ARE RESEARCHERS DELIBERATELY BYPASSING THE TECHNOLOGY TRANSFER OFFICE? AN ANALYSIS OF TTO AWARENESS

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ABSTRACT

Most universities have established technology transfer offices (TTOs) to enhance the commercialization of academic research. Nonetheless, many researchers bypass these TTOs and take their inventions directly to the marketplace. While TTO bypassing has typically been portrayed as deliberate and nefarious behavior, we argue that such actions could be unintentional as many researchers may simply be unaware of the TTO's existence. Taking an information-processing perspective and using data on 3,216 researchers in 24 European universities, we examine characteristics of both researchers and TTOs associated with TTO awareness. Our evidence confirms that only a minority of researchers are aware of the TTO at their university. Researchers who do so either possess experience as an entrepreneur, or closed many research and consulting contracts with industry partners. Moreover, when they reside in universities incorporating a traditional TTO structure, researchers are less likely to be familiar with the TTO's existence. Yet, this negative association between traditional TTO structures and TTO awareness is alleviated by researchers' industry work experience. Policy implications of these findings are discussed.

Keywords: TTO awareness, TTO bypassing, Information-processing, Knowledge corridor, Structural autonomy, Academic entrepreneurship

JEL-codes: L26, M13, O32

1. INTRODUCTION

Over the past decades, universities have become increasingly entrepreneurial, assuming a mandate for the realization of commercial value from research and encompassing a "third mission" alongside the traditional tasks of education and research (Etzkowitz 2003; Rothaermel et al. 2007). The interest of universities in research commercialization is inspired by pressures from policy makers viewing commercialization activities as a key source of innovation and national competitiveness (Lam 2011; Mansfield 1998). At the same time, reduced public research budgets have forced universities to develop alternative and complementary strategies to raise funds (Ambos et al. 2008; Shane 2004a). Finally, the passage of the US Bayh-Dole Act in 1980 (Grimaldi et al. 2011; Mowery et al. 2002; Shane 2004b), followed by similar changes in the legislative framework in most European countries (OECD 2003; Wright et al. 2008), contributed to greater exploitation and diffusion of knowledge and technologies developed in academia.

Nevertheless, research commercialization remains a challenging task due to an inherent tension between academic and commercial demands (West 2008). Several barriers inhibit the technology transfer process. Industry-university collaborations amplify the risks of information leakages incurred by firms, and are frequently plagued by conflicts of interest that arise from the different incentive schemes that firms and universities are exposed to. In addition, scientific knowledge generated within academia is often too general to be applied in an industry context (Clarysse et al. 2011; Gilsing et al. 2011). Consequently, universities have taken several initiatives to foster the linkages between industry and science (Perkmann et al. 2013; Phan and Siegel 2006) and to formalize technology transfer (Siegel et al. 2003). The establishment of technology transfer offices (TTOs) figures prominently among these initiatives (Siegel et al. 2007). TTOs stimulate university researchers to disclose their inventions, evaluate the commercialization potential of these inventions, and subsequently engage in various support services such as partner search, management of intellectual property rights and business development (Phan and Siegel 2006; Siegel et al. 2003). They also fulfill a dual boundary spanning role by bringing researchers into contact with experts, companies and financiers outside university

boundaries, and by bridging the gaps with the central university and/or between different research teams within university boundaries (Huyghe et al. 2014).

Given the potential benefits related to TTO establishment, it comes as no surprise that the academic literature has devoted considerable attention to the phenomenon. Numerous studies have investigated the way TTOs are structured (e.g., Bercovitz et al. 2001; Markman et al. 2005), the activities they perform (e.g., Huyghe et al. 2014; Siegel et al. 2007), and the entrepreneurial output they generate in terms of number of technologies licensed, patents granted and spin-offs created (e.g., Coupe 2003; Link and Scott 2005; Lockett and Wright 2005). Yet, scholars have also recognized that many researchers do not resort to TTOs when commercializing their scientific discoveries but take these inventions directly to the marketplace. Consequently, universities miss out on opportunities to generate revenues (Markman et al. 2008). For instance, in a German context, Krücken (2003) estimated a ratio of nine entrepreneurial projects set up by researchers through informal links to every formal one established through the TTO. This has been referred to as "technologies going out the back door" (Thursby et al. 2001; Siegel et al. 2004), "the gray market of technology transfer" (Kenney and Patton 2009) or "TTO bypassing" (Kumar 2010; Markman et al. 2006; 2008), and has typically been treated as nefarious behavior.

In this paper, we argue that researchers may not always purposefully bypass the TTO when they pursue research commercialization activities. A researcher may take an invention directly to the marketplace simply because s/he is not aware that a TTO exists at his/her university. As a result, Sellenthin (2009)'s conclusion that researchers who regard the support of the TTO as helpful or valuable will not circumvent it, only holds if the researchers have detected the TTO, and can thus evaluate its activities and decide whether or not to call upon its support. This may seem a trite observation but is perhaps not surprising in the complex context of a university environment. It is consistent with Schmiemann and Durvy's (2003) suggestion that TTOs need to gain much more visibility, particularly in European universities, in order to act more effectively. Along the same lines, Krücken (2003) accentuated the need for greater TTO visibility if technology transfer officers are to act as agents of change in establishing academic entrepreneurship as a legitimate and desirable activity. Accordingly, we suggest that a necessary condition for researchers to consult the TTO and to take advantage of its services is TTO awareness.

Surprisingly, to date, no scholars have considered the extent to which researchers are aware of the existence of a TTO at their university, nor analyzed factors that explain heterogeneity in TTO awareness. To address this knowledge gap, our study investigates the impact of characteristics of both researchers and TTOs on TTO awareness. Specifically, using information-processing theory as the overarching framework complemented by insights from the knowledge corridor thesis and arguments on structural autonomy, we examine the impact of researchers' prior knowledge and TTOs' degree of structural autonomy on TTO awareness. Besides looking into the direct effects, we also shed light on the interplay between researcher and TTO characteristics. To empirically test the associations between these determinants and TTO awareness, we employ a unique cross-sectional dataset of 3,216 researchers in 24 universities located in five culturally different European countries.

Our key contribution is to the literature on academic entrepreneurship and technology transfer and is twofold. First, our study enriches prior work by highlighting that not all bypassing behavior is deliberate. A lack of TTO awareness may be a major limiting factor in researchers' ability to use TTO initiatives. Second, to our knowledge, this research is the first to propose and test factors associated with TTO awareness, thereby recognizing the importance of both individual and TTO attributes. Besides being relevant to scholars, our study has valuable implications for practitioners, including TTOs, university managers and policy makers. In particular, our findings indicate under which circumstances TTOs are more (less) likely to be detected by researchers thus reducing (increasing) the probability of TTO bypassing. Our results further suggest that policy remedies designed to address shortcomings in the effectiveness of academic entrepreneurship that target university researchers may, at least partially, be looking in the wrong place. Rather attention may also need to be given to enhancing the profile of TTOs.

The remainder of this paper is organized as follows. We first present our theoretical framework and hypotheses, followed by a description of our data collection procedure and variable construction. Subsequently, we present our findings, discuss the theoretical and managerial implications of our results, and propose directions for further research.

2. THEORETICAL BACKGROUND AND HYPOTHESES

To explain why some researchers detect the TTO within their university while others do not, we build upon insights from information-processing theory. This theory recognizes that there are differences in the way people acquire and interpret information in their environment (Lord and Maher 1990). Such diversity originates from the fact that people tend to occupy different and unique "information environments" (Huber and Daft 1987), i.e. the subset of information in the environment that is subject to being sensed varies from one individual to another.

Acquiring and interpreting information is particularly demanding in complex environments (Forbes 1999), characterized by high levels of information load and diversity (Hansen and Allen 1992). In such environments, large volumes of ambiguous information make it challenging for individuals to scan all relevant information and reduces the degree of overlap among the information sources scanned by different individuals (Forbes 1999). This is the case in the context of our study. Due to their fuzzy and differentiated goals, the variety of external and internal stakeholders they deal with, and their inherent labor intensity (Bartell 2003), universities can be considered complex environments. Hence, there is likely to be great heterogeneity in terms of the information sources scanned by different researchers and, thus, the information environments that different researchers occupy.

This logic implies that researchers may be more or less likely to detect the TTO based on differences in their particular information environments. In what follows, we contend that such differences can stem from characteristics of the individual (i.e. the researcher) and his/her environment (i.e. the TTO). To investigate the influence of these attributes on researchers' information environments and, ultimately, TTO awareness, we complement information-processing theory with insights from the knowledge corridor thesis and arguments on the structural autonomy of TTOs.

2.1. Researcher Characteristics: The Role of Prior Knowledge

Prior experiences influence the amount and nature of the information that individual researchers process. In particular, an individual's idiosyncratic life circumstances, including prior (work and educational) experiences, create a "knowledge corridor" that shapes the information s/he can see, interpret and respond to (Ronstadt 1988; Venkataraman 1997). Several entrepreneurship scholars have built on this knowledge corridor thesis to explain how prior experiences lead to differences in the likelihood of identification and exploitation of opportunities for the commercialization of new products and services (Ardichvili et al. 2003; Gruber et al. 2013; Shane 2000) as well as opportunities for innovation (Cliff et al. 2006; Shepherd and DeTienne 2005). As individuals have a tendency to mostly notice information related to the information they already know (Von Hippel 1994), they are usually unaware of opportunities that lie outside their knowledge corridor. We extend the knowledge corridor thesis beyond the discovery of entrepreneurial or innovation opportunities by arguing that a researcher's prior experiences will influence her/his likelihood to identify research commercialization opportunities in the university context.

From this perspective, researchers with prior work experiences limited to traditional university tasks of education and research are located in a knowledge corridor (hereafter, the traditional academic corridor) that makes them poorly receptive to research commercialization opportunities and relatively unlikely to detect the TTO at their university. Conversely, knowledge acquired through prior work experiences outside academia enables researchers to escape the traditional academic corridor and leads

them to occupy a different information environment. In particular, experiences in the private sector as either employees or entrepreneurs (hereafter, industry work experience) allow researchers to gain knowledge about industrial needs, market functioning and the differences between science and industry (Wennberg et al. 2011). This knowledge is likely to shape researchers' information environments, and make them increasingly alert not only to research commercialization opportunities but also to commercialization initiatives at the university, such as TTO establishment. Hence:

> **Hypothesis 1**: Researchers with industry work experience are more likely to be aware of the TTO's existence than researchers that lack such experience.

Experience in industry-science interaction, gained through prior engagement in contract research and consulting activities with the private sector, could also extend researchers' stock of knowledge and allow them to escape the traditional academic corridor. Researchers who closed more research and consulting contracts with industry are likely to be better aware of the market potential of their scientific discoveries (Gulbrandsen and Smeby 2005; Krabel and Mueller 2009) as well as the potential benefits and problems related to the commercialization of research results (Fritsch and Krabel 2012). Accordingly, these researchers are likely to have a superior ability to recognize research commercialization opportunities and, by extension, a greater likelihood to detect the TTO at their university. Therefore, we predict a positive association between the number of research and consulting contracts that a researcher has closed with industry and her/his TTO awareness. Hence:

> **Hypothesis 2**: Researchers who closed more research and consulting contracts with industry are more likely to be aware of the TTO's existence.

2.2. TTO Characteristics: The Role of Structural Autonomy

In exploring environmental determinants of TTO awareness, we concentrate on the structural autonomy of the TTO. A focus on the TTO's structural dimension is warranted given its implications for the coordination of activities, the facilitation of internal and external information flows and the alignment of incentives (Bercovitz et al. 2001). As such, structural autonomy is likely to affect whether the TTO's existence belongs to a researcher's information environment.

Specifically, we draw on the classification put forward by Markman et al. (2005), distinguishing between three TTO structures that vary in the degree to which they have autonomy in the pursuit of research commercialization. These archetypes are the traditional university structure, the non-profit research foundation, and the for-profit venture extension. As the latter form is rather uncommon in practice and only negligible differences exist in terms of TTO structural autonomy between the non-profit research foundation and the for-profit venture extension, we combine these two categories. Accordingly, in line with Markman et al. (2008), we make a distinction between traditional and non-traditional (or autonomous) TTO structures. Traditionally structured TTOs reside inside universities, are run and controlled by university management, and generally consist of university staff. In contrast, non-traditional TTO structures are established outside universities, have largely independent management and function mostly autonomously. As a result, traditional TTOs need to seek formal university administration approval in building infrastructure to facilitate their mission, while non-traditional TTOs have greater flexibility in this regard.

This variation in terms of structural autonomy for TTOs is likely to impact the information environments that researchers occupy. We expect that traditional TTOs will to a lesser extent than non-traditional TTOs distribute information on their existence to researchers for a number of reasons. First, these TTOs may mistakenly assume that they must be on a researcher's radar as they reside in the same overall university structure. Second, traditional TTOs must spend time and effort in following university rules or seeking approval from university management. Consequently, less time is left for reach-out efforts in order to enter researchers' information environments. Finally, traditional TTOs may face difficulties in contacting researchers as they are bounded by the bureaucratic culture, and inherently the communication procedures, within the university (Siegel et al. 2003). Conversely,

non-traditional TTOs are known to hold "open house" visits, to have a larger "communication bandwidth" and to interact more frequently with faculty (Markman et al. 2008: 30). Taken together, traditional TTOs are less likely to permeate into researchers' information environments, and researchers are thus less likely to detect TTOs when these have limited structural autonomy. Hence:

> **Hypothesis 3:** Researchers working at universities incorporating a traditional TTO structure are less likely to be aware of the TTO's existence than researchers at universities with a non-traditional TTO structure.

2.3. Interplay between Researcher and TTO Characteristics

Thus far, we have presented prior knowledge of the researcher and structural autonomy of the TTO as separate factors simultaneously affecting the information environments that researchers occupy and, thus, influencing their TTO awareness. It is however important to understand the joint impact of these attributes. In this respect, we argue that the negative effect of traditional TTO structures will be mitigated by researchers' prior knowledge. Indeed, the TTO's existence is less likely to be part of a researcher's information environment when s/he is employed at a university where the TTO has a low degree of structural autonomy, unless the particular researcher has moved through knowledge corridors that promote the integration of TTO information in the individual's information environment. Hence:

> **Hypothesis 4:** The negative relationship between working at universities incorporating a traditional TTO structure and the likelihood of TTO awareness is weaker when researchers have industry work experience.

> **Hypothesis 5:** The negative relationship between working at universities incorporating a traditional TTO structure and the likelihood of TTO awareness is weaker when researchers closed more research and consulting contracts with industry.

3. METHODOLOGY

3.1. Data Collection and Sample

Our study utilizes a unique cross-sectional dataset constructed in 2012 and 2013 through face-to-face interviews with TTO managers and an online survey directed to academic researchers. The data were collected at 24 universities in five European countries. The five countries were selected building upon the societal clusters proposed by the Global Leadership and Organizational Behavior Effectiveness research program (GLOBE), that groups countries on the basis of cultural dimensions (Gupta et al. 2002; Javidan et al. 2006). Starting from the four GLOBE clusters in Europe, we randomly selected at least one country per cluster: Sweden (Nordic Europe), Spain (Latin Europe), Slovenia (Eastern Europe), Germany and Belgium (Germanic Europe). Within each country, we randomly selected two level 1 NUTS regions: East Sweden (SE1) and South Sweden (SE2), Community of Madrid (ES3) and East Spain (ES5), Slovenia (S10), Bavaria (DE2) and North Rhine-Westphalia (DEA), Brussels Capital (BE1) and Flanders (BE2). Next, we made a list of all the universities located in those geographical regions using secondary sources (including reports by ministries of education, university rankings, technology transfer networks and general internet searches), and contacted their TTOs through email and/or telephone. TTO managers in 40 out of the 58 universities identified and contacted were willing to take part in our research. Nine of the 40 universities were dropped due to respondents' ultimate unavailability to participate in face-to-face interviews. Another seven universities were excluded as the distribution of our survey among researchers was unfeasible due to privacy policies or nonexistence of staff directories. We thus have a final sample of 24 universities.

During the interviews with the TTO managers of these 24 universities, we acquired information on a range of university and TTO characteristics (e.g., human and financial resources, annual commercialization output, history and structure of the TTO). Primary data were verified and complemented with secondary data from annual reports, and university and TTO websites. Moreover, we asked for assistance to contact researchers from different scientific disciplines within each university and requested them to fill out our online questionnaire.

The survey population consisted of 32,358 pre- and post-doctoral researchers. We received 6,442 failure messages indicating that email addresses were invalid or our message could not be sent, resulting in a usable population of 25,916 researchers. A total of 4,515 responses were received (17% of the usable population, which is comparable to previous research in this domain; e.g., Obschonka et al. 2012). Exclusion of partial responses resulted in a final sample of 3,216 researchers who fully completed the required questions (12% of the usable population). T-tests revealed no statistically significant differences between respondents who filled in all questions and those who provided incomplete responses, and between early and late respondents, in terms of age, gender, educational background, discipline or country.

3.2. Measures

3.2.1. Dependent Variable

TTO awareness was measured through the online questionnaire by asking researchers whether they were aware of the existence of a TTO at their university. The variable takes a value of 1 where the researcher has detected the TTO and 0 otherwise.

3.2.2. Explanatory Variables

Industry work experience was captured by asking researchers whether they had previously been employed in the private sector, and whether they had ever been entrepreneurs. The dummy variable was coded 1 if the answer was positive to either one of these questions and 0 otherwise. 48% of the respondents reported to possess industry work experience.

Number of closed contracts was assessed through the online survey in which we asked researchers to specify how many research and consulting contracts they had closed with industry partners. The average number of contracts closed per researcher was 0.61. The distribution of this variable is skewed as only 13.4% of our respondents indicated that they had engaged in industry-science interaction, and the average number of contracts these researchers had closed was 4.5. Accordingly, we computed the variable as the natural logarithm of the number of closed contracts.

Traditional TTO structure was assessed during the interviews with the TTO managers, drawing on Markman et al.'s (2005) TTO classification based on the structural autonomy dimension. This variable takes a value of 1 in the case of a traditional TTO structure and 0 otherwise. 34% of the respondents were found to reside in a university incorporating a traditional TTO structure.

3.2.3. Control Variables

Gender indicates whether the researcher is male (value 0) or female (value 1). Following prior research on technology transfer, men are generally more likely to engage in commercialization endeavors than women (e.g., Landry et al. 2007; Obschonka et al. 2012). This difference may similarly be associated with a diverse likelihood of detecting the TTO at the researcher's university. The data obtained through the online questionnaire indicates that 52% of our sample consists of men.

Scientific discipline dummies were included in our analyses, using the responses to the online questionnaire. Researchers in our sample were active in medicine & pharmaceutical sciences (15%), engineering, technology & computer sciences (25%), life & agricultural sciences (14%), natural

sciences & mathematics (16%), or social & behavioral sciences (30%). Throughout our analyses, the latter category is used as the reference category. We controlled for scientific discipline as inventions in one field of research may have more (or less) market potential than inventions in other fields (Powers 2003), therefore making a researcher more (or less) likely to be aware of technology transfer practices and the existence of a TTO as a facilitator.

Post-doc position denotes whether the survey respondent was a pre-doctoral (value 0) or post-doctoral researcher (value 1). We expect pre-doctoral researchers to have had fewer opportunities to get acquainted with technology transfer practices at their universities. 35% of the researchers in our sample were occupying a post-doctoral position.

Educational background was controlled for through the inclusion of two binary variables (0 = no, 1 = yes), capturing whether the researcher had a technical degree (e.g., bio-science, physics, electronics, mechanics, robotics, telecom…) and/or a non-technical degree (e.g., economics, law school, psychology, MBA...). We controlled for education as researchers with a technical background are more likely to produce research results which are codified (Pilegaard et al. 2010), and therefore are easier candidates for engagement in commercialization activities. The results of the online questionnaire show that 49% of the respondents had a technical degree and 40% had a non-technical degree.

Scientific productivity is computed as the natural logarithm of the number of publications a researcher has, self-reported in the online questionnaire. Specifically, we asked researchers to report on their total publications in books or scientific journals incorporated in the (social) science citation index list. We control for publication output as recent studies have found that researchers excelling in research are also more likely to engage in knowledge transfer activities (Powers and McDougall 2005; Landry et al. 2007). The respondents in our sample had an average of 9 publications.

TTO size was controlled for, as larger TTOs are likely to gain more visibility than smaller ones. Information on the total number of FTE staff working for the TTO (including IP and licensing staff, excluding staff employed in science parks or incubator facilities) was obtained directly from the TTO managers during face-to-face interviews, and verified with secondary data (i.e., TTO websites and reports). On average, researchers worked at universities with 24 people employed in the TTO. Following the distribution of the number of FTE staff, the variable TTO size was computed as the natural logarithm of this number.

Country dummies were included as controls. Sample researchers were employed at universities in Sweden (25%), Germany (25%), Spain (16%), Slovenia (5%) and Belgium (29%). Throughout the analyses, we used Sweden as the reference category as this country introduced the academic exemption or professor's privilege, which asserts full ownership of intellectual property rights to faculty and is likely to affect technology transfer activities (Klofsten and Jones-Evans 2000).

4. RESULTS

4.1. General Findings

Table 1 provides an overview of the descriptive statistics and correlations. Interestingly enough, our data confirm the relevance of our research: TTO awareness cannot be taken for granted as only 44% of the respondents detected the TTO at their university. Table 1 also reveals that correlations among explanatory variables tend to be low. In addition, the variance inflation factors are all below 5 (maximum VIF = 3.14), indicating that multicollinearity is unlikely to be a concern in our study (Hair et al. 2010).

<< Insert Table 1 about here>>>

Table 2 subsequently presents the results of our analyses on the researcher and TTO characteristics associated with TTO awareness. We used hierarchical logistic regression analysis to test our five hypotheses. The models are adjusted for 24 university clusters using the cluster option in STATA.[1]

<< Insert Table 2 about here>>>

The coefficients of the variables included in the control model indicate that female researchers are less likely to be aware of the TTO's existence. Researchers in medicine, engineering, and especially in life sciences are further more likely to have detected the TTO, just as researchers occupying a post-doctoral position and those having a higher publication output. Respondents with a non-technical educational background have a lower likelihood of TTO awareness. Finally, researchers in Slovenia, Germany, Spain and Belgium are more likely to have identified the TTO compared to their peers in Sweden.

The full model allows us to test the direct effect hypotheses (H1-H3). As to the direct effect of industry work experience, while we find that the odds of being aware of the TTO's existence are 19% higher when the variable *Industry work experience* equals 1 rather than 0, this result is only statistically significant at the p<.10 level, and we thus do **not find support for H1**. Conversely, our analyses provide **support for H2**, which suggested a positive influence of the number of research and consulting contracts closed by the researcher. The results show that for every increase in the natural logarithm of the number of contracts closed (or for every increase by 2.7 contracts), there is an increase in the odds of being aware of the TTO's existence by 4% (p<.01). Our full model further indicates that researchers working in a university incorporating a TTO with a traditional structure are less likely to detect the TTO. Specifically, the odds of being aware of the TTO's existence are 29% lower for a researcher working at a university with a traditional TTO than for a researcher at a university with a non-traditional TTO structure (p<.05). Hence, we find **support for H3.**

To test the moderating effect hypotheses (H4-H5), we estimate an interaction model including the interaction terms between the dummy *Traditional TTO structure*, and the variables *Industry work experience* and *Number of closed contracts*, respectively. Inspecting the interaction model, our analyses **corroborate H4**, but we do **not find support for H5**. Specifically, as far as the first moderation effect is concerned, for researchers working at a university incorporating a traditional TTO, the odds of TTO awareness increase by 68%[2] in case the researchers also gained any work experience in the private sector, as either employees or entrepreneurs (p<.001). As such, it is evident that industry work experience mitigates the negative impact of a traditional structure on TTO awareness. As for the second hypothesized moderation effect, our results show that, for every unit increase in the natural logarithm of the number of research and consulting contracts closed by a researcher, the odds of TTO awareness increase by 1%[3] for individuals working in universities incorporating a traditional TTO structure. This effect is small and insignificant.

4.2. Robustness Checks and Post Hoc Analyses

We conducted a number of additional analyses to assess the robustness of our results and to provide more fine-grained insights into the factors associated with TTO awareness.

First, although we corrected for potential unobserved university effects, other cluster effects may have biased our results. Researchers in our sample are also embedded in different departments, and recent research has pointed to the importance of departmental influences (Bercovitz and Feldman 2008; Rasmussen et al. 2014). While most statistical packages only allow clustering by one variable,

[1] This hierarchical estimation technique adjusts the standard errors by computing a cluster robust standard error for the coefficient, as such accounting for potential unobserved university effects.
[2] Calculated as $((e^{-.01+.53})-1)\%$.
[3] Calculated as $((e^{.05-.04})-1)\%$.

we followed Petersen (2009) and used the logit2 command in STATA to apply two-dimensional clustering, in which the models were adjusted for potential unobserved effects due to both department- and university-grouping. The results remained identical after controlling for both department-specific (501 departments) and university-specific (24 universities) error components.

Second, as we argued that prior industry work experience was likely to affect the probability of TTO awareness, we tested hypothesis 1 by combining experience in the private sector as an employee and experience as an entrepreneur. In order to better understand the role of prior industry work experience, we split the dummy variable included in the estimates presented above into two separate dummy variables, respectively measuring 1) whether the researcher had been an entrepreneur before, and 2) whether the researcher had previously been employed in the private sector but had never been active as an entrepreneur. In the estimates of the model where the industry work experience dummy was replaced by these two new dummy variables, the dummy equaling one for individuals with entrepreneurial experience has a positive and significant coefficient ($B=.52$, $p<.001$), while the coefficient of the other dummy variable is not significant. These findings indicate that researchers who have been entrepreneurs before are much more likely to be aware of the TTO's existence than researchers with prior experience in the private sector as employees but without entrepreneurial experience. This result is not truly surprising. As entrepreneurs must be multi-skilled (Lazear 2004; Stuetzer et al. 2013), they tend to invest in acquiring the broad knowledge base and skill set required to run a business. Conversely, individuals who work for others do not need a balanced investment strategy, but can specialize in one skill. As a consequence of this difference in the investment strategies of entrepreneurs and employees, entrepreneurial experience is likely to extend an individual's stock of knowledge to a greater extent than any work experience as an employee. Hence, entrepreneurial experience is likely to create a broader knowledge corridor and information environment than any other work experience in the private sector.

Third, we carried out additional analyses to address potential endogeneity issues. In particular, researchers who had detected the TTO may already have contacted it and closed research and consulting contracts with industry thanks to the TTO's support. In this case, industry-science interaction experience does not help researchers to escape the traditional academic corridor thus making them more likely to identify the TTO, but it is the TTO that enabled researchers' engagement in contracts with industry. In order to rule out this alternative explanation, we also asked survey respondents whether they had ever been in contact with the TTO, and subsequently reran our analyses with this alternative dummy as dependent variable. If the positive association between the number of closed contracts and TTO awareness were in fact the result of the positive impact of TTO contact on the number of research or consultancy contracts, our additional analyses would reveal a positive association between industry-science interaction experience and our new dependent variable. However, the estimates of this latter model do not provide indications of any statistically significant relationship between the number of contracts closed by researchers and the likelihood that they contacted the TTO. Accordingly, we are confident that our findings are not caused by these alternative explanations.

5. DISCUSSION AND CONCLUSIONS

While the literature on academic entrepreneurship has devoted substantial attention to the TTO as an important facilitator in the process of research commercialization, much less is known about TTO bypassing behavior by researchers. In this study, we argued that circumvention of the TTO may purely stem from the fact that researchers are unaware of the existence of a TTO at their university. The empirical evidence in a sample of 3,216 researchers in 24 European universities supported this argument: less than half of our respondents (i.e. 44% of our sample) had identified the TTO at their university. Hence, before investigating the determinants of TTO bypassing behavior, it is worthwhile to shed light on the antecedents of TTO awareness. To the best of our knowledge, no prior work has studied such factors.

Building upon information-processing theory, we argued that researchers may be (un)aware of the TTO's existence due to differences in their particular information environments. Then, using the knowledge corridor thesis and arguments on the structural autonomy of TTOs, we formulated hypotheses on the relationships between a series of individual and TTO attributes and TTO awareness. Our results indicate that researchers who have entrepreneurial experience, as well as those who closed more research and consulting contracts with industry, are more likely to detect the TTO. Furthermore, we found that TTO awareness is lower for researchers working at universities incorporating a traditional TTO structure than for those in universities with a non-traditional TTO structure. However, this negative relationship between a traditional TTO structure and the likelihood that researchers detect the TTO is alleviated by researchers' industry work experience.

This work both contributes to the academic literature and offers implications for university or TTO managers and policy makers. First and foremost, our study complements academic entrepreneurship and technology transfer literatures which have extensively studied TTOs and their structures, activities and outcomes. In particular, it adds to recent studies which have drawn attention to TTO bypassing behaviors, by highlighting that TTO bypassing is not always intentional; in many cases, researchers might simply be unaware of the TTO's existence. This implies that, in order to understand under which circumstances researchers are more (or less) likely to involve the TTO in their entrepreneurial endeavors, it is crucial to take into account to which extent TTOs are detectable by researchers. Therefore, future research looking into TTO bypassing behavior will benefit from correcting for TTO awareness and its drivers.

Moreover, our study responds to a call by Markman et al. (2005) to study the antecedents and consequences of different TTO structures. In particular, we complement research on the factors that affect the choice of specific TTO structures (Brescia et al. 2015) and studies on the impact of TTO structures on technology transfer outcomes (e.g., Bercovitz et al. 2001), by showing that the structure of the TTO may also have implications in terms of TTO visibility to researchers. Our study further complements prior works on the impact of researchers' prior knowledge on academic entrepreneurship (e.g. Mosey and Wright 2007), by suggesting that experience does not only affect the likelihood and outcomes of researchers' engagement in research commercialization, but also the likelihood of research calling upon the TTO when pursuing research commercialization activities, as it affects researchers' TTO awareness.

Finally, this paper adds to the literature on information-processing and the knowledge corridor thesis by extending the use of these theoretical perspectives to new domains. On the one hand, our study responds to a call by Forbes (2007) to apply insights from information-processing theory outside managerial decision-making contexts. On the other hand, we extend the knowledge corridor thesis beyond the identification and exploitation of entrepreneurial opportunities.

Our study has a number of practical implications for technology transfer officers, university managers, and public policy makers. First, our findings suggest that TTOs in general and traditional TTOs trying to overcome their limited autonomy in particular, should invest significantly more effort in communicating and marketing their services to researchers. The TTO may especially benefit from extending its reach-out efforts towards those researchers who have not gained entrepreneurial experience and who have never been engaged in contract research and consulting activities with industrial companies. Furthermore, university managers should help TTOs to overcome their restricted visibility, for instance by granting more structural autonomy or by fostering their promotion campaign (e.g., endorsement of TTO services in a university-wide newsletter, organization of pitch competitions involving the TTO). Our research may further inspire public policy makers who often provide funding for establishing technology transfer functions at universities.

In spite of its merits, our study also has a number of limitations that open up avenues for future research. First, our cross-sectional design allows us to study an intermediate factor, namely TTO awareness, but prevents us from studying to which extent and under which conditions TTO awareness eventually results in increased interaction between researchers and TTOs and in more effective

technology transfer. Future studies using a longitudinal research design could investigate these unanswered questions. Second, while we purposefully opted to examine the influence of TTOs' structural autonomy, future research could study the impact of other factors on TTO awareness and thereby take into account factors at different levels, namely the level of the university, faculty, department or research group. For instance, future studies could look into the effects of the reward and incentive systems in place within the university, or the collective engagement of researchers in commercialization activities at the department or research group level.

Despite these limitations, our study contributes to widening the research and policy debate about the effectiveness of academic entrepreneurship. Our findings suggest that researchers, universities and policy makers seeking to understand how the returns to academic entrepreneurship can be enhanced need to explore both the behavior of TTOs as well as that of researchers.

Table 1: Correlations and Descriptive Statistics

Variable		1	2	3	4	5	6	7	8	9	10
1	TTO awareness	1									
2	Traditional TTO structure	**.09**	1								
3	Industry work experience	.00	**-.12**	1							
4	Number of closed contracts	**.15**	.06	**.13**	1						
5	Gender	**-.12**	.00	**-.11**	**-.10**	1					
6	Technical degree	**.13**	.00	.01	**.13**	**-.22**	1				
7	Non-technical degree	**-.14**	.02	**.07**	**-.08**	**.19**	**-.65**	1			
8	Post-doc position	**.19**	**-.14**	-.02	**.09**	-.01	-.02	-.01	1		
9	Scientific productivity	**.13**	**-.05**	.02	**.04**	**-.04**	.03	-.02	**.38**	1	
10	TTO size	**.09**	**-.49**	-.08	**-.08**	**.06**	**-.04**	**.00**	**-.09**	-.06	1
Mean		.44	.34	.48	-.15.85	.48	.49	.40	.35	-5.58	2.78
SD		.50	.47	.50	6.56	.50	.50	.49	.48	13.85	1.02

Pearson correlation coefficients (1-tailed), indicating significant correlations ($p<.05$) in **bold** ($n = 3,216$)
Correlations of binary variables (1, 2, 3, 5, 6, 7, 8) should be interpreted with care.

Table 2: Hierarchical Logistic Regression Analysis for TTO awareness (adjusted for university clusters)

	Control model		Full model		Full model with interaction effects	
	B (s.e)	e^B (odds ratio)	B (s.e.)	e^B (odds ratio)	B (s.e.)	e^B (odds ratio)
Explanatory variables						
Industry work experience (H1)			.17† (.10)	1.19	-.01 (.10)	.99
Number of closed contracts (H2)			.04** (.01)	1.04	.05*** (.01)	1.05
Traditional TTO structure (H3)			-.34* (.13)	.71	-1.19*** (.29)	.30
Interaction terms						
Traditional TTO structure * Industry work experience (H4)					.53*** (.14)	1.70
Traditional TTO structure * Number of closed contracts (H5)					-.04* (.01)	.97
Control variables						
Gender	-.50***(.11)	.61	-.47*** (.10)	.62	-.48*** (.10)	.62
Medicine & pharmaceutical sciences	.56*(.23)	1.76	.54* (.22)	1.72	.56* (.23)	1.75
Engineering, technology & computer sciences	.62* (.25)	1.86	.54* (.24)	1.72	.88* (.22)	1.72
Life & agricultural sciences	.84***(.23)	2.32	.87*** (.22)	2.38	.88*** (.22)	2.41
Natural sciences & mathematics	.12 (.22)	1.13	.16 (.21)	1.17	.19 (.21)	1.20
Technical degree	.19 (.12)	1.21	.16 (.12)	1.18	.17 (.12)	1.18
Non-technical degree	-.17† (.09)	.84	-.22* (.09)	.81	-.22* (.09)	.80
Post-doc position	.82*** (.11)	2.26	.74*** (.10)	2.10	.74*** (.10)	2.09
Scientific productivity	.01*** (.00)	1.01	.01***(.00)	1.01	.01*** (.00)	1.01
TTO size	-.12 (.10)	.89	-.17† (.09)	.85	-.17† (.09)	.85
Slovenia	.41**(.14)	1.51	.55*** (.15)	1.73	.59*** (.16)	1.81
Germany	.62***(.15)	1.85	.84*** (.18)	2.32	.86*** (.19)	2.36
Spain	1.02***(.20)	2.78	1.12*** (.15)	3.08	1.12*** (.16)	3.05
Belgium	1.69***(.21)	5.40	1.80*** (.20)	6.03	1.77*** (.20)	5.85
Constant	-1.17*** (.33)		-.49† (.29)		-.16 (.31)	
Model specification						
χ^2	496.56***		539.64***		555.66***	
Log Likelihood	-1,983.40		-1,935.88		-2,205.70	
Pseudo R^2	.111		.122		.126	

Unstandardized regression coefficients with standard errors are reported in the table.
†p<.10; *p<.05; **p<.01; ***p<.001 (n = 3,216)

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