-term relationships given that they contribute to achieving the TTO's mission. "

> !!! The interviewer should emphasize that the question is *purposefully ambiguous* with regard to the function and type of external relationships as those are of interest to the study and, thus, shouldn't be predetermined by the researcher!!!

AAllocated time: 15min.

Cumulative time: 40min.

Q4: "What can you tell us about the internal infrastructure of the TTO that a) codifies b) creates, c) supports/enhances, d) renews, e) protects and f) maintains, the knowledge inherent in human capital and external relationships discussed earlier? Such infrastructure can consist of, e.g., established organizational routines, organizational culture, official or unofficial guidelines, rules, information systems that personnel can share information through, explicitly communicated strategies, brands, IPRs and so forth."

Allocated time: 15min.

Cumulative time: 55min.

Q5: "Referring constantly to the elements you have described in the previous questions so far – human capital, external relationships and internal infrastructures – please, elaborate as vividly as possible on the process that

technologies are transferred by starting from the lab toward its ultimate application in the field from the perspective of the TTO."

Allocated time: 45min.

Cumulative time: 100min.

END OF INTERVIEW

Some notes for the researcher:

- It is always valuable to emphasize that **characterizing** concrete elements of intellectual capital in detail is key. The true value of the study relies to a great degree on in-depth depiction and characterization of the elements. *E.g.* simple statements on external contacts in the form "a couple of IT-focused VCs regularly work together with us." should be followed by clarifying questions like "how would you depict your relationship to them?" and "how was the relationship established?" *etc*.
- Anecdotes are of great value. They anchor theory to reality.
- Interviewers **must avoid** leading questions in the form "isn't it true that…" or questions that ask the interviewee to explicitly depict phenomena that should arise from the complexities of the interview as a coherent whole: e.g. "what is knowledge management from the perspective of a TTO" or "**how** does a TTO create value".