TECHNOLOGY TRANSFER OFFICES AS BOUNDARY SPANNERS IN THE PRE-SPIN-OFF PROCESS: THE CASE OF A HYBRID MODEL

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Abstract

Over the past decades, universities have increasingly become ambidextrous organizations reconciling scientific and commercial missions. In order to manage this ambidexterity, technology transfer offices (TTOs) were established in most universities. This paper studies a specific, often implemented, but rather understudied type of TTO, namely a hybrid TTO model uniting centralized and decentralized levels. Employing a qualitative research design, we examine how and why the two TTO levels engage in diverse boundary spanning activities to help nascent spin-off companies move through the pre-spin-off process. Our research identifies differences in the types of boundary spanning activities that centralized and decentralized TTOs perform and in the parties they engage with. We find geographical, technological and organizational proximity to be important antecedents of the TTOs' engagement in external and internal boundary spanning activities. These results have important implications for both academics and practitioners interested in university technology transfer through spin-off creation.

Key words Technology transfer office – Boundary spanning – Proximity – Nascent spin-offs
JEL Classification L26 - M13 - O32

1. Introduction

Universities are increasingly active in the commercialization of their research results, the so-called 'third mission' related to entrepreneurship and economic development (Etzkowitz 2003; Rasmussen et al. 2006). The commercialization of research results goes beyond the traditional, scientific dissemination mechanisms, such as publications, and includes university spin-offs, patents, licensing, collaborative research, contract research and consulting (Wright et al. 2008). Such mechanisms have received considerable attention over the past decade (Siegel et al. 2007; Van Looy et al. 2011). This entrepreneurial tendency of universities is inspired by decreasing university budgets and increasing pressure from policy makers who view the commercialization of academic research as a key driver of national competitiveness (Ambos et al. 2008). As such, universities have to become "entrepreneurial universities" which have the ability to generate a focused strategic direction, both in formulating academic goals and in translating knowledge produced within the university into economic and social utility (Clark, 1998). While many universities have taken initiatives to promote technology transfer between science and industry (Phan and Siegel 2006), it is recognized that commercialization of research results poses major challenges. At the heart of the problem is the inherent tension between academic and commercial demands (Hackett 2001; West 2008). As the university's third mission cannot be considered separately from the traditional academic remit of research and teaching (Van Looy et al. 2011), universities have to act as ambidextrous organizations pursuing research excellence while promoting research commercialization (Ambos et al. 2008; Raisch and Birkinshaw 2008). One of the pathways to

obtain organizational ambidexterity is so-called structural ambidexterity, or the use of 'dual structures' and strategies to separate different types of activities, in which actors deal with one or the other activity (Andriopoulos and Lewis 2009). In a university context, scholars have recommended the establishment of an autonomous unit, a technology transfer office (TTO), alongside traditional structures related to teaching and research (Ambos et al. 2008; Siegel et al. 2007; Tushman and O'Reilly 1996). TTOs engage in various support services for the commercialization of academic research, most notably, partner search, management of intellectual property and business development. A growing number of studies have focused on the commercialization of research results and technology transfer and, in particular, have analyzed the role of TTOs. However, this literature still suffers from two important gaps.

First, TTO activities have been widely studied (Siegel et al. 2007). Researchers have looked into the role of the TTO in licensing (Siegel et al. 2003b), patenting (Coupe, 2003) and the creation and performance of university spin-offs (Link and Scott 2005; Lockett and Wright 2005; Lockett et al. 2003). Quite surprisingly, little is known about the role of TTOs *during the pre-spin-off process*. While the creation of university spin-offs[1] typically represents the central route to public research commercialization (Debackere and Veugelers 2005; Wright et al. 2008), little is known about the role of the TTO in this process. Hence, we study TTO activities and how these help nascent spin-offs during the pre-spin-off process.

Second, a large body of research has documented the activities performed by TTOs in the commercialization of university-based intellectual property. TTOs stimulate researchers to disclose their inventions and evaluate their patentability, technological validity and commercialization potential (Siegel et al. 2003a; Vohora et al. 2004). Further, TTOs alleviate the asymmetric information problem between industry and university (Macho-Stadler et al. 2007) and mitigate the uncertainty related to the profitability of new inventions (Hoppe and Ozdenoren 2005). Strikingly, most studies have considered TTOs to be centralized and hierarchical structures, embedded at the central level of the university. By contrast, a number of studies have argued that TTOs can take different organizational forms. Markman et al. (2005) identified three TTO structures, which vary by the degree of autonomy granted to TTOs in their pursuit of technology commercialization opportunities. These three archetypes are a traditional university structure, a nonprofit research foundation, and a for-profit venture extension. Along the same lines, Bercovitz et al. (2001) classified four organizational forms for TTOs, the functional or unitary structure (U-form), the multidivisional form (M-form), the holding company (H-form), and the matrix structure (MX-form), while Debackere and Veugelers (2005) studied an example of a decentralized TTO.

However, in general, limited attention has been given to the activities performed by *more decentralized organizational structures*, in which responsibilities for technology transfer activities are located close to research groups and individuals (Bercovitz et al. 2001), often in combination with a centralized TTO level. This is quite surprising, as centralized and hierarchical TTO models are not considered conductive to universities' spin-off activity (Apple 2008). Accordingly, we address this gap in the literature by studying a largely neglected form of TTO, which we typify as a "hybrid TTO model". This is a combination of

[1] University spin-offs are defined as new ventures initiated within a university setting and based on technology derived from university research (Rasmussen and Borch 2010).

the traditional hierarchical structure, in which a TTO is established at the central level of the university, complemented by decentralized TTOs at the level of the research groups and departments. As TTOs are boundary spanners, serving as a bridge between academic and commercial contexts (Siegel et al. 2003a), a central concern is to understand the differences in the nature of these activities between the two levels.

Accordingly, our study addresses these gaps in the literature by examining the following research questions: "How (i.e., through which boundary spanning activities) do centralized and decentralized levels in a hybrid TTO structure help academic researchers throughout the pre-spin-off process? Why do they differ in the activities they engage in?" In other words, in addition to providing a better understanding of the boundary spanning activities performed by TTOs at different levels, we study the antecedents of their engagement in these activities. As such, following the nature of our research questions, which are *how* and *why* questions, we employ a qualitative research design. Specifically, we analyze the hybrid TTO model of Ghent University. By studying six cases of nascent university spin-offs within Ghent University longitudinally during the pre-spin-off process, we were able to identify both the activities that TTOs engage in to advance the pre-spin-off process and the antecedents of TTOs' involvement.

In addressing these research questions, we aim at contributing to the literature in a number of ways. First, we respond to recent specific calls in the TTO literature to explore the functioning of TTOs (Djokovic and Souitaris 2008) within different structures (Markman et al. 2005), the type and determinants of activities TTOs engage in (Comacchio et al. 2012; Markman et al. 2008) and how universities contribute to the process of university spin-off creation (O'Shea et al. 2005). Responding to these calls is important for both research and practice as failure to recognize how TTO structures and processes are operationalized can obscure understanding of how TTOs create value. Second, our research contributes to the wider academic entrepreneurship literature. This literature includes studies at macro-level (studying the role of government and industry), meso-level (focusing on university and the central TTO) and micro-level (studying firms and individual entrepreneurs) (Djokovic and Souitaris 2008). In particular, recent work at the meso-level has emphasized the importance of the subunit or department level (Bercovitz and Feldman 2008; Kenney and Goe 2004), with special attention devoted to workplace peers (Kenney and Goe 2004; Louis et al. 1989; Stuart and Ding 2006) and the department chair, that constitute the "localized social environment" (Bercovitz and Feldman 2008). Third, by exploring a more fine-grained breakdown of the role of TTOs we add to the general organizational ambidexterity literature applied to the university context. Fourth, we add to the proximity literature which general focuses on inter-organizational dimensions by considering intra-organizational aspects.

This article unfolds as follows. The next section positions our research within boundary spanning theory and proximity literature. We then present the methodological approach used for the longitudinal inductive study of six nascent spin-offs cases. In the fourth section, the empirical findings are presented and four sets of propositions are derived. Finally, we reflect on our results and discuss their implications for practice and further research.

2. Theoretical perspectives

Following Suddaby (2006), we adopt an inductive approach and build our case studies in the context of relevant theory. Heeding the recent call to devote research attention to boundary spanning activities in the research commercialization process (Markman et al. 2008), we rely on boundary spanning theory to address our first research question which relates to the activities performed by centralized and decentralized TTOs. In order to examine our second research question and shed light on why TTOs engage in different activities, we draw on proximity literature. Indeed, boundary spanners face the challenge of linking agents that are distant from each other along diverse dimensions (Williams 2002), including geographical, organizational and technological dimensions. In what follows, we elaborate on boundary spanning theory and literature, and focus on proximity as an important framework in explaining the antecedents of engagement in boundary spanning activities.

2.1. Boundary spanning theory

Boundary spanning theory originates from organizational ambidexterity theory and argues that organizations assign specific individuals or units a role in managing the boundaries with other organizations that supply critical resource inputs or that are responsible for the distribution of their outputs (Zhang et al. 2011). Boundary spanners are agents who gain knowledge from one domain and move it to be applied in another (Tushman and Scanlan 1981). As such, these boundary spanners can help organizations to obtain organizational ambidexterity, i.e. to be aligned and efficient in responding to market demands, while simultaneously being adaptive to changes in the environment (Gibson and Birkinshaw 2004). This traditional role can be identified as *external boundary spanning*. In the academic context, following the new demands on universities, new organizations were established to span boundaries between science and external stakeholders (Hellström and Jacob 2003). Scholars have explored the mediating role of boundary spanning organizations between science, policy and the corporate sector (Cash 2001; Guston 1999; Parker and Crona 2012) and have indicated that a core task of these organizations lies in facilitating the technology transfer process (Booz and Lewis 1997; Howells 2006). Concretely, Siegel et al. (2003a; 2007) identified boundary spanning activities as the actions taken by TTOs to serve as a bridge between "suppliers" of research results (i.e., university scientists) and "customers" (namely firms, entrepreneurs and venture capitalists) who operate in different environments and can potentially help to commercialize academic research. In this conventional view, TTOs are the formal gateways between university and industry (Rothaermel et al. 2007) and facilitators of industry-science linkages (Wright et al. 2008).

While external boundary spanning has been extensively documented in the literature, less attention has been devoted to *internal boundary spanning*. However, if a specific organizational unit is created with the responsibility for external boundary spanning, new boundaries arise within the organization, which faces the challenges of managing internal knowledge and resource flows between its different units (Tsai 2002). For instance, Piercy (2009) indicated that, in an operational context, the main challenge faced by executives responsible for sales and marketing processes is being effective in the management of cross-organizational and cross-divisional relationships. Similarly, a product manager needs to engage in both external boundary spanning with outsiders, including customers, consultants

and investors, as well as in "internal boundary spanning" between the units of production, finance, advertising and engineering (Lysonski 1985). In the context of universities, Markman et al. (2008) have suggested that, besides external boundary spanning between academics and corporations, internal boundary spanning between different university departments involved in the commercialization of academic research is an important and complex task, which may be performed by TTOs as well. However, the role of TTOs in internal boundary spanning has so far remained largely neglected. In line with the previous arguments, we found boundary spanning theory to be an important framework in studying the centralized and decentralized TTO's engagement in pre-spin-off activities.

2.2. Dimensions of proximity

Proximity is crucial in inter-organizational collaborations and alliances as it stimulates knowledge transfer and knowledge sharing (Knoben and Oerlemans 2006; Nooteboom 1999). Recently, researchers have also pointed to the importance of proximity for the formation and effectiveness of university-industry linkages (Laursen et al. 2011; Messeni Petruzzelli 2011; Woerter 2012).

Although proximity has frequently been treated as a purely spatial phenomenon, taking a multidimensional perspective is important. Besides the geographical dimension, organizational, institutional, social and cognitive aspects are equally important for successful knowledge exchange (Boschma 2005). Knoben and Oerlemans (2006) synthesized these aspects into three main types of proximity. *Geographical* proximity refers to the spatial or physical distance between economic actors (Boschma 2005). Short distances literally bring people together, favor information contacts and facilitate the exchange of tacit knowledge (Jaffe et al. 1993). Second, *organizational* proximity relates to the extent to which relations are shared in an organizational arrangement (Boschma 2005). This type of proximity incorporates organizational structure and culture, performance measurement systems and language. Organizational proximity is in place when interactions between actors are facilitated by rules and routines of behavior, and a same system of representations or set of beliefs (Torre and Ralet 2005). Finally, *technological* proximity is based on shared technological experiences and knowledge bases (Knoben and Oerlemans 2006). The mutual understanding makes people more likely to access knowledge from individuals that exhibit greater technological proximity. Similarities in the knowledge bases allow actors to effectively identify, interpret and communicate about relevant knowledge.

Even though prior literature has largely focused on the role of proximity in inter-organizational collaborations, proximity may also facilitate interactions between different units within the same organization. Intra-organizational proximity may foster the way different units share knowledge with each other. For instance, whereas organizational proximity has often been defined as proximity in the cultures of different organizations, organizational units may have distinct subcultures, making it relevant to study intra-organizational aspects of proximity as well (Ashkanasy et al. 2000; Hofstede 1998). Indeed, we found that, in a hybrid TTO model, specific dimensions of proximity were important in explaining the engagement of centralized and decentralized TTOs in internal and external boundary spanning.

3. Methodology

3.1. Inductive case study approach

We employed a longitudinal multiple case study design. Most studies on academic entrepreneurial activity are based upon cross-sectional data linking university characteristics to the creation of university spin-offs. However, to understand how the two TTO levels can advance the pre-spin-off process and why their activities differ, we need to adopt a longitudinal and qualitative approach to capture the changes over time and reduce problems of retrospective biases (Pettigrew 1990; Rasmussen and Borch 2010; Yin 2003).

While our approach is inductive, we framed it in the context of the theories presented above. We followed an iterative process involving a back-and-forth journey between the data collected and existing literature and theories (Van Maanen et al. 2007). We follow the norm to present inductive research in the traditional discrete categories and in the same sequence as quantitative research (Suddaby, 2006). Even though the theoretical framework is presented up front, the selection of theory and its development emerged from the empirical research.

3.2. Identification of cases and data collection

The cases all originated from one university, the University of Ghent (UGent) in Belgium. UGent is a general university, offering all curricula, ranging from engineering and exact sciences to human arts (Wright et al. 2008). Selecting a single site is appropriate for various reasons. First, as extensive data collection is needed at different levels, this research is ideally handled in the context of one university. Second, focusing on one university enhances homogeneity in case design, which is important to draw valid conclusions. Third, single site studies have been successfully applied by other scholars (Shane and Stuart 2002; Zhang 2009). Moreover, UGent is a particularly suitable site because this university has applied a hybrid TTO model which combines centralized and decentralized elements and which corresponds to our research focus.

The UGent TTO was professionalized in 2000, following a grant from the Flemish Government which boosted technology transfer activities at the university. This grant allowed for the implementation of a commercialization policy to turn scientific research into economic returns. Universities receiving the grant got full autonomy to develop their own policy. Consequently, while the UGent TTO had traditionally been organized in a purely centralized form, the organizational structure was broken up into two different units, thus creating a hybrid structure composed of centralized and decentralized TTO levels. At 31st December 2011, the TTO consisted of 30 people at the centralized level, complemented by 21 Technology and Business developers (who constitute the decentralized TTO level), each in charge of a multi-disciplinary valorization cluster, i.e. a cluster of cross-faculty and complementary research groups working on a particular technology or expertise. It is the responsibility of both levels within the hybrid structure to foster and facilitate the translation of the results of UGent's scientific research into commercial products and services that maximize the benefit to society. Together with the financing of the decentralized TTO level, a program for pre-industrial proof-of-concept project funding with a maximum budget of

50,000 Euro (StarTT projects) and pre-venture capital funding for start-up creation with a budget ranging from 250,000 to 500,000 Euro per project (Stepstone projects) was established. As of 31st December 2011, UGent had spun off about 40 companies. Additional descriptive characteristics of the selected university are reported in Table 1.

[Insert Table 1 about here]

We draw on six longitudinal cases of nascent spin-offs where the phenomenon of interest (i.e. TTO involvement in the pre-spin-off process) is "transparently observable" (Eisenhardt 1989). Using a finite number of cases (between four and ten, as suggested by Brown and Eisenhardt 1997), allowed us to balance the need to generate rich theory with large amounts of data. Triangulation combining several data sources was used to map the situation and evolution of each nascent spin-off during the pre-spin-off process. In line with Pettigrew (1973), an embedded research design was adopted, in which different people in various positions were interviewed. In particular, we interviewed pre-founding team members, decentralized and centralized TTOs and department heads. Following Eisenhardt (1989), for every case, we gradually built up a picture of the nascent spin-off development that was cross-validated by different actors looking at issues from different angles. Interviews were recorded, and transcriptions were made by one of the authors as part of the data analysis process. The face-to-face interviews lasted between one and two hours. Archival data such as business plans, project proposals and curricula vitae were obtained from each informant. In addition, relevant written documentation was obtained from the university website, TTO website, research groups' websites and newspaper articles. By combining the different sources of information over a period of three years, in which interview rounds were conducted every 6 to 9 months, an in-depth description of both the pre-spin-off process and the role of the centralized and decentralized TTOs was obtained.

The interviews were carried out following a narrative approach (Polkinghorne 1988). During each interview, the pre-founding team members were asked to describe the status of their spin-off project, and the main elements in which they had progressed over the months prior to the interview, as well as the role and contribution of their TTOs. Decentralized and centralized TTOs were requested to describe the evolution of each spin-off project, the activities they had performed and how their involvement helped each pre-founding team to proceed. This type of narrative interviewing, in which there is minimum interruption by the interviewer, was used to obtain a better understanding of the events and to avoid the influence of interviewers' personal views and theoretical perspectives on the data collection. The interview transcripts and documentary evidence were read and reread as data were collected and emerging themes were refined as this process progressed. Patterns of observations were identified and an iterative process allowed us to match empirical data with theoretical explanations. To avoid confirmation biases, two of the authors were kept at a distance from the data collection process (Doz 1996). A total of 63 interviews involving 21 different people were conducted over four interview rounds.

3.3. Description of the cases

Table 2 provides some key characteristics of the six nascent spin-off cases selected for this study. For confidentiality reasons, the nascent spin-offs are labeled as case A to F.

The six nascent spin-off cases were identified and selected after consulting the centralized TTO management. We deemed it necessary to draw on a heterogeneous set of cases, as our focus was to provide a better understanding of the TTO role in the pre-spin-off process, irrespective of the phase of the process, the technology or type of spin-off. Consequently, the six nascent spin-offs were in different phases of the pre-spin-off process. Drawing on Vohora et al. (2004), we considered five phases in the development of university spin-offs: research phase, opportunity framing phase, pre-organization phase, re-orientation phase and sustainable returns phase. Each phase is characterized by a specific group of activities that the (nascent) spin-off must accomplish in order to progress to the next phase. As this research focuses on the pre-spin-off process, we do not consider the phases after firm establishment, i.e. the re-orientation and sustainable returns phases. The six nascent spin-offs were in different research domains, and a mix of technology and service-based spin-offs (Pirnay et al. 2003) was obtained.

[Insert Table 2 about here]

4. Results

Our six cases provide insights that inform our research questions which focus on understanding 1) the boundary spanning activities of centralized and decentralized TTOs in a hybrid TTO structure, as well as the differences in activities between both levels and 2) the antecedents of the engagement in these activities.

4.1. Boundary spanning activities within the hybrid TTO model

In each interview round, all respondents were asked to reflect on the support activities performed by both TTO levels in the hybrid structure, which had a positive impact on the nascent spin-off progress. Table 3 provides a detailed overview of the activities carried out by centralized and decentralized TTOs for each of the six nascent spin-offs since the origin of the spin-off idea.

Our first set of results relates to the type of activities carried out within a hybrid TTO, and indicates clear differences between the centralized and decentralized levels. Extant TTO literature has focused attention solely on TTOs' external boundary spanning role. Our study complements existing research by providing a more fine-grained analysis of the external boundary spanning activities carried out by centralized and decentralized TTOs throughout the pre-spin-off process. Additionally, we find that both TTOs also play an *internal* boundary spanning role *within the university* that is crucial to help researchers move through the pre-spin-off process.

[Insert Table 3 about here]

Moreover, we extend previous literature by highlighting that the type of (internal and external) boundary spanning differs according to the level in the TTO structure. As illustrated

in Table 3, centralized and decentralized TTOs engage in *different* external and internal boundary spanning activities during the pre-spin-off process. The differences rely in both the type of activities and the parties with whom the two TTO levels interact while performing their activities. We elaborate on these differences in what follows.

External boundary spanning

The centralized TTO level engages to a larger extent in external boundary spanning activities towards experts by looking for (patent) experts (cases A, B and D), market consultants or future CEOs (cases A and B).

In case A, the centralized TTO attracted and financed two external consultants for business development support, and temporarily involved an external patent expert. The PhD researcher A1 commented:

> *"Since the TTO has provided support through a number of consultants, things are really moving much faster. Before, we did not even have time to do market analyses. Now, one consultant goes out to talk to potential customers, whereas the other coaches us in doing the market analyses."*

PhD researcher B4 underlined the value of the centralized TTO fulfilling this external boundary spanning role in order for nascent spin-off B to progress:

> *"Even though DTTO2 was willing to provide us assistance with patent applications, DTTO2 lacked the required know-how and practice which slowed down the procedure. Along the way, our pre-founding team learned to approach the centralized TTO for such matters. In order to speed up this application process and to deal with specific issues professionally, CTTO4 got us in touch with patent experts."*

Moreover, the centralized TTOs engage in looking for additional team members and, in particular, potential CEOs. CTTO1 noted:

> *"Before company establishment, nascent spin-off A will need to attract a production expert, who understands shift work and who can take care of cost calculation. The recruitment initiative can either come from us or the team itself. I have also contacted a potential CEO for the company. The research team is aware of this, and I will introduce this person later on. If there is no match with the people already involved in the team, there is no chance this person will become the future CEO."*

Similarly, in case B, DTTO2 expected the centralized TTO to play an important role in the recruitment of the future CEO. CTTO3 commented:

> *"Once the pre-founding team of nascent spin-off B has reached a technological milestone, I will use my network to find external consultants or managers who are capable of founding a technology company."*

The centralized TTO invoked the help of an external expert to review the technology, which was believed by the researchers to be important in strengthening their business case. DTTO4 involved in nascent spin-off D commented:

> *"The activities carried out by the centralized TTO which are valuable to us are contract and IP management issues, provided by the staff themselves or through the involvement of external patent experts."*

In later phases of the pre-spin-off process, the centralized TTO also carries out external boundary spanning between the pre-founding team and potential financiers. For instance, CTTO2 involved in case A explained:

> *"Every story needs cash, either from an investor or from a client. The weakness of nascent spin-off A is the lack of communication with (potential) financiers. It is my job to encourage the team members to act proactively towards the investment community and to facilitate the communication with future investors."*

In contrast to the centralized TTOs, the decentralized TTOs mainly engage in external boundary spanning towards industrial companies (see cases A, C, D, E and F), which are potential customers, partners and suppliers of nascent spin-offs. Interviewed academic researchers frequently pointed to the significance of their decentralized TTO's industry contacts for the nascent spin-off's evolution. In case A, one of the researchers said that it would have been useless to continue the development of the spin-off idea without this type of support from the decentralized TTO. For case D, DTTO4 described his principal tasks as twofold:

> *"On the one hand, I engage in scouting. This means I try to find applications for the technology which are relevant to the industry. On the other hand, it is my responsibility to talk to industry and maintain these contacts."*

Another illustrative comment from postdoc F1 in case F is:

> *"So far, DTTO5 took care of first contacts and relationships with industrial companies. Moreover, when some interesting new research results are developed, DTTO5 will search for feedback from the industry. Obviously, such feedback is valuable, and even crucial, for the future spin-off."*

Further, she noted that the spin-off idea actually originated from DTTO5's industrial contacts.

Additionally, companies interested in a technology or searching for a collaborator, who want to contact the inventors, typically approach the decentralized TTOs. In case C, DTTO3 explained:

"The technology the team has at its disposal at this moment might be enough for the industry, but the team believes that more added value is necessary before the spin-off can be established. However, one organization already contacted me to use the technology in the context of mobility campaigns."

Similarly, in nascent spin-off A, DTTO1 explained that he acts as contact person for industrial companies:

"The relationship with one large pharmaceutical player has evolved relatively quickly. At one point, the company approached me to inform whether it was possible to give them a sample of the product produced with our proprietary technology."

These insights lead us to the following propositions concerning the different external boundary spanning roles of centralized and decentralized TTOs:

Proposition 1a: Centralized TTOs are more likely than decentralized TTOs to engage in external boundary spanning between pre-founding teams and external experts and financiers.

Proposition 1b: Decentralized TTOs are more likely than centralized TTOs to engage in external boundary spanning between pre-founding teams and industrial companies.

Internal boundary spanning

With regard to the internal boundary spanning role of the centralized TTOs, our data reveal two interesting patterns. First, the communication of the university objectives and spin-off policy to pre-founding team members was frequently mentioned as one of the important support activities (cases A, D, E and F). DTTO5 of case E commented as follows:

"At faculty level, it sometimes seems very hard to follow up on how objectives of the university change. For instance, while the university used to encourage professors to engage in spin-offs formally, nowadays they prefer professors to stay out of spin-offs, and even not engage in the board of directors, since it often gives rise to conflicts of interest. The centralized TTO is aware of the changes in strategy and objectives, and communicates them to us, so that we can live up to the expectations."

The centralized TTO also has to clarify the university's interpretation of the third mission to the members of pre-founding teams. Increased commercialization activity has become an explicit part of the university mission and is promoted as a strategic objective. This observed internal boundary spanning activity was described by DTTO4, responsible for case D:

"Communicating the university policy to professors is crucial, as they are typically more reluctant towards university-industry collaborations and spin-off creation. As such, effective communication with them is a priority for the centralized TTOs. They explain

that the university still pursues scientific excellence as core objective, while at the same time engaging in a commercialization trajectory."

Second, centralized TTOs often provide the pre-founding teams with assistance in writing project proposals and early-stage business plans. Our cases revealed that the centralized TTO is a valuable partner for securing internal funds by assisting the pre-founding teams with StarTT and Stepstone project applications (cases A, B, C, D and F). CTTO1 commented as follows:

"It is often remarkable that neither researchers nor the decentralized TTOs understand how they should write a proposal for StarTT or Stepstone financing. In case A, the team sent me the first version of their project proposal. Even though one of the main decision criteria for Stepstone financing is the commercialization potential, they did not even mention the commercialization possibilities. So I helped them to write that part."

Similarly, in case B, CTTO3 said:

"I assisted DTTO2 and the research team of case B in writing the StarTT and Stepstone projects. As an advisor within a centralized TTO, you read through many project proposals, and you can identify the important prerequisites for such projects to gain approval, for instance the part on the commercialization potential of the technology."

As to the decentralized level, several interviewees underlined that one of the main internal boundary spanning activities for the decentralized TTO during the pre-spin-off process is linking the members of the pre-founding team to the centralized TTO level (cases A, B and D). DTTO2 explained:

"The centralized TTO has a very direct way of communicating things to the research team. Sometimes the researchers come to me when they have received a message from the centralized level, and they start arguing why they do not agree with this message. I then simply take some more time to explain the reasoning behind the message, and in the end, they often agree with the centralized TTO."

In case B, postdoc B1 similarly argued:

"The main role of DTTO2 is to be the liaison between us and the centralized TTO. As simple post-doctoral researchers, it would be hard for us to open doors at the centralized TTO".

In addition, PhD researcher B3 noted:

"I would not like to be in the shoes of DTTO2 as she is somewhere in between the department head, the researchers and the centralized TTO."

Consequently, one of the core activities performed by the decentralized TTO concerns linking the centralized TTO and the pre-founding team. DTTO4 elaborated on this type of internal boundary spanning activity:

> *"You have to know how to approach the researchers. In case D, during the first meeting at the centralized TTO, there were 4 people around the table firing questions at professor D1. After the meeting, the professor wanted to stop the project. He felt there were too many 'coaches' and too few 'do-ers' around the table. Nowadays, I serve as the link between the research team and the centralized TTO, and I do the communication with the centralized TTO".*

In many cases, it was the decentralized TTO who identified the opportunity, or proposed the opportunity to the centralized TTO (cases B, C, E and F). For instance, DTTO3 commented on the origin of the spin-off idea for case E:

> *"When I had just started working as a decentralized TTO, I organized a seminar on spatial information. I knew researchers in archaeology, geography and IT departments were working on this topic, and I thought it would be interesting to join forces across faculties. The idea for the spin-off originated from those first contacts."*

A similar event occurred in nascent spin-off F, where DTTO5 first initiated and now monitors the collaboration between different research groups within veterinary sciences, bioengineering and biotechnology departments. As such, the decentralized TTO establishes links between different research teams with similar interests.

These insights lead us to propose the following differences in the internal boundary spanning activities between decentralized and centralized TTOs:

> **Proposition 2a**: Centralized TTOs are more likely than decentralized TTOs to engage in internal boundary spanning between pre-founding teams and central university management.
>
> **Proposition 2b**: Decentralized TTOs are more likely than centralized TTOs to engage in internal boundary spanning between pre-founding teams and other research teams, and engage in internal boundary spanning between pre-founding teams and the centralized TTO level.

A summarizing representation of these first two sets of propositions is shown in Figure 1.

[Insert Figure 1 about here]

4.2. Antecedents of boundary spanning activities within the hybrid TTO model

Given the different nature of the activities that centralized and decentralized TTOs perform in the pre-spin-off process and the different parties involved, it is likely that the

antecedents of technology transfer activities will be different for the two levels. Our cases provide insights into the role of different dimensions of proximity as antecedents of the external and internal boundary spanning activities carried out by TTOs during the pre-spin-off process.

External boundary spanning

As to the centralized TTO, the six nascent spin-off cases reveal that this TTO level has a tight relationship with the central university decision making level. This organizational proximity allows centralized TTOs to represent and act on behalf of the university towards external stakeholders during the pre-spin-off process. One of the members of the pre-founding team of case A stated:

> *"It is good that CTTO2 understands the overall university objectives and is able to communicate these appropriately to us and, even more importantly, towards external parties such as future investors. His clear understanding of university goals enables him to simultaneously take the interest of the nascent management team and the university into consideration during negotiations."*

Further, our respondents frequently affirmed that, as a consequence of the organizational proximity towards the central university management, the centralized TTOs are well connected to the recruitment and investment firms within the university network. In nascent spin-off F, the post-doctoral researcher commented:

> *"The centralized TTO level already has connections with relevant parties, such as hiring agencies and venture capitalists, with whom the university has interacted during prior spin-off processes. This allows them to get in touch with suitable parties for attracting additional team members or funding*."

Accordingly, *organizational proximity* is a key antecedent of the external boundary spanning activities which the centralized TTOs engage in.

As to the decentralized TTO level, our interviews reveal that an important antecedent of the decentralized TTO's engagement in external boundary spanning activities is *technological proximity*. Common scientific or professional backgrounds explain why decentralized TTOs engage in boundary spanning towards industrial companies and the centralized TTO. For instance, the postdoc researcher involved in case F said:

> *"It is an advantage that DTTO5 possesses experience in veterinary medicine, as this allows him to co-judge which proteins are important as well as to identify relevant market parties."*

In case A, PhD researcher A2 noted:

"DTTO1's background and his judgment of the technological possibilities are invaluable in negotiations with industrial companies."

These insights lead us to propose the following differences as to the dimensions of proximity that influence the different external boundary spanning activities of decentralized and centralized TTOs:

Proposition 3a: Organizational proximity is a more pronounced antecedent of the external boundary spanning activities of centralized TTOs than it is for decentralized TTOs.

Proposition 3b: Technological proximity is a more pronounced antecedent of the external boundary spanning activities of decentralized TTOs than it is for centralized TTOs.

Internal boundary spanning

With regard to the centralized TTO level, interviewees often stated that centralized TTOs are aware of the university strategy, internal procedures, common practices and (in)formal rules. This *organizational proximity* appears to be an important determinant for why they engage in internal boundary spanning activities between pre-founding teams and the central university management. The postdoctoral researcher in case F said:

"The centralized TTO is successful in providing guidance for spin-off development. This is reflected in the previous track record of the people working at the centralized TTO. They possess knowledge on how to deal with different issues and follow standardized university procedures."

As such, *organizational proximity* is found to be an important antecedent of the centralized TTO's engagement in internal boundary spanning.

As to the decentralized level, decentralized TTOs are geographically closely located to the research groups as their offices are located on site. In contrast, the workspace of the centralized TTO level is situated on a spot which is physically more distant from the researchers. DTTO4 describes why geographical proximity affects his internal boundary spanning activities as follows:

"The most important responsibility in my job is what I call "corridor dynamics". I have my office in the same building as the academic staff, so I am around, I am on the mailing list of the faculty, so I go and talk to people at receptions, without forcing anything."

The result is that geographical proximity facilitates face-to-face contact and the exchange of information between decentralized TTOs and research teams. Another illustrative comment was made by researcher B4:

"Only once a month, we have a meeting with the centralized technology transfer officer, whereas DTTO2 makes an effort to stay informed and gives feedback on a more regular basis. Further, DTTO2 is nearby, easier to reach and more actively involved as our closest sounding board. We can easily discuss the emails and information she got from the centralized TTO ."

Consequently, we argue that a first antecedent of decentralized TTOs' internal boundary spanning is their *geographical proximity* towards the research groups.

Our interviews also demonstrate that technological proximity is a second important antecedent of decentralized TTOs' internal boundary spanning activities. Since decentralized TTOs are delegated to a specific cluster of research groups, they generally are familiar with the cluster research or technology domain. As such, they are able to understand the members of the pre-founding team and to communicate information about the nascent spin-off to the centralized TTO and other research groups. The overlap of their knowledge bases facilitates successful knowledge exchange. For instance, in case B, DTTO2 has a PhD and experience in biosciences, which enables her to interact easily with the researchers and to explain the technology in basic terms to the centralized TTO who lacks such knowledge. DTTO2 stated:

"I am the biggest supporter of the team. I push and pull at the same time. I talk to people. I am the memory of the nascent organization."

In the majority of our cases, researchers indicated that the decentralized TTO was involved in opportunity recognition and/or technology development thanks to his/her technological proximity. For case A, the PhD researcher A1 described it as follows:

"DTTO1 has initiated the whole project. He came up with the spin-off idea and remains one of the driving forces behind it. His background allows him to evaluate the feasibility of the technology and to make sure that products are market ready, of course in consultation with the pre-founding team members. "

As such, a second important antecedent of the decentralized TTO's engagement in internal boundary spanning is *technological proximity*.

These insights lead us to present the following propositions on the importance of different dimensions of proximity for the internal boundary spanning activities performed by decentralized and centralized TTOs:

Proposition 4a: Organizational proximity is a more pronounced antecedent of the internal boundary spanning activities of centralized TTOs than it is for decentralized TTOs.

Proposition 4b: Geographical and technological proximity are more pronounced antecedents of the internal boundary spanning activities of decentralized TTOs than for centralized TTOs.

This second set of propositions is summarized in Figure 2.

[Insert Figure 2 about here]

5. Conclusions

Our purpose was to provide new insights into the role of TTOs in the pre-spin-off process to help the pre-founding team to advance. In doing so, we looked beyond the traditional centralized TTO structures and studied a hybrid TTO model which consists of centralized and decentralized levels. Our qualitative analysis has highlighted the existence of a dual boundary spanning role for the two levels within hybrid TTOs. Specifically, the centralized level tries to help pre-founding teams through external boundary spanning activities, by which they bring team members into contact with external experts and financiers. Conversely, external boundary spanning activities at the decentralized level help pre-founding teams get in touch with industrial companies. Moreover, we find that also their *internal* boundary spanning role is not to be neglected. Centralized TTOs are helpful in bridging the gap between the pre-founding teams and the central university level, whereas decentralized TTOs contribute by spanning boundaries between different research teams and between pre-founding team members and the centralized TTO.

Further, we show that the engagement of centralized and decentralized TTOs in different boundary spanning activities is explained by different dimensions of proximity. Whereas the boundary spanning activities of the centralized TTO level are mainly explained by its organizational proximity to the central university management level, geographical and technological proximity cause decentralized TTOs to carry out their boundary spanning activities, implying that they are located physically close to the research teams and share similar knowledge bases.

6. Limitations and directions for further research

This research has a number of limitations which suggest areas for further research. First, we concentrate on one structure by which universities can organize their TTO functions, namely the "hybrid TTO model". While this model has been frequently used in practice, it has been largely understudied, with previous research often considering TTOs to be centralized units. However, further research might usefully compare the boundary spanning role and drivers of hybrid versus non-hybrid, i.e. entirely (de)centralized, TTO structures. Second, TTOs typically are involved in a wide set of technology transfer mechanisms, ranging from licensing over collaborative research to facilitating spin-off creation. This study specifically focused on the role and drivers of TTOs in the latter activity. Further research could purposefully assess the activities of TTOs in alternative commercialization avenues such as collaborative research, contract research and know-how based consulting, and protection of intellectual property. Moreover, future studies could look at how the choice between licensing and spin-off creation is made by centralized versus decentralized TTO levels. Finally, as this study is qualitative, further research is needed both to formulate the sets of propositions we have developed into testable hypotheses and to test those hypotheses on large samples and in comparative contexts.

In summary, further research could purposefully assess the role of TTOs in other types of technology transfer activities, hereby integrating samples including different TTO models.

7. Contributions and implications

In spite of its limitations, our research makes a number of contributions to the academic literature. First, it contributes to the *TTO literature*, which has called for research to explore the activities of TTOs and their determinants (Comacchio et al. 2012; Djokovic and Souitaris 2008), and various structures by which research institutions house their TTO functions (Markman et al. 2005). As such, our research extends previous TTO research which has mostly focused on centralized TTOs and almost neglected decentralized and hybrid models despite these latter being quite common in practice. Further, our research contributes by showing the importance of TTOs engaging in internal boundary spanning activities. While the organizational behavior literature has emphasized the need for internal and external boundary spanning in other contexts (e.g. in product management, Lysonski 1985; in multiunit organizations, Tsai 2002), so far, the technology transfer literature has to a large extent neglected this double function and has mainly concentrated on the external boundary spanning role. Our findings however indicate that, in order for TTOs to help firms to move through the pre-spin-off process, not only external, but also internal boundary spanning activities are a prerequisite.

Second, this study contributes to the *academic entrepreneurship literature* which has emphasized the importance of the subunit or department level (e.g., Kenney and Goe 2004; Louis et al. 1989). This literature has shown that individuals tend to conform to localized norms (Bercovitz and Feldman 2008). Hence, the department chair and workplace peers may play an important role in realizing the university's third mission. Our study indicates that, while examining the localized social environment, in addition to taking into account the workplace peers and the department chair, it is important to consider also decentralized TTOs. By inducing and helping some scientists to engage in the pre-spin-off process, decentralized TTOs may indeed contribute to create a localized social environment that stimulates research commercialization. This paper further enriches the literature on academic entrepreneurship by concentrating on the largely unexplored pre-spin-off process.

Third, we add to the *organizational ambidexterity literature applied to the university context*. Prior studies in this stream have recognized the challenges that universities face when engaging in research, teaching and technology transfer and have highlighted the advantages of structural ambidexterity in successfully pursuing these different activities. Specifically, it has been suggested that autonomous units devoted to technology transfer activities (i.e. TTOs) should be established alongside traditional structures related to teaching and research. Our study shows that, while creating such structures, new intra-organizational boundaries may arise which should not be overlooked.

Fourth, we contribute to the *literature on proximity*. An extensive body of literature has analyzed the different dimensions of proximity (Boschma 2005; Knoben and Oerlemans 2006), but has typically considered proximity as an inter-organizational concept. Here, we extend these studies by highlighting the relevance of intra-organizational proximity, i.e. proximity between different units within the same organization.

Our research also has relevant implications for practitioners. Specifically, this study identifies determinants of (hybrid) TTOs' contribution to the pre-spin-off process, which is of relevance to policy makers and university managers when implementing dual structures at ambidextrous research organizations. Our research can provide guidance for TTOs to understand which activities are regarded as helpful to the pre-spin-off process, while presenting directions for university management and policy makers on why different TTO levels are driven to engage in these activities. As such, it offers indications on the implementation of TTO structures and recruitment policies. As to the former, we have shown that decentralized TTOs engage in important internal boundary spanning as a consequence of their geographical proximity to research teams, thus suggesting that these officers should be placed within departments, physically close to the research teams. As to the guidelines for recruitment policies, since the technological proximity between the decentralized TTO level and research teams is another important determinant of internal boundary spanning, TTO managers could maximize the contribution to the pre-spin-off process by hiring decentralized TTOs with education and work experience in areas close to those of the research teams they are supposed to work with. It is important, however, to strike the right balance between having sufficient understanding of the technology with the ability to provide the complementary expertise to develop it commercially. Furthermore, our study can be helpful for nascent academic entrepreneurs in understanding the possible role fulfilled by TTOs in a hybrid model.

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Founding year	1817
Organizational status	Public
Position in Academic Ranking of World Universities	89
Number of faculties	11
Number of students	32,000
Number of staff	7,100
Annual research budget	About 235 million EUR
Medical school	Yes
Science parks	2
Business incubators	3
University seed capital fund (size; maximum investment per company)	Baekeland (11.1 million EUR; 500,000 EUR)
Number of staff at centralized TTO	30
Number of staff at decentralized TTO	21

Table 1: Key characteristics of University of Ghent on the 31st of December 2011

	Spin-off type*	Pre-founding team		Faculty	Field of research	Technology	Pre-spin-off internal funding	Number of patents applied for (granted)	Number of interviews (number of rounds)	Phase 1st interview round	Phase last interview round
		Academics involved	Non-academics involved								
Case A	Technology-oriented	PhD researcher A1° PhD researcher A2° Professor A3	2 Consultants°	Engineering	Textiles	Development and production of custom made products using nanofibres by electrospinning	- May 2009: Stepstone for prototype machine + patent costs - June 2010: Stepstone for market exploration + external business development support + product development and testing	5 (1)	11 (4)	Opportunity framing	Pre-organization
Case B	Technology-oriented	Postdoc B1° Postdoc B2° PhD researcher B3° PhD researcher B4° Professor B5	2 Consultants	Bioscience Engineering	Biochemical and microbial technology	Metabolic modeling and engineering of micro-organisms	- June 2009: Stepstone for technology development + external market consultant(s)	2 (0)	21 (4)	Opportunity framing	Pre-organization
Case C	Technology-oriented	PhD researcher C1° Professor C2 Professor C3 Professor C4 Professor C5 Business developer	/	Engineering	Telecommunication and information processing	Mobile tracking services	- March 2010: Stepstone for technological feasibility + business plan + potential partners/customers	1 (1)	8 (4)	Opportunity framing	Opportunity framing
Case D	Service-oriented	Professor D1 Professor D2 Professor D3 Laboratory team	Engineering team of industry partner	Sciences	Pharmacology	Design and optimization of granulation process	- April 2011: Stepstone for purchase machine from industrial partner + technology development	1 (1)	7 (4)	Opportunity framing	Opportunity framing
Case E	Service-oriented	Postdoc E1° Postdoc E2 PhD researcher E3° PhD researcher E4 Professor E5	/	Sciences	Telecommunication and information processing	Commercial archaeology	/	/	6 (3)	Opportunity framing	Pre-organization
Case F	Technology-oriented	Postdoc F1° Professor F2 Professor F3 Professor F4	/	Sciences	Virology, parasitology and immunology	Development of vaccines, therapeutics and diagnostics	- May 2011: Stepstone for technology development + external business developer and consultant	1 (0)	6 (2)	Opportunity framing	Opportunity framing

Table 2: Key characteristics of the six nascent spin-offs

Legend. * The core business of technology-oriented spin-offs is rooted in codified knowledge exploited for industrial purposes; conversely, service-oriented spin-offs are devoted to the exploitation of tacit knowledge in a logic of expertise providers (Pirnay et al. 2003). Technology spin-offs are usually based on patents, often long term research, require a lot of financing, often external management and have a longer pre-spin-off process. Service spin-offs arise from services which are often first offered by the university, but then are put into an independent unit. This latter spin-off type usually does not require external management nor external capital. ° Individuals interviewed.

	Centralized TTO level		Decentralized TTO level	
	Representative*	Activities	Representative	Activities
Case A	CTTO 1° CTTO 2°	- Involve external patent expert (E) - Assist with the Stepstone project application (I) - Prepare university seed capital fund proposal (I) - Look for external CEO and market consultant (E) - Initiate contact between team and financiers (E)	DTTO 1°	- Foster technology development - Assist with the Stepstone project application (I) - Search for and interact with potential partners and customers (E)
Case B	CTTO 3° CTTO 4°	- Involve patent attorney and external technology expert (E) - Assist with the StarTT and Stepstone project applications (I) - Look for external consultants or managers (E) - Look for a CEO (E)	DTTO 2°	- Initiate and endorse opportunity recognition - Link centralized TTO to pre-founding team (I) - Assist with the Stepstone project application (I) - Bridge different opinions in team (I) - Filter industry contacts (E)
Case C	CTTO 5° CTTO 2°	- Provide help with patent application - Assist with the Stepstone project (I) - Join meetings with industry partner (E) - Build legitimacy for team towards industry (E)	DTTO 3°	- Foster technology development - Look for applications of the technology (E) - Search for first customer contacts (E) - Connect team to potential partners and customers (E)
Case D	CTTO 3° CTTO 4°	- Assist with the Stepstone project application (I) - Provide help with IP and licensing issues (E) - Contracts with industry partner (E) - Help to write the business plan (E) - Look for external experts (E)	DTTO 4°	- Assist with the Stepstone project application (I) - Link centralized TTO level to pre-founding team (I) - Monitor license agreement with industry partner (E) - Look for applications of the technology (E) - Manage contacts with industry (E)
Case E	CTTO 5°	- Provide help with patent application - Translate university objectives to team members (I) - Negotiate distribution/license contract (E)	DTTO 3°	- Endorse opportunity recognition - Search for data for the market analysis (E) - Help to write the business plan (E) - Initiate collaborations between different faculties and research groups (I)
Case F	CTTO 4°	- Assist with the Stepstone project application (I) - Provide help in administration	DTTO 5°	- Initiate and endorse opportunity recognition - Look for applications of the technology (E) - Help to write the business plan (E) - Manage relationships with industrial companies (E) - Check the relevance of research results with industry (E) - Monitor collaboration between different faculties and research groups (I)

Table 3: Support activities of centralized and decentralized TTOs in the six nascent spin-offs in pre-start-up process

* Two names in a cell indicate that the initially authorized person at the centralized TTO level was replaced by a different person

CTTO = centralized technology transfer officer; DTTO = decentralized technology transfer officer

(E) = external boundary spanning activity; (I) = internal boundary spanning activity

° Individuals interviewed.

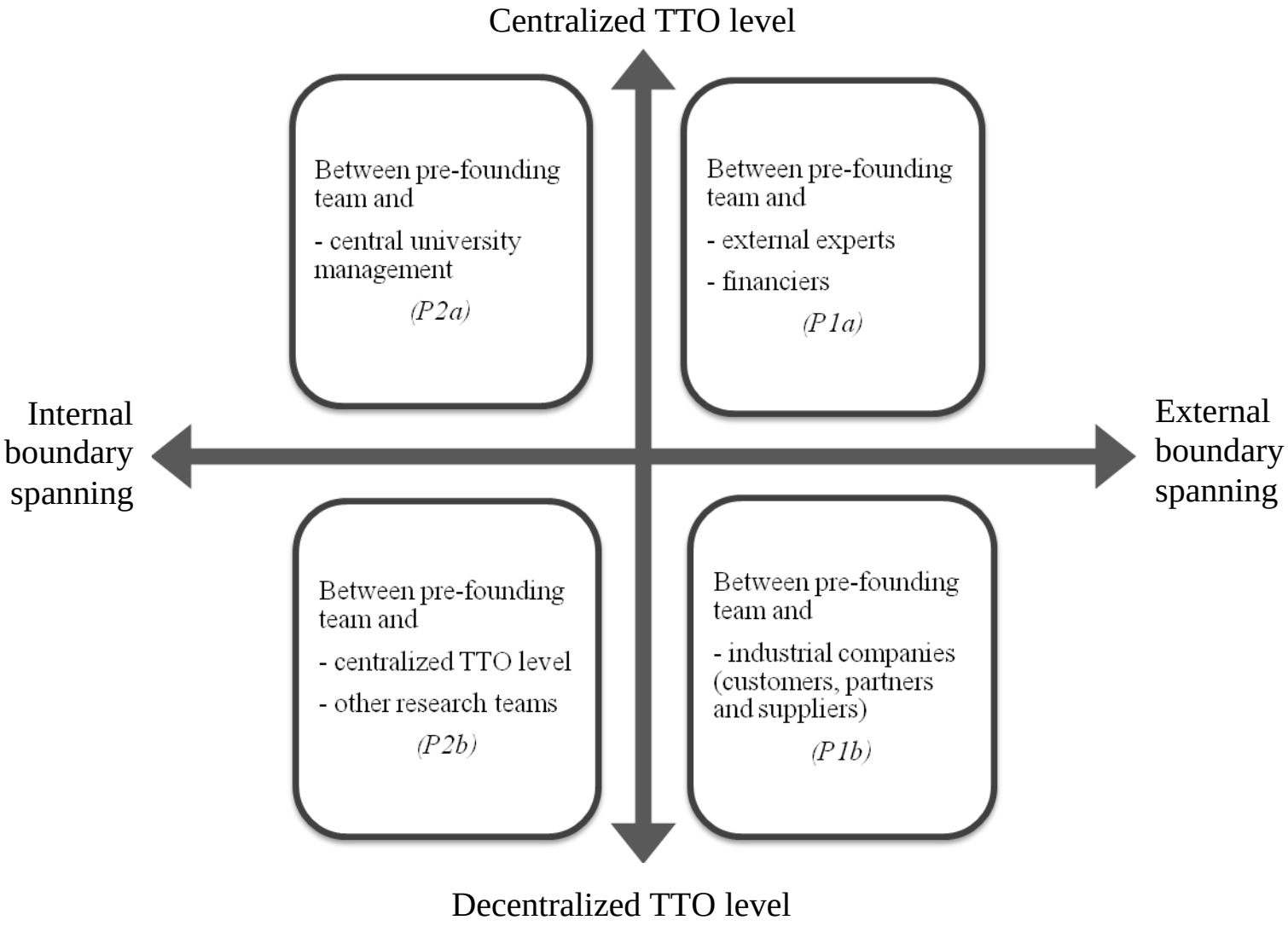

Figure 1: Boundary spanning activities at different TTO levels

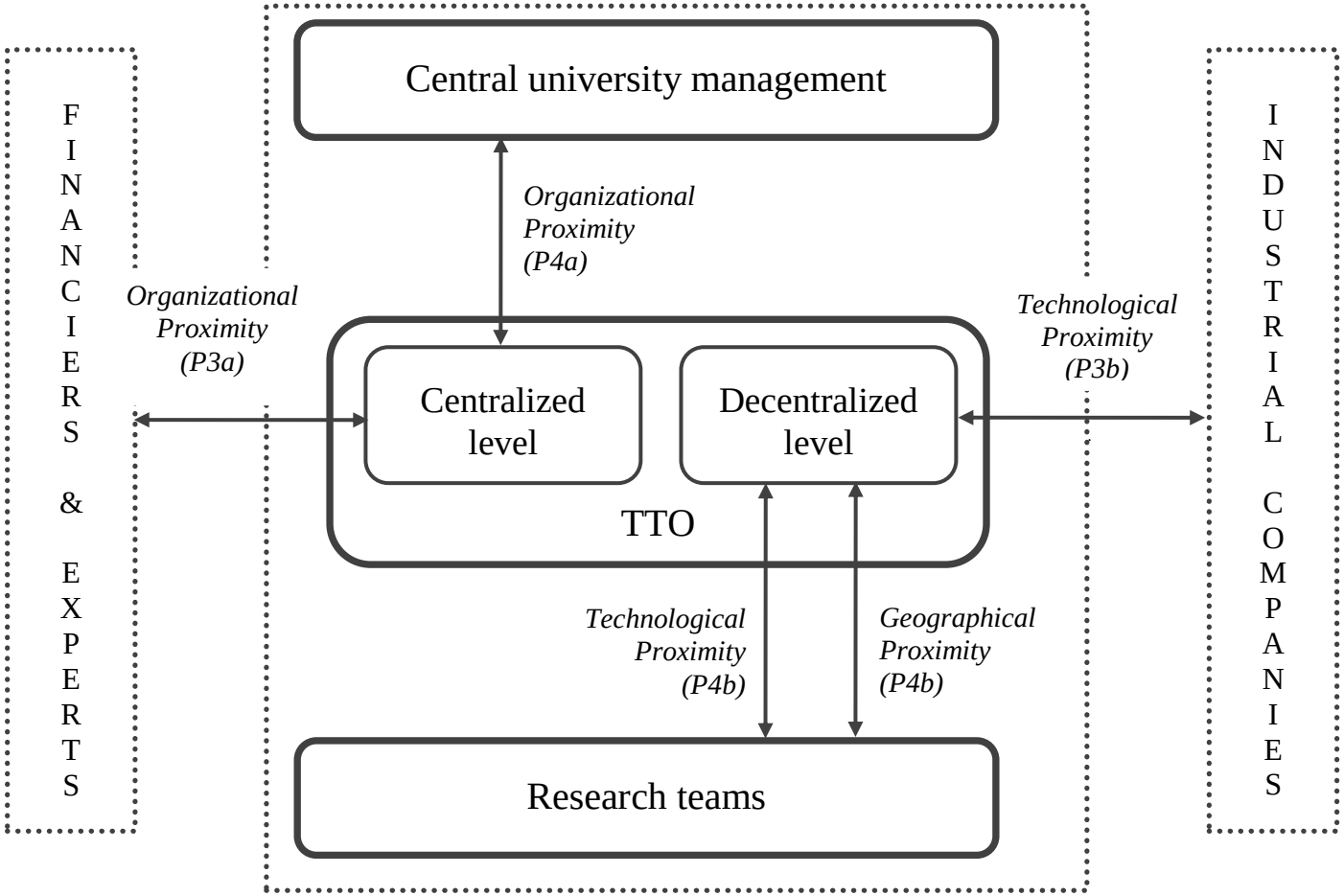

Figure 2: Proximity as an antecedent of boundary spanning activities at different TTO levels