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ECARES working paper 2012-045

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Forthcoming in Journal of Technology Transfer. The final publication is available at http://link.springer.com (DOI: 10.1007/s10961-012-9289-0).

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Abstract Despite the growing interest in university-to-industry technology transfer, there are very few studies on the governance of universities' technology transfer offices (TTOs). The few existing ones tend to focus on U.S. universities and generally tackle one dimension of the governance. The present paper aims at contributing to this literature in two ways. First, it takes into account the diversity of organizational models with a theoretical perspective: the paper presents a discussion on which combinations of four structural dimensions should yield viable configurations. Four main types of TTOs are identified: (1) classical TTO; (2) autonomous TTO; (3) discipline-integrated Technology Transfer Alliance; and (4) discipline-specialized Technology Transfer Alliance. Second, the paper relies on 16 case studies of universities located in six European countries in order to address the pros and cons of the four types of TTOs. The results provide both a conceptual understanding and an empirical overview of how universities organize their technology transfer and intellectual property management.

Keywords: Technology transfer offices, organizational structure, governance, academic patents.

JEL Classification: L30, O31, O32, O34

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1 Introduction

Commercialization of new knowledge created by universities gained in importance among scholars, university managers, and policy makers over the past 30 years (Geuna and Muscio 2009). Reasons for the growing interest were the adoption of the Bayh-Dole Act in 1980 and the rising number of university-to-industry technology transfer agreements in the United States.[1] The European Commission's Lisbon Strategy in 2000 emphasized the importance of creation and diffusion of academic knowledge to foster regional economic development. Newly implemented policies at various universities as well as public initiatives emerged to promote technology transfer activities. The abolishment of the so called "professor's privilege"[2] in several European countries (e.g., Denmark and Germany) is one example of a major change in university policies. Many national and regional governments strongly supported universities' efforts to establish technology transfer offices (TTOs). These changes were accompanied by a surge in academic patenting and university-to-industry technology transfer (Geuna and Nesta 2006; Mowery et al. 2001). In this respect, universities have sought to develop systematic and professional knowledge transfer and intellectual property (IP) management in different ways.

Since the mid 1980s, a large body of literature has emerged that essentially analyzes the phenomenon of technology transfer and the factors that determine the performance of universities' TTOs. Empirical studies evaluating the productivity of TTOs, are based on measuring the 'outputs' and 'inputs' of technology transfer and use a production-function framework (e.g., Chapple et al. 2005; Link and Siegel 2005; Siegel et al. 2003a; Thursby and Kemp 2002; Thursby and Thursby 2002; Van Looy et al. 2011). TTO characteristics, the technological knowledge produced by the university, characteristics of the university itself, and the demand for technology are identified as important determinants of the number of licensing agreements and royalties generated (Conti and Gaulé 2009; Lach and Schankerman 2008; Link and Siegel 2005; Friedman and Silberman 2003).

Only recently attention has begun to focus on organizational factors influencing universities' technology transfer (Hülsbeck et al. 2011; Conti and Gaulé 2009; Sellenthin 2009; Link and Siegel 2005; Siegel et al. 2003a; Bercovitz et al. 2001). However, systematic analysis, taking into account several dimensions of the governance of TTOs, is missing so far. The present paper addresses this gap by analyzing the diversity of organizational models of technology transfer and knowledge management activities. To this end, we first identify four key dimensions of organizational structure and their values. Then, the viable combinations of these values are assessed. Finally, drawing on these viable configurations, a typology of organizational models of TTOs is put forward. Finally, the typology is tested on 16 case studies of TTOs located in six European countries.

Our qualitative analysis presents new evidence on the diversity of governance models of technology transfer processes. We argue that these models can be classified into four main groups. The *classical TTO* exclusively serves one university and is integrated into its administrative structure. The *autonomous TTO* is similar, but has a significantly higher degree of autonomy from the university's administration. This autonomy particularly concerns budget allocation, human resource management, and reporting obligations. The *discipline-integrated Technology Transfer Alliance* (TTA) serves the technology transfer activities of several universities and is organized outside a university's administrative structure. Finally, the *discipline-specialized TTA* is focused on one academic discipline (e.g., life sciences or engineering) and, like the discipline-integrated TTA, serves several universities. Each of these groups must opt for an appropriate degree of specialization (i.e., from specialization to IP management to full integration towards industry funding of research projects and the creation of spin-offs).

The optimal design of a TTO depends on the university it serves, on its institutional history, and evolves over time. Consequently, each university must take its goals and characteristics as well as environmental factors into account when organizing its technology transfer. The analysis presented in this paper indicates that a comparison of universities with different goals and concomitant organizational models of technology transfer may be misleading if these differences are not taken into account. On a management level, the results of this paper provide guidance to support universities in designing the organizational structure of their technology transfer activities.

The paper is structured as follows. The next section identifies the relevant structural dimensions and discusses the literature on TTOs' organizational structure along these dimensions. Section 3 is devoted to the analysis of the combinations of organizational values that should be viable and suggests a typology of

[1] Evidence of the direct effects of the Bayh-Dole Act on the growth of university patenting and licensing is limited. Empirical research by Mowery et al. (2001) challenges the assumption that the Bayh-Dole Act is the main influencing factor; other factors such as an increase in biotechnology research also play important roles.

[2] The "professor's privilege" means that researchers rather than the universities own the IP of the inventions generated by their research activities. As of November 2011, the professor's privilege is still in force in Sweden and Italy. Opposing the overall trend, Italy introduced this model in 2005. However, even with Bayh-Dole Act-like regulations, many academic inventions are filed by third parties, which makes it difficult to assess the 'productivity' of universities (c.f. Saragossi and van Pottelsberghe de la Potterie 2003).

organizational models of TTOs. The case studies are presented and classified in Section 4. The final section is devoted to concluding remarks.

2 Relevant structural dimensions of TTOs' governance

The increasing importance of technology transfer for universities, industry, and policy makers raises the question of which factors influence the success of such activities. The following determinants of TTO productivity have been identified: organizational structure and practices, other characteristics of the TTO (e.g., age), quality and type of the technology produced by the academic institution, quality of the research institution, and regional demand for technology (Van Looy et al. 2011; Belenzon and Schankerman 2009; Sellenthin 2009; Lach and Schankerman 2008; Chapple et al. 2005; Di Gregorio and Shane 2003; O'Shea et al. 2005; Friedman and Silberman 2003; Siegel et al. 2003a; Thursby and Kemp 2002).[3] In line with the focus of this study, we address the organizational structure in detail.

The organizational structure of TTOs is increasingly recognized as important determinant. Bercovitz et al. (2001) for instance examine the relationship of organizational structure and performance of U.S. universities' TTOs based on the theoretical work by Chandler (1962, 1977, 1990) and Williamson (1975, 1985). They analyze four generic organizational forms: the functional form, the multidivisional form, the holding form, and the matrix form. Each organizational form has specific attributes—information processing capacity, coordination capability, and incentive alignment—which determine the efficiency of technology transfer. Bercovitz et al. (2001) hypothesize, first, that TTOs organized in a matrix form have a higher overlap of industry partners in research contracts and licensing agreements than other organizational forms. Second, the numbers of invention disclosures, licenses, and patents per full-time equivalent are assumed to be highest in the multidivisional and holding form. Third, the matrix form is suggested to be most suitable to maximize research support in exchange for lower royalties. The three hypotheses are confirmed on the basis of three U.S. universities.

Debackere and Veugelers (2005) use the TTO of K.U. Leuven as a benchmark case in Europe and discuss organizational practices along this case in detail. They compare its structure with the TTOs of 11 European universities and find strong parallels. Governance structures have major impact on university-to-industry relations. Incentive management and the pooling of critical resources are seen as important structural variables. The authors argue that the involvement of research groups via a matrix structure is critical for the technology transfer success. Mathieu et al. (2008) present an alternative case (the Université Libre de Bruxelles), which illustrates the potential for nurturing entrepreneurial activities locally (i.e., in specific laboratories) as well as the possibilities and limitations of top-down actions instilling entrepreneurial culture among academic rank and file. A minimum level of entrepreneurial activity has to be reached before an organizational structure is put in place.

We follow previous research in assuming that the governance and organizational structure of technology transfer organizations matters. As Williamson (1985) puts it: "Organization form matters (p. 209)." Yet, a universally optimal organizational structure does not exist; rather, it is contingent on the TT organization's environment and situation. Since giving a complete overview of the extensive organizational literature would go beyond the scope of this paper, we concentrate on the theory directly related to formal organizational structures.

Empirical analyses and comparisons of organizational structures require definitions of the dimensions relevant for the study and the operationalization of these dimensions (Pugh et al. 1968). However, organizations are institutionally complex by their very nature and have a large number of dimensions. Therefore the trade-off between precision and complexity with increasing dimensions has to be taken into account. For certain research questions, only some of these dimensions are relevant. Consequently, it is essential to select the relevant dimensions out of the possible ones (Meyer et al. 1993).[4]

The derivation of relevant dimensions of a formal organizational structure is based on the idea of the bureaucracy model put forward by Max Weber (1947). Weber's unidimensional concept of organizational structure was further developed by many researchers, including Pugh et al. (1968) and Child (1972). The structural dimensions most widely discussed by these authors are specialization, centralization, standardization, formalization, and configuration. In the present analysis, the structural dimensions specialization and configuration are used to characterize the organizational structure of TTOs.[5] We split each of these into two dimensions: specialization into discipline and task specialization; configuration into level of autonomy granted and degree of exclusivity.

[3] See Siegel et al. (2007) for a more detailed overview of key studies on TTO effectiveness.

[4] One might suggest taking all dimension into account for a comprehensive analytic framework, however, this would make the analysis very complex. From a scientific point of view it is crucial to reduce complexity.

[5] Standardization and formalization are not considered because the former describes to what extend activities are fixed. Since the technology transfer process is already well defined in most of its dimensions, this structural dimension does not help to differentiate between types of TTOs' organizational structure. Formalization denotes to which extent organizational rules are written down and filed.

(a) *Degree of discipline specialization*: The degree of discipline specialization ranges from *discipline-specialized* to *discipline-integrated*. In the context of universities' technology transfer and as used in this paper, discipline specialization means that decisions regarding technology transfer are taken on the departmental level and are focused on one specific scientific discipline. In contrast, a discipline-integrated TTO structure implies that decisions about technology transfer activities are taken at the institutional level with the same rules and processes for all the departments.

(b) *Degree of task specialization*: The degree of task specialization defines the distribution of tasks within the organization. By specifying the degree of specialization, the area of responsibility is determined (Mackenzie 1978). The degree of task specialization can be gradually varied on a continuum from generalization (or full integration) to specialization (which, in the present case, turns out to be specialization on IP management). The key function of a TTO is to act as an intermediary between the university and industry. This role is multifaceted, with three main activities: (1) research funding and services, (2) IP management (including the selection of declaration of invention and out-licensing negotiations), and (3) spin-out services (Clarysse et al. 2005; Debackere and Veugelers 2005; Meyer and Tang 2007; Siegel and Phan 2005; Van Looy et al. 2011). The literature on TTOs and university-to-industry technology transfer mainly focuses on TTO activities related to IP management and spin-out services. A broader definition should however be adopted, including research funding services such as research contract negotiation and the promotion of publicly funded research projects. The reason for broadening the definition is that the organizational unit responsible for patents and licensing activities is, in many cases, simultaneously responsible for research funding services and/or spin-out services (Debackere and Veugelers 2005), and IP typically matters at the start of the entrepreneurial process of spin-out creation. Furthermore, the outcomes of research funding services, IP management, and spin-out services/incubation interact with each other (Mathieu 2011; Van Looy et al. 2011).

Based on the discussion we suggest the following values for the degree of task specialization. A *fully integrated* TTO is responsible for all three activities within one organizational unit. When the activities related to research funding services and IP management are executed by the TTO, it is *backward integrated*. A *forward integrated* TTO would be responsible for IP management and spin-out services. Specialization on IP management (*IP specialized*) denotes the highest degree of specialization. Specializations on activities other than IP management would probably not be referred to as TTOs and, thus, are beyond the scope of this paper.

Prior research discussed discipline and task specialization explicitly and implicitly. Meyer and Tang (2007) analyze the influence of various IP management practices on measures of patent value in the U.K. university context. The observed difference regarding the TTO set-up are related to structural integration, level of collaboration with university research funding services, and the degree of specialization (either by disciplines and technology fields or by technology transfer functions). Since the focus of the study is on IP management processes and their relations to patent value, the authors do not discuss the various organizational structures in detail. Hülsbeck et al. (2011) analyze, among other factors, the degree of division of labor within the TTO. They find that a lack of division of labor, measured as task per employee, negatively affects the number of invention disclosures. Moreover, Bercovitz et al. (2001) and Debackere and Veugelers (2005) discuss discipline and task specialization implicitly in the context of the matrix organizational form.

(c) *Level of autonomy*: Markman et al. (2005b) address the influence of different levels of autonomy granted to the TTO on new venture creation and licensing strategies. They show that autonomy granted to the TTO is an important dimension of the organizational structure. The authors differentiate between three organizational forms with increasing autonomy: traditional university structure, nonprofit research foundation, and for-profit private extension. The organizational form with the lowest degree of autonomy is found to be more likely to license in exchange for sponsored research. Licensing that induces new venture creation, in contrast, is supported by for-profit private extensions. The European Commission (2009) also includes the level of autonomy granted as an important structural variable in their final report on knowledge transfer.

Based on these findings, we distinguish between *dependent* and *independent* TTOs. A dependent TTO has to report to the university administration (e.g., office of the provost or vice rector for research) and has limited decision-making autonomy with respect to budget, incentives, and human resource management.

(d) *Degree of exclusivity*: This structural variable indicates whether an organizational unit (the TTO) serves more than one customer (university), as opposed to having an exclusive relationship with one institution. Closely related to the degree of exclusivity is the ownership status of the TTO, discussed in prior research (Muscio 2010, European Commission 2009; Meyer and Tang 2007). Muscio (2010) finds for example for Italy that a TTO solely managed by one university is more likely contacted by the researchers. In line with property right theory, exclusivity (non-exclusivity) goes in most cases along with sole ownership (shared ownership). Consequently, we merge these two strictly speaking distinct dimensions, and refer to it as the degree of exclusivity.

3 Typology of TTO organizational structures

3.1 Non-feasible combinations of values of organizational dimensions

There are four dimensions through which the organization of university technology transfer can be characterized. The advantages and drawbacks of specific values of each dimension are assessed along the following main criteria, as summarized in Table 1: (1) relationship of TTO with researchers and with industry partners, (2) exploitation of economies of scale and synergies, and (3) conflicts of interests and concomitant communication and coordination costs. It is assumed that the university's management aims at maximizing a TTO's efficiency and effectiveness as well as minimizing its costs.

[INSERT Table 1 ABOUT HERE]

Three of our four dimensions can take on two possible values each, while one can take on four values. Thus, the number of combinations of values of *two* dimensions equals $4 \cdot (2 + 2 + 2) + 2 \cdot (2 + 2) + 2 \cdot 2 = 36$ (see Table 2). It is on the level of these combinations that we discuss the feasibility of configurations, where a "configuration" is a combination of values of all four dimensions. Obviously, if a combination is not feasible, then any configuration containing it is not feasible either. An example for a configuration is a discipline-specialized, dependent, exclusive, and fully integrated TTO. There are $4 \cdot 2 \cdot 2 \cdot 2 = 32$ configurations and thus potential organizational structures of TTOs.

(1) Discipline specialization is not compatible with a strong IP specialization. The first dimension we address is the *degree of discipline specialization.* The drawbacks of a discipline-specialized structure are lower resource efficiency and higher coordination and communication costs, for example, due to potential conflicts of interest. TTOs that specialize in one discipline and in IP management should rarely be observed because the interdependencies between IP management and other technology transfer activities are intense (Mathieu 2011; Van Looy et al. 2011). Consequently, the coordination and communications costs would strongly increase, intensified by discipline specialization, and in most cases exceed the advantages associated with efficiency gain due to a better relationship of the TTO and its stakeholders.

(2) Discipline specialization is not compatible with a dependent organization. The drawbacks of a discipline-specialized structure can be worsened if associated with a *dependent (or non-autonomous)* organizational structure. Managers on the department level optimize their strategy depending on local goals (Bercovitz et al. 2001). As a result, university administration has to install mechanisms aligning deviating objectives to university technology transfer strategy for several departments, increasing administrative costs for the university. It logically follows that this combination is to be avoided; TTOs organized within university administration are rarely discipline-specialized and should not be.

(3) Discipline specialization is not compatible with exclusivity. The inefficiencies due to lower economies of scale and less synergy exploitation observed in a discipline-specialized structure are perceived as too strong to be compensated by a single university. As a conclusion, the combination of exclusivity and discipline specialization should rarely be observed.

Summarizing, the incompatibilities (1) to (3) conjecture that a discipline-specialized TTO will not also be IP specialized, dependent, and exclusive. But the discipline-specialized TTO is compatible with lower degrees of task specialization, non-exclusivity and autonomy.

(4) An IP specialized TTO is not compatible with dependency. Under full dependency and with an IP-specialized TTO, monitoring costs are increased due to the need for simultaneous control of different organizational units by university administration (namely, research funding services and incubation of spin-out companies in addition to the TTO). Moreover, the exploitation of synergies between different organizational units is more difficult and concomitant overhead costs are increased. Therefore, IP specialization and dependency is likely to be an inefficient configuration.

(5) An IP specialized TTO is not compatible with exclusivity. TTOs specialized on IP management exclusively serving one university should be rarely observed for the following reason. Specialization is associated with lower potentials for synergy exploitation between the technology transfer activities, since they are executed in different organizational units. In an exclusive organizational structure, this disadvantage of specialization is serious because the effect cannot be compensated by, for example, a strong pooling of inventions. There is, therefore, a higher need for economies of scale and, hence, working for several universities.

(6) Backward integration is not compatible with non-exclusivity. By definition, backward integrated TTOs are responsible for research funding services and IP management. This implies that combining with a non-exclusive organizational structure is not feasible. The main argument here is that universities compete with respect to research funding services (especially privately funded research contracts), which requires intense and trustful collaboration between the TTO personnel and researchers. A non-exclusive organizational structure means that universities are sharing the services of one TTO. The concomitant competition effect could lead to a distrust of researchers toward the TTO officers. Consequently, backward integrated organizational structure is not compatible with a non-exclusive organizational structure.

(7) Non-exclusivity is not compatible with dependency. The combination of dependency and non-exclusivity is perceived as not being feasible. Dependency and non-exclusivity contradict each other. If the TTO is established and its services are used by more than one university, it is unlikely that it is integrated into the

administrative structure of one single university. From the perspective of the other participating universities, this combination is associated with high coordination costs and negatively affects the relationship between TTO and researchers.

Table 2 summarizes the above discussion. The incompatible combinations are marked in gray, the others are considered feasible.

[INSERT Table 2 ABOUT HERE]

3.2 Feasible organizational configurations

The exclusion of non-feasible combinations of values of structural dimensions reduces the number of possible TTO configurations from 32 to 12. These governance models are shown in Table 3.

[INSERT Table 3 ABOUT HERE]

Four general types of TTO organizational models can be identified; each type differs with respect to the degree of specialization:

The first type is best described with the term *classical TTO* (I). It is discipline-integrated, dependent, and exclusive. The TTO can be responsible for all technology transfer activities (fully integrated (1)), for IP management and research funding services (backward integrated (2)), or for IP management and spin-out services (forward integrated (3)).

The second type is denoted *autonomous TTO* (II). The autonomous and the classical TTO model differ in terms of the level of autonomy granted. As with the classical TTO, the autonomous TTO model can be fully integrated (4), backward integrated (5), or forward integrated (6), but not IP specialized.

The third type is the *discipline-integrated Technology Transfer Alliance* (III) (*discipline-integrated TTA*). In contrast with the other two types, it serves more than one university. This TTO model is compatible with full integration (7), forward integration (8), or IP specialization (9). It should be noted that universities using the services of a discipline-integrated TTA usually have an internal university-specific TTO, with a reduced size.

The last model is the *discipline-specialized Technology Transfer Alliance* (IV) (*discipline-specialized TTA*). In contrast to the discipline-integrated TTA, the degree of discipline specialization is high and the TTA can be specialized on IP management and spin-out services (forward integrated (10)) or on all three transfer activities (fully integrated (11)).

It is important to note that the organizational structure can change over time due to, for example, learning effects or economies of scale. Moreover, the choice for one model may also largely depend on external factors such as the university's culture and history, strategic orientation and management style, and national and regional political constraints.

4 Case studies

The various combinations of TTO structural dimensions, and the typology presented in the previous section, should be compared with real cases in order be assessed and validated. The 16 case studies presented in this section are based on in-depth interviews with key personnel of the TTOs. The semi-structured interviews were conducted face-to-face with the interviewees during the period of January 2009 to October 2011 and lasted about 90 minutes on average. To reduce social desirability and to improve the willingness to participate in the interviews, the interviewees' anonymity was secured.

To enrich the information gained from the interviews additional information was gathered from secondary sources, mainly TTOs' and universities' websites as well as official university reports, and proceeded with data triangulation (Eisenhardt 1989; Yin 2003). To validate the collected information, the interviewees were asked to check the information.

Key figures of the sample are presented in Table 4.[6]

[INSERT Table 4 ABOUT HERE]

Despite the growing interest in university technology transfer, empirical evidence about specific characteristics and performance measures of European TTOs is still scarce. The ProTon 2009 Europe Survey,[7] the CEMI Survey 2008,[8] and the ASTP Survey 2007[9] are, to the best of our knowledge, the most recent large-

[6] Since TTAs (case K and L) are serving more than one university, figures related to the number of students are not specified.

[7] Available at: http://www.interface.ulg.ac.be/docs/Proton21052010.pdf.

[8] Available at: http://cemi.epfl.ch/files/content/sites/cemi/files/shared/research/CEMI-TTO-survey-2008.pdf.

scale empirical projects in Europe regarding university TTOs. According to the CEMI Survey 2008,[10] 60% of the European TTOs were founded after 1998, 23% between 1988 and 1997, and 17% before 1988. In our sample, 50% of the TTOs were founded after 1998, hence, the average age of TTOs in 2008 is 14.8 years. The size of the TTOs, as measured by the average number of full-time employees (FTEs) per institution, is much larger in the current sample than the average in Europe (17.7 vs. 10.8[11]).

In terms of geographical coverage, the TTOs come from six different countries within Europe: Belgium, France, Germany, Switzerland, the Netherlands, and the United Kingdom.[12] According to the Shanghai academic ranking of world universities, published by the Institute of Higher Education of Shanghai Jiao Tong University, six TTOs are part of universities ranked among the top 100, five among the top 200, three among the top 300+.[13]

Each case study was classified with respect to the new typology. First, each case was classified along the dimensions degree of discipline and task specialization, level of autonomy[14], and degree of exclusivity. Second, the configuration of each case was matched to the typology. The results are presented at the end of the Table 3.

The case studies suggest that 1) autonomous TTOs often do not take care of research funding services (not backward integrated), and 2) classical TTOs not associated with a TTA, in most cases, do not take care of incubation and spin-out services. We conclude that three main types emerge in practice: the backward integrated classical TTO (cases B, D, and E), the forward integrated autonomous TTO (F, H, I, and J), and the highly specialized to fully integrated TTAs (case K and L).

In the following we concentrate the discussion on these emerging types and on the implications for the technology transfer governance process, especially regarding IP related transfer activities, which include the following steps: disclosing inventions, conducting early economic assessment, deciding if the invention should be patented, filing the patent, searching for licensees, negotiating the contract conditions (with industry partner or spin-out companies), and monitoring royalties.[15]

4.1 Differences between the classical and the autonomous TTO model

One of the most important input factors for technology transfer processes is the number and quality of inventions disclosed to the TTO. To foster invention disclosure, two formal activities are common: technology "scouting," and raising awareness among researchers about technology transfer.[16] The first interesting finding from the case studies is that only one of the classical TTOs is active in internal technology "scouting." However, three out of six autonomous TTOs (cases H, I, and J) are actively scouting for possible inventions (e.g., regular and systematic visits of the departments). Regarding "awareness," the common channel to inform academic researchers is to give classes to Ph.D. students. However, cases I and H perform a novel approach to increase the number of invention disclosures. They train selected researchers on technology transfer activities. Those researchers act as the first informal contact point for their colleagues. No formal causality can be deduced from this observation, but it hints that autonomy leads to more dynamic approaches, probably to secure the sustainability of their venture. Nothing would preclude classical TTOs to do so, but they probably have less explicit or implicit incentives. Indeed, more classical TTOs are often at least backward integrated and, hence, might have other priorities such as the private funding of academic research.

Deciding which invention to patent and finding exploitation partners are the next process steps. Differences in regard to who is making the decision about patenting as well as differences in the inventor involvement could not be found between the autonomous and the classical TTO type. The decision about patenting is made by either one TTO employee, who is responsible for the invention, or a committee, generally composed of the TTO team. It is worth mentioning that only two TTOs (cases E and F) explicitly involve the inventor in the decision about patenting and only three TTOs systematically involve the inventor in the contract negotiations. The inventor acts in all cases as an information source to find potential exploitation partners. Next to using the

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[9] Available at: http://www.astp.net/Survey/Summary_2007_ASTP_report.pdf.

[10] In order to achieve comparability, the CEMI Survey was chosen; since the other two surveys also included in the target population other public research organizations. The survey was conducted in the summer of 2008, total 211 answers (59, 4% respond rate), and were obtained from TTOs located in Western Europe.

[11] This number refers to the year 2007.

[12] All TTOs in our sample are located in countries where institutional ownership system is in practice.

[13] Available at: http://www.arwu.org/.

[14] The degree of autonomy granted is operationalized along three criteria: (1) reporting directly to the Vice-Rector of research/innovation or similar authorities, (2) being independent from university administration regarding budget management, and (3) enjoying decision-making authority with respect to human resource management (e.g., specification of incentive schemes for TTO personnel and decisions regarding staff hiring).

[15] For a more detailed discussion of the transfer process see, for example, Siegel et al. (2003a).

[16] Although faculty members are obliged to disclose their inventions, empirical research by Thursby et al. (2001), Siegel et al. (2003a; 2003b), Saragossi and van Pottelsberghe de la Potterie (2003), and Markman et al. (2008) indicate that many technologies are not disclosed to the TTO.

inventor as information source, the most frequent activities to identify licensees are networking and advanced marketing techniques. This result is particularly interesting given existing research on inventor involvement. For example, in a theoretical model, Jensen et al. (2003) outline that the commercial success of a licensed invention is more likely if the inventor is involved. Markman et al. (2005a) show that inventor involvement speeds up the commercialization time. In turn, the shorter the commercialization time, the greater the licensing stream and the more spin-outs are created.

Regarding the licensing strategy, autonomous TTOs are all taking equity in spin-out companies. However, only one classical TTO is allowed to take equity in spin-outs. Licensing for equity is associated with financial flexibility for the licensee. This flexibility is supposed to allow spin-outs to bring the technology more quickly to the market (Markman et al. 2005b). Bray and Lee (2000) show that taking equity in start-ups compared to average cash-license agreement produces, in most cases, greater rate of return in the long run. However, they recognize that taking equity is not always the most profitable approach, especially considering technologies with very high market potential. From this we may conclude that an autonomous organizational structure is more likely to actively support spin-outs. However, this result might be mainly driven by two facts: autonomous TTOs are more likely forward integrated on the one hand, and the legal framework might prevent classical TTOs to take equity in spin-outs on the other.

The final process steps, after the conclusion of the contract, are royalty splitting and royalty monitoring. Regarding the latter, we do not identify differences between the two TTO types. Although in respect to revenue splitting, we identify two different systems used by the TTOs: linear and nonlinear royalty schedules. The first system is based on constant shares for the inventor, department/laboratory/university, and/or the TTO. In the second system, the share for the inventor decreases with an increase in the royalties.[17] All classical and three autonomous TTOs use the linear system and three autonomous TTOs (cases C, G, and I) have the nonlinear system in practice. All TTOs recognize the positive effect of incentive schemes and institutionalize it. Additionally, interviewees stated that the second system gives additional incentive to researchers and helps spin-out companies in the early start-up phase. This is also in line with the finding that autonomous TTOs are more actively involved in spin-out support.

Furthermore, the cases reveal information regarding the organizational integration of the two TTO types. All classical TTOs were integrated as a department. Four of the six cases classified as independent are organized as a subsidiary, fully owned by the university (cases F, H, I, and J). However, two TTOs (cases C and G) are organized as departments within the universities and are independent. This leads to the assumption that the organizational integration as subsidiary is most likely to correspond with an independent configuration, but the organizational integration as department can match with both—a dependent and an independent configuration. That is, TTOs organized as subsidiaries are not likely to be responsible for research funding services and are independent.

Taken as a whole, the case studies reveal differences between the classical and autonomous type, especially regarding how the TTO is raising awareness, which licensing strategy they perform, and which system is used to compensate faculty. The key question is related to whether the TTO is forward or backward integrated, the latter generally leads to a classical TTO.

4.2 Differences between the TTO and TTA model

The discipline-integrated TTA (case K) serves 28 universities. The TTA was founded as a private company by two nonprofit organizations and all universities in the alliance are members of one of these founding organizations. All universities engaged in the network can, however, operate a university-specific TTO, which is reduced in size and exclusively serves the founding university. The university-specific TTO is necessary, for example, if the universities in the alliance are not obliged to automatically disclose their inventions to the discipline-integrated TTA. To improve our understanding, we interviewed four university-specific TTO executives (case Ka-Kd) next to TTA executives.

Case L is classified as discipline-specialized TTA. The nonprofit, autonomous research institute has departments, labs, and research facilities in four universities in the field of life sciences. A central service function of this research institute—the discipline-specialized TTA—is responsible for research funding services, IP management, and spin-out activities. The TTA is only in charge of inventions that result from basic research of the labs and departments connected to the institute but located at different universities. The research institute is independent in every aspect and is governed by a board of directors composed of representatives of the networked universities, the government, and the industry.

The first step of the technology transfer process in a discipline-integrated TTA, as in the traditional TTO model, is the invention disclosure by the researcher. The recipient of the invention disclosure is, in our case, the

[17] An inventor’s share in our sample varies from 25% to 85%. Lach and Schankerman (2008) find an average inventor share of 39% and 42% for 34 private and 68 public universities, respectively. They find that the form of royalty system is not significantly related to observed university characteristics.

university-specific TTO. The university-specific TTO controls the invention disclosure form for correctness and completeness and decides whether or not to forward it to the TTA. All activities related to awareness and information diffusion in this case are under the responsibility of the university-specific TTO. The monitoring of the relationship inventor-TTO and confidence-building measures are two of the major tasks of the university-specific TTO. This is in line with the argument that a non-exclusive organizational structure implies a less intensive relationship between TTA officers and researchers (cf. Section 3). University-specific TTOs, however, reduce this negative effect: the main issue to address is to keep a degree of confidence for the researchers. In the case of a discipline-specialized TTA, the university-specific TTO is usually not involved in the transfer process. The inventors, as in the TTO model, communicate directly with the TTA. This is in line with the argument that discipline specialization reduces the negative effects of a non-exclusive structure. Visiting hours in the departments, bilingual TTO staff, low administrative hurdles, and a long history are key factors for a high percentage of invention disclosure.

The decision about patenting is made by the employees of the TTA. The result of the decision has to be communicated to the university-specific TTO or to the inventors directly. In the case of a positive decision, the university has to agree that the invention is to be patented. This is necessary because the university is the actual owner of the invention. In the case of a negative decision, the university-specific TTO or the inventors have the option to patent the invention themselves. In the discipline-specialized TTA case, however, the situation is somehow different. The TTA owns the IP right together with the university. Thus, the TTA is fully responsible and independent in all process steps. The decision about patenting the invention is based on a close collaboration with the inventors and is made in a regular meeting of the whole TTA team. In comparison with the TTO type, the coordination and communication costs in this process step are much higher for the discipline-integrated TTA but not for the discipline-specialized TTA.

The next step, searching for exploitation partners, is executed by the TTA (both integrated and specialized) in close collaboration with the university-specific TTO and/or the inventor. Both TTA types plan this process step in a more systematic way than most of the TTOs organized as classical or autonomous. One example for this is that the discipline-integrated TTA has institutionalized a regular meeting concerning marketing approaches for the inventions it handles. This is not the case in classical or autonomous TTOs in our sample. The discipline-integrated TTA uses several databases, established contacts, and information on patent applicants active in the field of the invention. No difference between the two types can be found regarding the involvement of the inventor during the negotiation phase.

Both TTAs are responsible for royalty control. However, interview evidence revealed that they are not always able to fulfill the task in the desired scope. This is equivalent to the result for the TTOs.

Regarding the royalty splitting, the discipline integrated TTA applies, by law, a linear royalty scheme and obtains the highest rate of all TTOs in the sample. The university-specific TTO, however, is not obliged to transfer the invention to the TTA. If the university-specific TTO decides to keep the invention in-house they have to bear the costs and the risks. The share for the researcher(s), however, remains the same. It is obvious that the TTA faces the risk that the university-specific TTO only transfers inventions with low prospects of success. The benefits of relying on the TTA have to outweigh these costs. This is possible due to, for example, pooling of inventions, greater visibility, and higher bargaining power of the TTA. The discipline-specialized TTA, in turn, uses a nonlinear royalty scheme. The particularity of the system is that the university as well as the TTA commit to reinvest part of the royalty in the department from which the invention originated. This agreement enables a 'win-win' situation for the involved universities and the TTA.

To conclude, the most prevailing difference between the TTO and the discipline-integrated TTA model relates to the division of labor and task specialization: information diffusion about technology transfer and marketing of the inventions. The university-specific TTO is, with respect to IP management, more an intermediary between inventor and TTA than a real transfer agent. Moreover, the discipline-integrated TTA is more specialized in marketing activities than the TTO type. This specialization may enhance the efficiency and effectiveness of technology transfer. However, the positive effect is decreased by higher coordination and communication costs. The discipline-specialized TTA model can prevent higher coordination and communication costs due to the specialization on a specific research area, which, in turn, allows a closer relationship with the researchers. However, the model requires a close collaboration and clear distribution of tasks between the TTA and the involved universities.

Another difference is that both TTA models pool inventions from several universities. Consequently, they are able to exploit economies of scale, have higher visibility for industry partners and researchers, and have more bargaining power. This effect is most interesting for universities with a smaller patent portfolio or universities with research areas that need to be treated differently.

Finally, the TTA involved institutions still need a university-specific TTO. Consequently, the TTA model is more a complement than a substitute for the TTO model.

5 Discussion and conclusion

This paper presents an analysis of how European universities have set the governance of technology transfer activities and provides a new typology of organizational models. Four types of TTOs are identified: the classical TTO, the autonomous TTO, the discipline-integrated TTA, and the discipline-specialized TTA. This typology is applied to 16 case studies of European universities.

The seemingly bewildering diversity of TTO models across Europe can be reduced through the theoretical discussion of viable configurations of structural dimensions. The qualitative analysis presented in this paper provides useful insights into TTOs' governance structures and their implications for the technology transfer process. The TTA type has several advantages for the technology transfer process. The pooling of inventions leads to larger patent portfolios and higher bargaining power. It enables small universities to take an active part in university-to-industry technology transfer. However, the case studies reveal that in a discipline-integrated TTA structure, university-specific TTOs are needed for "boundary spanning" between the TTA and the researchers. This results in higher coordination and communication costs for the discipline-integrated TTA model. It is less effective in helping private funding of research, and even less in deciding how to allocate it across universities. The discipline-specialized TTA model does not face this negative effect due to a more intensive relationship with researchers. The specialization in a specific research area makes this possible. However, the TTO type also has positive effects on the technology transfer process. The relationship between TTO staff and academics is more intense; the university is able to align strategic goals of the TTO to those of the university; and direct competition or friction between universities can be prevented.

Consequently, the strategy and goals of each university have to be taken into account in order to select the right governance model. The findings suggest, for example, that universities interested in spin-out creation would evolve toward an autonomous TTO. The universities more interested in the private funding of their research activities would prefer the classical, dependent, TTO model. The discipline-integrated TTA model has advantages for smaller universities and discipline-specialized TTAs are especially suitable for research areas that need different technology transfer practices than others. Which governance model is suitable can consequently change over time.

The typology and qualitative analysis presented in this paper lead to the conclusion that comparing universities with different goals and governance models for technology transfer can be misleading. Measuring performance of TTOs without taking into account the governance characteristics and their degree of specialization as identified in this paper, may result in biased conclusions. Studies measuring the effectiveness and efficiency of TTOs based on, for example, the number of spin-out companies, do not take into account that this output measure is not appropriate for IP specialized and backward integrated TTOs. Not differentiating between the different types of TTO induces a risk to compare "apples to oranges."

Altogether, this study contributes to the literature in several ways. First, there is currently no theoretical framework for TTO governance structures in the European context. Existing research focuses only on TTOs exclusively serving one university (Bercovitz et al. 2001; Debackere and Veugelers 2005; Markman et al. 2005b). This study extends the stream of research by analyzing the TTA governance model and provides rich insights into the current technology transfer process in Europe. Second, the results provide important implications for the measurement of TTOs' productivity. Evaluating all TTO types based on the same output variables without taking the governance structure into account may result in biased perception of the relative TTO performance. Third, the typology and qualitative analysis presented provide analytical support for university management in designing a coherent organizational structure of technology transfer activities.

Future studies might analyze the quantitative impact of different TTO types on the efficiency and effectiveness of technology transfer activities. In particular, a quantitative assessment of the performance differences of TTOs with varying degrees of specialization would provide valuable information for practitioners, policy makers, and researchers. Finally, an important issue is to assess the extent to which a TTO must perform 'research funding services', which are generally performed in classical forms of TTOs. The research question would consist in identifying the synergies between private funding of research and academic patenting.

Acknowledgements The authors would like to thank the European Science Foundation (ESF-APE-INV) for support for this project. The authors are also grateful for comments received from the participants at the 2011 EPIP Conference in Brussels and the 2TS Conference in Augsburg. Moreover, we like to thank Florence Honoré and all interviewees for their support.

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Table 1 Strengths and weaknesses of specific values of TTO's structural dimensions

	Discipline integration ***(vs. discipline specialization)***	**Weak task specialization** ***(vs. high task specialization)***	**Weak autonomy** ***(vs. high autonomy)***	**Exclusive** ***(vs. non-exclusive)***
Relationship between TTO and academics	Less intensive	-	-	More intensive
Relationship between TTO and industry partners	Less intensive	-	-	Less intensive
Exploitation of economies of scale	Higher	Higher	-	Lower
Exploitation of synergies	Higher	Higher	Higher	Lower
Conflicts of interest and concomitant coordination and communication costs	Lower	Lower	-	Lower
Further strengths	-	· Lower search costs for researcher and industry partners	-	· Less competition effects between universities · Higher probability of being integrated in the university culture
Further weakness	· Less technological specialization	· Less specialized in one of the technology transfer activity	· Less flexible regarding remuneration and incentive scheme	· Higher search costs for industry partners

Table 2 Values of structural dimensions – 36 possible combinations

Structural dimension	*Description of structural dimension*		**Values**		**a_1**	**a_2**	**b_1**	**b_2**	**b_3**	**b_4**	**c_1**	**c_2**	**d_1**	**d_2**
Degree of discipline specialization	*Disciplines served by the TTO*	*All disciplines*	**Discipline-integrated**	**a_1**										
		One discipline	**Discipline-specialized**	**a_2**						1		2	3	
Degree of task specialization	*Technology transfer activities performed by the TTO*	*Research funding services, IP management, and spin-out services*	**Fully integrated**	**b_1**										
		IP-management and spin-out services	**Forward integrated**	**b_2**										
		Research funding services and IP-management	**Backward integrated**	**b_3**										6
		IP-management	**IP specialized**	**b_4**								4	5	
Level of autonomy	*Dependency of the TTO on university administration*	*TTO is independent of university administration in regard to budget and human resource management. TTO has not to report directly to university administration.*	**Independent**	**c_1**										
		TTO is dependent of university administration in regard to budget and human resource management. TTO has to report directly to university administration.	**Dependent**	**c_2**										7
Degree of exclusivity	*One common TTO serves several universities*	*TTO serves exclusively one university*	**Exclusive**	**d_1**										
		TTO serves several universities	**Non-exclusive**	**d_2**										

Note: Non feasible combinations are marked in grey.

Table 3 Typology and cases

(a) Degree of discipline specialization	Discipline-integrated									Discipline-specialized	
(c) Level of autonomy granted	Dependent			Independent							
(d) Degree of exclusivity	Exclusive						Non-exclusive				
(b) Degree of task specialization	Fully integrated	Backward integrated	Forward integrated	Fully integrated	Backward integrated	Forward integrated	Fully integrated	Forward integrated	IP specialized	Fully integrated	Forward integrated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
TTO Type	**I. Classical TTO**			**II. Autonomous TTO**			**III. Discipline-integrated TTA**			**IV. Discipline-specialized TTA**	
Cases		**B** (FR) **D** (FR) **E** (BE) **Kb** (DE)	**A** (FR) **Ka** (DE) **Kc** (DE) **Kd** (DE)	**G** (NL)	**C** (CH)	**F** (BE) **H** (UK) **I** (UK) **J** (NL)			**K** (DE)	**L** (BE)	

Table 4 Key figures

Variables	Mean (median)	Std. dev.
Number of students	22,160 (26,000)	66,500
Number of researchers	5,375 (3,906)	5,919
Age of TTO (in 2008)	14.8 (11.0)	10
Number of FTEs	17.7 (14.9)	15