

Performance of university technology transfer offices: evidence from Europe and Japan

University
technology
transfer offices

Szabolcs Pronay

University of Szeged, Szeged, Hungary

Tamara Keszey

Corvinus University of Budapest, Budapest, Hungary

Norbert Buzás

University of Szeged, Szeged, Hungary

Takayuki Sakai

Faculty of Science, Graduate School of Science, Kobe University, Kobe, Japan, and

Kensuke Inai

University of Tokushima, Tokushima, Japan

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Abstract

Purpose – This study aims to improve the understanding of the factors that influence the performance of universities' technology transfer offices (TTOs), units charged with the responsibility for aiding the commercialization of research innovations.

Design/methodology/approach – To empirically test the link between factors affecting TTO performance and whether these effects are contingent on a country-specific environment, survey data were collected from 187 TTO stakeholders (TTO heads, TTO employees and university researchers) in 18 countries of Europe and Japan, and structural equation modeling (SEM) was used.

Findings – The results show that the internal embeddedness of a TTO within a university is the most important factor in determining a TTO's performance. A TTO's performance is positively affected by its marketing capabilities and social embeddedness. Strict patent portfolio management has no significant impact on TTO performance in Japan and has a negative effect on European TTOs' performance.

Originality/value – This study highlights the role of organizational and interorganizational factors in TTO performance; moreover, this is one of the few multi-continent (Europe and Asia) studies in the domain of university–industry collaborations, expanding the current understanding of the contingent roles of the region of operation, which has remained unexplored, as extant studies were typically conducted in only one country.

Keywords University–business collaboration, Technology transfer office, Structural equation modeling, Knowledge-based view

Paper type Research paper

1. Introduction

Over the last decades, universities' traditional mission of teaching and research has changed and been amended with the so-called “third mission,” referring to activities that connect universities with the rest of society through knowledge transfers between universities and industry, business, government and society (Laredo, 2007). The third mission refers to all activities concerned with the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments for the purpose of representing an essential source of innovation for these external actors and serving as an engine of societal and economic development for regions and countries (Molas-Gallart and Castro-Martínez, 2007). Universities need to step out of the academic sphere and establish value-creating relations not only with businesses but also with the public sector (external stakeholders) and thus go beyond the traditional first and second missions of education and research (Bozeman *et al.*, 2015).



University actors, however, are traditionally comfortable within habitual academic frameworks; additionally, collaboration with external stakeholders requires specific new skills that researchers and universities often lack (Sandström *et al.*, 2016; Angiola *et al.*, 2018). Recognizing the need to assist academics with engagement in specific domains of activities with external stakeholders and aid collaborations, many—including almost all European—universities have established so-called technology transfer offices (hereinafter TTOs) (De Beer *et al.*, 2017). TTOs are dedicated for identifying and supporting research within universities that are of potential commercial interest and formulating strategies for how to exploit it. The primary motives of TTOs are to protect and commercialize the university's intellectual property (IP), while the secondary motives are to facilitate technological diffusion and secure additional research funding (Siegel *et al.*, 2003).

However, measuring the performance of university TTOs, which is typically based on capturing tangible metrics of the conversion ratio from “inputs” to “outputs” of technology transfer, raises issues that are highly relevant from a managerial perspective (De Beer *et al.*, 2017). The third mission also involves universities making efforts to improve social well-being. Yet, the use of purely tangible indicators can give a distorted picture of the real TTO performance of universities and may even reduce performance in the third mission. For instance, Molas-Gallart and Castro-Martínez (2007) claim that available factual data on commercialization (as an example of a tangible indicator) apply to disciplines such as biotechnology, where markets exist close to university research, but not to fields such as the theoretical physics or philosophy, where direct market-based applications are more limited and contributions to civil society and private sector are likely to occur through other channels. The use of purely tangible indicators may not capture the full set of true TTO outputs, potentially leading to flawed strategic decision-making by TTO and university executives (De Beer *et al.*, 2017).

Although there is a great potential for transnational sharing of best practices across TTOs, it is currently limited, considering the contextual factors of countries (De Beer *et al.*, 2017). A high number of extant studies in this domain reveal that different countries and regions differ in terms of the longevity of collaboration between science-based institutions and industry, the performance of academic–industry knowledge transfer in terms of revenue from patents, the size of venture capital fundraising and the strength of institutional ties or financial links with the state, to mention a few (Zaichenko, 2018; Croce *et al.*, 2014; Gerbin and Drnovsek, 2016; Comacchio *et al.*, 2012). While more multi-country research is needed to break down these barriers, empirical studies typically focus on single countries, and only a minimal number of studies are carried out in multiple country and continent environments.

Against these backdrops, building upon emerging results in the literature of university–industry technology transfer (hereinafter UITT) and recent studies that attribute more “soft skills” to TTO performance (Secundo *et al.*, 2016; De Beer *et al.*, 2017), this study proposes perception-based, intangible TTO performance metrics and measures important variables that influence this performance. To address the aforementioned gap related to the lack of understanding of the pattern differences of technology transfer that may emerge in various countries, this study uncovers whether the role of patent portfolio management contributes to TTO performance differently in Europe than in Japan. To the best of our knowledge, this is one of the first multi-continent studies in the domain of UITT that focuses on TTO performance by comparing European and Japanese TTOs. While European TTOs are rather diverse in terms of state influence, patenting practices, revenues and researchers' positions and attitudes, to mention a few characteristics, Japan has taken a unique path by being a laggard in UITT compared with Europe but has a strong emphasis on patent licensing (Etzkowitz *et al.*, 2008; Ito *et al.*, 2016); hence, Europe and Japan are especially well suited for a study aiming to highlight the roles of contingencies in the region of operation.

The remainder of this paper is organized as follows. The following section presents the theoretical background of the study and identifies the gaps in the extant body of empirical papers that this paper aims to fill. Then, the conceptual framework and the hypotheses are presented. Next, the study's research method and key findings are shown. The article concludes with a discussion of the study's theoretical contributions, managerial implications, limitations and suggestions for future research.

2. Theoretical background and research gaps

This study is theoretically anchored in the UITT literature. Prior studies in this domain have made significant contributions for understanding the various forms of knowledge and technology exchange between universities and nonacademic spheres. These empirically investigated forms include market and nonmarket spillovers (Mowery and Ziedonis, 2015), university–industry research partnerships and alliances (de Wit-de Vries *et al.*, 2018; Galán-Muros and Davey, 2017; Estrada *et al.*, 2016), academic spin-offs (Marzocchi *et al.*, 2017; Miranda *et al.*, 2017), new venture projects (M'Chirgui *et al.*, 2016) and academic entrepreneurship (Sandström *et al.*, 2016; Marion *et al.*, 2012; Hayter, 2016; Tartari and Salter, 2015; Forti *et al.*, 2013).

A part of the UITT literature is made up of studies examining the specific role of TTOs in this literature. In this subsection of the UITT literature, three research gaps emerge. First, more research is needed to capture TTO performance beyond tangible metrics. As shown in Table 1, the conceptualization and operationalization of TTO performance is divergent in the extant literature. The effectiveness of university technology transfer is frequently associated with tangible measures, such as the number of patents (e.g. the number of patent applications, the number of patents sold, share of researchers within the university holding more than a specific number of patents, etc.) or the number of indexed publications (e.g. O'Kane *et al.*, 2015; Zaichenko, 2018).

Authors, however, point out those tangible measures may be misleading, as they say little about the quality of the patents or fail to comprehensively capture the technology transfer performance of universities, for example, aiming to contribute to societal well-being (Guerzoni *et al.*, 2014). An early but well-known study notes that “patents are flawed measures (of innovative output), particularly since not all new innovations are patented and since patents differ greatly in their economic impact” (Pakes and Griliches, 1980). Molas-Gallart and Castro-Martínez (2007) claim “that any approach to data collection and analysis that focuses purely on university commercial activities is likely to miss large and important parts of the picture” and increased attention on IP commercialization strategies may even hamper universities' societal value delivery.

To address these concerns, recent studies have started to place more emphasis on intangible metrics to capture TTO performance. For example, Secundo *et al.* (2016) proposes a conceptual model that captures key TTO efficiency areas, including IP strategy and policy, organization design and structure, human resources, technology, industry links and networking over various stages of the TTO maturity level, and (De Beer *et al.*, 2017) empirically tests this model in the United Kingdom and various European countries. Other intangible metrics of TTO performance include academics' willingness to cooperate with TTOs or firms' engagement with TTOs (Comacchio *et al.*, 2012; Muscio, 2010).

Second, there is a need for additional research into factors that may affect TTO performance. As Table 1 shows, there are only a limited number of studies that uncover the factors affecting TTO performance. These factors include individual-level antecedents, such as researchers' experience with the patenting system, academic confidence in TTOs and TTO managers' industry background or access to human capital (Muscio, 2010; Comacchio *et al.*, 2012). Studies also reveal that TTO performance is influenced by

Studies	TTO performance conceptualization	TTO performance operationalization	Factors affecting TTO performance	Country of investigation
<i>Empirical papers with tangible metrics</i>				
Sellenthin (2009)	Academics' willingness to apply for patents through the TTO	Patenting of university research (Researchers who applied for patents, researchers who hold granted patents and share of researchers with five or more patents)	(1) Experience with the patenting system (2) The reward system of universities' rewards patents (3) Supporting infrastructure for patenting and commercialization	Sweden and Germany
Clarysse et al. (2011)	TTO efficiency	Number of patent applications of that university	Not investigated	United Kingdom
Zaichenko (2018)	Technology transfer performance (not specifically TTO performance)	Number of indexed publications	Not investigated	Russia
Munshaw et al. (2018)	Outcomes of university support	Number of patent applications at the individual level	Not investigated	United States
<i>Empirical papers with intangible metrics</i>				
Muscio (2010)	Efficiency and effectiveness	Academics' willingness to cooperate with TTOs	(1) Academics confidence in TTOs (2) TTO managers' industry background (3) Academic research performance	Italy
Comacchio et al. (2012)	The boundary spanning role of TTOs evaluated by firms collaborating with universities	Dichotomous variable (yes/no) whether respondent firms have engaged with TTOs	(1) Internal qualified human capital (2) External human capital (3) R&D partners research activity	Italy
De Beer et al. (2017)	Efficiency	Self-evaluated indicators of TTO human resource management, networking, university–industry links and networking	Not investigated (the focus is on how TTO efficiency evolves into the TTO maturity level)	United Kingdom and various /not specified/ European countries
<i>Conceptual papers</i>				
Sorensen and Chambers (2008)	Knowledge access through TTOs	Conceptual paper (no empirical analysis)	Not investigated	Not applicable (conceptual paper)
Johnson (2011)	Performance to the next level and eventual commercialization	Conceptual paper; TTO performance is not conceptualized	Not investigated	Not applicable (conceptual paper)

Table 1.
Overview of studies on
TTO performance

(continued)

Studies	TTO performance conceptualization	TTO performance operationalization	Factors affecting TTO performance	Country of investigation
Secundo et al. (2016)	Efficiency	Self-evaluated indicators of TTO IP strategy and policy, organization design and structure, human resource, technology, industry links and networking	Not investigated (the focus is on maturity level of TTO based on efficiency areas)	Not applicable (conceptual paper)

Table 1.

supporting processes, such as the infrastructure of the reward system of the university and supporting infrastructure ([Sellenthin, 2009](#)). However, extant empirical studies largely remain silent on how the capabilities of TTOs influence their performance.

Third, studies on both TTOs (see [Table 1](#)) and more broadly on university–industry knowledge and technology transfer typically gather single country data; there are a few exceptions with multi-country and multi-continent studies (see [Table 2](#)). However, crucial to many academics and practitioners interested in university–industry knowledge and technology transfer is elucidating the understanding of TTO differences in various geographical areas (c.f. [De Beer et al., 2017](#)). Scant research highlights that technology transfer systems in Europe differ significantly from those in the United States, with a long history of direct collaboration between science-based institutions and industry ([Comacchio et al., 2012](#)). [Bacchiocchi and Montobbio \(2009\)](#) point out that in the United States, university patents are cited more often than companies’ patents; however, in Europe and Japan, there is no evidence of a superior abundance of university patents.

Study-type	Europe	America and Australia	Asia
Single-country study	Italy (Forti et al., 2013) United Kingdom (Tartari and Salter, 2015 ; Marzocchi et al., 2017 ; Clarysse et al., 2011 ; Tartari et al., 2014) Spain (Estrada et al., 2016 ; Criaco et al., 2014 ; Olaya Escobar et al., 2017) France (Levy et al., 2009) Russia (Zaichenko, 2018)	United States (Conti and Liu, 2015 ; Jha and Welch, 2010 ; Marzocchi et al., 2017 ; Mowery and Ziedonis, 2015 ; Hayter, 2016) Brazil (Freitas et al., 2013)	Taiwan (Chen et al., 2013) South Korea (Park and Leydesdorff, 2010) Japan (Kodama, 2008)
Multi-country study	33 countries in Europe (Galán-Muros and Plewa, 2016) Two countries: France and Germany (Robin and Schubert, 2013) Two countries: Sweden and Germany (Sellenthin, 2009)	Australia (Rampersad, 2015)	
Multi-continent study	Six countries: Europe (four largest countries), Japan and United States (Bacchiocchi and Montobbio, 2009) Four countries: Sweden, Japan, Brazil and United States (Etzkowitz et al., 2008) Two countries: United Kingdom and Japan (Ito et al., 2016)		

Table 2.
Geographical dispersion of key empirical studies in the domain of university–industry collaboration

3. Conceptual framework and hypotheses

Against the gaps introduced in the previous section, we focus on factors affecting TTO performance in countries of Europe and Japan. This study conceptualizes TTO performance as the degree to which TTOs are perceived as being able to effectively commercialize technologies. This conceptualization is in line with recent studies (Zaichenko, 2018; Johnson, 2011) and with the seminal work of Bozeman (2000).

Regarding the variables influencing TTO performance, we build upon knowledge-based view theory. The knowledge-based view has been widely used to examine knowledge management processes in organizations (Nonaka, 1994; Grant, 1996) and is considered a promising theoretical perspective for understanding university entrepreneurship (Hayter, 2016). The knowledge-based view focuses on the kinds of resources and capabilities that organizations should possess to use, apply and exploit the specialist knowledge of their members (Nonaka, 1994; Grant, 1996). According to knowledge-based view theorists, organizations exist to generate and integrate knowledge for subsequent use in strategic actions for sustainable competitive advantage; hence, an organization's ability to acquire new knowledge by generating, renewing and accumulating its knowledge stock becomes critical (Grant, 1996; Spender, 1996). This is especially important for organizations in highly dynamic industries, such as universities where new knowledge is continuously emerging, and organizations that have to maintain a continuous source of new knowledge to gain and sustain competitive advantage.

Knowledge-based view theorists suggest that the process of knowledge management is influenced by organizational support that facilitates the implementation of knowledge management processes (Nonaka, 1994; Grant, 1996). Triggered by the third mission paradigm shift, to facilitate knowledge management processes related to exploitation and transfer of academic knowledge outside the academic environment, universities have to adapt both structurally and strategically. As part of this adaptation process, we consider four antecedent variables and examine how social embeddedness, internal embeddedness, marketing capabilities and patent portfolio management affect TTO performance (see Figure 1).

3.1 Social embeddedness

The social sphere gains increasing recognition in the knowledge transfer context. The Quadruple Helix concept (Carayannis and Campbell, 2009) and the responsible innovation approach (Stilgoe *et al.*, 2013) are prime examples of the proliferation of this phenomenon. A related concept, social embeddedness, refers to TTOs' active collaboration in value creation with external stakeholders (civil society and local communities). It is manifested, for example, by taking into consideration local communities during the technology transfer processes, initiating and taking part in open innovation with stakeholders or offering society control over university innovation processes.

Schwartz (2004) claims that "No matter how clever the idea or great the implementation is, an invention typically lives or dies depending on how well it can be integrated into a large social and technological context." When TTOs are socially embedded and have better access and insights into a large "social context," they can develop a larger network of stakeholders that can be called upon during the commercialization of new technologies. Social embeddedness facilitates communication among different actors who are actively involved in the process of technology transfer, leading to higher performance outcomes.

H1. Social embeddedness is positively related to TTO performance.

3.2 Internal embeddedness

Internal embeddedness is defined as TTOs' active collaboration in value creation with internal stakeholders, such as researchers. Universities are traditional institutions for basic

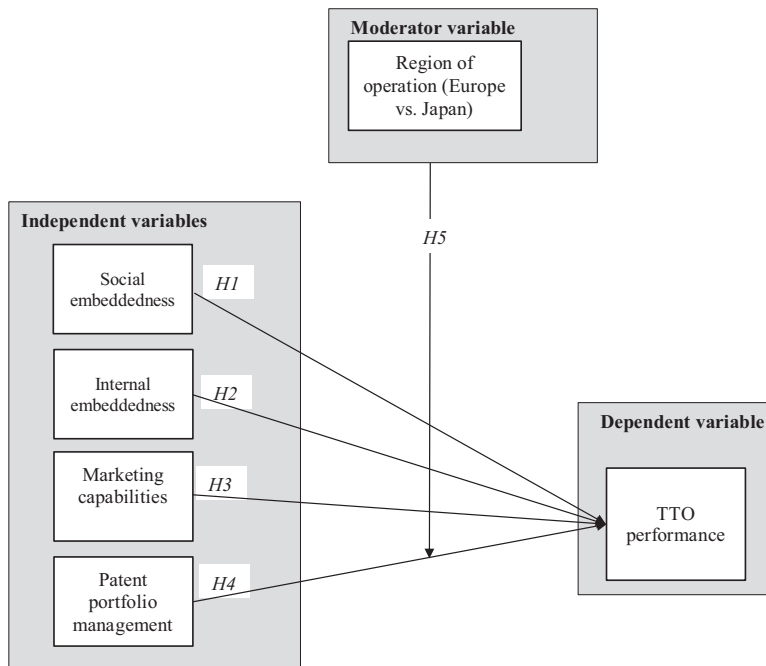


Figure 1.
Research framework

research and are considered to be temples of science (Nelson, 2004). As a consequence, a commitment to science is fundamental for researchers working there, a fact that often conflicts with their motivation to commercialize (Haeussler and Colyvas, 2011). Therefore, TTOs need to prove their scientific commitment to become legitimate in the eyes of researchers; however, they often fail to do so, and academics generally do not accept their legitimacy (O'Kane *et al.*, 2015).

Nevertheless, an essential condition of the operation of the TTO is that it maintains appropriate relations with researchers and builds legitimacy in their eyes. Powers (2003) shows that TTOs with a more mature research team hold more patents and sell more licenses. In spite of absent researcher acceptance, researchers may choose the novelty destruction (publication) of IP. Aldridge and Audretsch (2011) highlight the social capital of academics as a central determinant of their likelihood of being involved in knowledge commercialization. However, academics often lack this social capital, which hampers commercialization. When TTOs have good social links and are well embedded internally, they can assist academics in patching structural holes in their networks. Consequently, the TTO needs to maintain good relations and be internally embedded in a network of researchers to encourage them to share their IP and participate in the UITT process.

H2. Internal embeddedness is positively related to TTO performance.

3.3 Marketing capabilities

The marketing capabilities of the TTO are defined as the extent to which a TTO is able to perform marketing tasks related to technology transfer. These tasks may involve organizing partnering events, creating a user-friendly online knowledge map of the patents and exploitable technologies available within the university, etc.

The university's exploitable technologies are mostly the result of basic research, which are not primarily motivated by industrial purposes but rather scientific curiosity (Perkmann *et al.*, 2013). The emerging results often halt within the framework of the research group due to academics' lack of commercial motivations and competencies (Bercovitz and Feldman, 2006); thus, university TTOs usually do not even know about marketable technologies. TTOs are charged with the responsibilities to act as a business intermediary between academics and external stakeholders by taking an initiating role. The commercialization of technologies often requires special marketing qualifications and skills, which researchers do not always possess, while stakeholders claim they have shortcomings (Swamidass and Vulasa, 2009). Thus, the more a TTO is equipped with marketing capabilities, the more likely the TTO will achieve high performance.

H3. Marketing capabilities are positively related to TTO performance.

3.4 Patent portfolio management

Strict patent portfolio management by the TTO is defined as its preference for keeping only those technologies within the portfolio that have significant business potential. TTOs that follow strict patent portfolio management discard those technologies from the portfolio that do not generate significant interest from the industry within a considerable amount of time and keep only those technologies that have significant business potential.

Traditionally, the main task of TTOs has been to ensure the patent protection of IP produced at universities, which results in licensing. The university patenting protocol is typically different from the industrial protocol, as a large number of basic research results are produced at universities day by day, but only a fraction is eventually patented; moreover, a significant proportion stops at the level of the research group or departments and remains unknown to the TTO (Bercovitz and Feldman, 2006).

The central element of the university technology transfer process is materialized knowledge in the form of a patent (Reeves, 2006). However, a patent should not be considered an end product; therefore, mere patent accumulation is not an efficient strategy (Sorensen and Chambers, 2008). Only a small percentage of university IP is eventually patented. The attitude of the TTO toward patents and the stricter and more commercialization-oriented management of the patent portfolio can influence stakeholders' opinions about the TTO. Strict portfolio management means that the TTO only includes IP in the patent portfolio that potentially generates a benefit to business. By doing so, instead of general patent accumulation, the TTO strictly filters and eliminates items of lower market potential. We assume that stricter patent portfolio management has a positive effect on opinions about TTOs since it shows an effort to be effective, which in turn enhances positive perceptions.

H4. Strict patent portfolio management is positively related to TTO performance.

3.5 Contingent role of region of operation

In 1980, in the United States, the Bayh–Dole Act created legal and institutional frameworks for effective technology transfer activities at universities. As a result, these institutions established a presence in the market as knowledge exploiters. This legislation passed IP rights from the federal government to the universities. This gave them the opportunity to profit from on-campus research and turns the results into innovative and practical goods. In Europe and Japan, this process took place years later. For example, in Germany, inspired by the Bayh–Dole Act, the Bundesministerium für Bildung Forschung (BMBF) (Federal Ministry for Science and Education) became active only in 2002, more than 20 years after Bayh–Dole was implemented in the United States (Grimm and Jaenicke, 2012). Similarly, in Japan, the Japanese government introduced the industry–university collaborations policy in

the late 1990s through the Technology Licensing Office Act in 1998 and the Japanese Bayh–Dole Act in 1999, almost 20 years after the US Bayh–Dole Act was introduced in 1980 (Ito *et al.*, 2016).

In Japan, prior to the launch of the 1998 Law to Promote Transfer of University Technologies, strong barriers existed between academia and industry for several reasons, including the legal restrictions placed on university researchers from seeking consultations outside academia, financially benefitting from entrepreneurial activity and using research and development funds to cover salaries and stipends (Etzkowitz *et al.*, 2008). The change in legislation aimed to encourage entrepreneurial attitudes in university researchers in Japan. For example, the law legalized the compensated consulting of researchers and the holding of management positions in private companies (Etzkowitz *et al.*, 2008).

The European and Japanese approaches have led to similar results in terms of increasing the number of patent applications (Takahashi and Carraz, 2011), while universities have entered the business market as active actors in technology transfer. TTOs and technology license offices (TLOs) have been established within universities (or outside but closely related to them) in these economies. The task of these units has been to facilitate the legal protection and commercialization of IP (Jensen and Thursby, 2001; Pawlowski *et al.*, 2000). Table 3 summarizes the key differences of TTOs in Europe and Japan.

Among the investigated independent variables that affect TTO performance, we focus on the differential effects of patent portfolio management in Europe and Japan; this is one factor that is, to a great extent, driven by legal environments that may differ in various countries.

As Table 3 shows, in Japan, patenting rates are higher compared with the United States, while industry funding is more common in the United States. Ito *et al.* (2016) also confirm that rates of university patents in Japan are particularly high compared with the United Kingdom: “However, Japanese universities currently possess, arguably, too many patents and receive relatively low income from patents, resulting in significant pressure on their budgets.” Patent portfolio management is less strict in Japan, as the number of patents held by university TTOs exceeds the Western average (Ito *et al.*, 2016; Walsh and Huang, 2014). Based on this, we can assume that strict patent portfolio management is a weaker expectation among stakeholders in Japan, and that it will thus have a weaker effect on opinions regarding the performance of TTOs.

H5. In the case of Japanese TTOs, strict patent portfolio management will have a weaker effect on TTO performance than in the case of European TTOs.

4. Methods

4.1 Research context and data collection

The data for this study were collected through a survey that was sent to TTOs operating in European and Japanese higher educational institutions. We chose the European TTOs as the context for our investigation, because while European TTOs show diversity in terms national specificities, yet they are homogenous in the sense of being less professional compared to their US counterparts resulting into fewer patents (Gerbin and Drnovsek, 2016; Bacchiocchi and Montobbio, 2009). The Japanese TTOs has a number of characteristics that make them unique compared to their European and US counterparts, including that Japanese TTOs have been set up late compared to their American and European counterparts; yet, the patenting rate is high compared to other countries, including the United States, while the higher education system is rather centralized (Etzkowitz *et al.*, 2008; Ito *et al.*, 2016). These unique features make Japan a prime context for studying the region and country-specific characteristics.

	Europe	Japan
TTO settings and the influence of the state	<ol style="list-style-type: none"> (1) The primary objectives of TTO are to diffuse an entrepreneurial culture of research, support university spin-offs and promote economic valorization of research output (Muscio, 2010) (2) In Russia, TTOs have no direct association to higher education institutes, maintain own science base and have strong institutional ties and financial links with the state (i.e. full or partial public ownership and government funding) (Zaichenko, 2018) 	<ol style="list-style-type: none"> (1) Centralized higher education (HE) system (Etzkowitz <i>et al.</i>, 2008) (2) Significant government HE influence (Etzkowitz <i>et al.</i>, 2008) (3) Government-imposed restrictions over interactions between universities and industry (Etzkowitz <i>et al.</i>, 2008) (4) Most TTOs affiliated with national universities are independent for profit corporations (to be able to hire competent staff at competitive salaries, which would not have been allowed if they had been university offices) (Etzkowitz <i>et al.</i>, 2008) (5) Managers are less close to researchers and managers of their universities (Etzkowitz <i>et al.</i>, 2008)
TTO patenting practices and revenues	<ol style="list-style-type: none"> (1) Overall increase in university patenting and magnitude is inferior relative to the United States (Bacchiocchi and Montobbio, 2009) (2) Strong national specificities in different countries (Bacchiocchi and Montobbio, 2009) (3) European revenue from academic–industry knowledge transfer is highly concentrated, with the top 10% of universities accounting for almost 90% of all revenue (Gerbin and Drnovsek, 2016) (4) Compared to the United States, European management of knowledge and IP is less professional and results into fewer patents (Gerbin and Drnovsek, 2016) 	<ol style="list-style-type: none"> (1) Income relies largely on income from patent licensing, compared to the United Kingdom, where income includes sale of shares in spin-off companies and Intellectual Property (IP) income includes nonsoftware licensing, software licensing, and others (Ito <i>et al.</i>, 2016) (2) Universities possess too many patents and receive relatively low income from patents, resulting in significant pressure on their budgets (Ito <i>et al.</i>, 2016) (3) Patenting rates are higher compared to the United States (Walsh and Huang, 2014) (4) Patents are less directly linked to commercial activity compared to the United States (Walsh and Huang, 2014)
Researchers' positions and attitudes	<ol style="list-style-type: none"> (1) In Germany, Denmark, Sweden and Austria institute of professor's privilege allowed university professors to retain the property right over their research findings (Bacchiocchi and Montobbio, 2009) (2) In the United Kingdom, France and Italy, the standard rule applies according to which the employers retain the property right (Bacchiocchi and Montobbio, 2009) 	<ol style="list-style-type: none"> (1) Lifetime employment in academia with seniority-based wages and retirement benefits (Etzkowitz <i>et al.</i>, 2008) (2) Since early 2000, university researchers can hold outside management positions, receive sponsored research from companies and hold stock or have an advisory or management position (Etzkowitz <i>et al.</i>, 2008)

Table 3.
Selected empirical studies on key differences of TTOs between Europe and Japan

As a research frame, we used the Association of European Science and Technology Transfer Professionals for the European TTO sample that counts over 800 members (<https://attp.info/learn-about-attp/>) and the TTOs of the 86 National Universities of Japan; convenience sampling technique was used in case of both the European and the Japanese TTOs. The

questionnaire was sent in an online form in English for the European sample, whereas the Japanese questionnaire was first translated into Japanese, back-translated for correction, translated back into Japanese again and then finally proofread by a native speaker. During the research, no ethical issues have been raised, as the response to the questionnaire was voluntary, based on the respondent's consent. We have treated the responses anonymously and used it for scientific purposes only in an aggregated manner.

The data gathering is not the result of experiments with participants or animals. The data collection resulted in 187 completed questionnaires.

The sample characteristics are presented in [Table 4](#).

The respondents have an average of 13 years of relevant work experience, so they presumably have proper insight into the operation of TTOs. In the course of collecting the data, we analyzed the sampling error resulting from nonresponse with a statistical method. Based on [Armstrong and Overton's \(1977\)](#) methodology, we compared the values of key variables found in our model in the quickly and slowly responding sub-samples, but we did not find significant differences. Analysis of variance did not indicate significant differences between the means of the key constructs between early and late respondents ([Armstrong and Overton, 1977](#)). Therefore, we concluded that nonresponse errors would not cause a systematic error in the sample, so we pooled data for subsequent analyses.

4.2 Measures

To enhance metrics reliability, the questionnaire was tested in a two-stage process. First, two academics evaluated the questionnaire. One of them, a former TTO director with notable experience in technology transfer, evaluated the statements according to their fit with TTO processes and proposed additional statements if he deemed it necessary. The other academic, one with several decades of experience in academic research, performed a semantic review of the questionnaire. Second, two TTO directors and two researchers tested the questionnaire. We asked them to mark all statements that they found confusing, incoherent or difficult to respond to. They were asked to briefly describe their problems with each item. We used five-point Likert-type scales to measure the concepts in our model. Each construct (TTO performance, social embeddedness, internal embeddedness, marketing capabilities and patent portfolio management) was measured with multi-item scales and consisted of at least three items ([Table A1](#)).

4.3 Measurement instrument validation

The validity and properties of the multi-item scales were assessed through confirmatory factor analysis (CFA) using IBM SPSS and AMOS softwares for the five constructs of performance, patenting, embeddedness, marketing and public value. The CFA results indicate a good fit (main fit indices: $\chi^2/df = 1.89$, $p < 0.01$, CFI = 0.92, IFI = 0.92, TLI = 0.90 and RMSEA = 0.07) based on the accepted cut-off values ([Byrne, 2010](#)). Factor loadings are statistically significant for each construction, the values of which exceed the threshold value

Region/country	TTO head	Respondent position			Sum
		TTO employee	Scholar/researcher	Missing	
Europe ^a	34	38	11	0	83
Japan	11	32	36	25	104
Sum	45	70	47	25	187

Note(s): ^ainvestigated countries are: Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, Germany, Hungary, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Switzerland and United Kingdom

Table 4.
Sample characteristics

of 0.6 (Anderson and Gerbing, 1988). The indices measuring the validity of all constructions in the model (composite reliability and Cronbach's alpha) exceed the threshold value of 0.7. The average variance extracted (AVE) values surpass the threshold value of 0.5 in each case (Bagozzi and Yi, 1988). The outcomes from these tests support the convergent validity of the constructs used. Furthermore, the square of the intercorrelation between two constructs is less than the AVE estimates of the two constructs for all pairs of constructs, thus providing support for discriminant validity (Fornell and Larcker, 1981). Table 5 presents the descriptive statistics for the model's key constructs.

5. Analyses and results

We tested our model using structural equation modeling (SEM) using AMOS 23.0 software. The fit indices show good values ($\chi^2(93) = 176.6$, $\chi^2/df = 1.899$, $p < 0.001$; RMSEA = 0.071; SRMR = 0.072; NNFI = 0.904 and CFI = 0.926). We summarized the results of the model testing in Table 6.

Our results supported the first hypothesis ($b = 0.199$ and $p < 0.05$) that social embeddedness has a positive effect on the assessment of TTO performance; hence, social embeddedness enables TTO members the sharing of knowledge within a larger network. These findings are in line with the current understanding of knowledge dynamics that highly hinges on the integration of diverse information from the network of sources (Marques, 2019). Our results support the second hypothesis ($b = 0.29$ and $p < 0.01$). Internal embeddedness plays an important role in human resource productivity, such as reducing turnover intentions (Coetzer *et al.*, 2019). Our study shows that the internal embeddedness of TTOs positively influences TTO performance. These results are in accordance with the prior literature and may be explained by the underlying mechanisms of embedded TTO members being more legitimate in the eyes of researchers, which in turn improves performance outcomes (O'Kane *et al.*, 2015). The third hypothesis that marketing capabilities have a positive effect on

Variable	Mean	Std. dev.	CR	CA	AVE	SUC	MAR	SE	PAT	IE
PRF	2.42	0.94	0.81	0.80	0.60	0.77				
MAR	2.90	0.95	0.81	0.79	0.53	0.29	0.73			
SE	3.06	0.71	0.77	0.76	0.54	0.38	0.22	0.74		
PAT (po)	3.05	1.01	0.78	0.76	0.55	-0.01	0.07	0.07	0.74	
IE	2.67	1.07	0.78	0.77	0.55	0.27	0.03	0.25	0.12	0.74

Table 5. Validity and reliability of measurement scales

Note(s): PRF: TTO performance; MAR: marketing capabilities; SE: social embeddedness; PAT: strictness of TTO patent portfolio management; IE: internal embeddedness; CR: composite reliability; CA: Cronbach's alpha and AVE: average variance extracted. The square root of AVE is shown on the diagonal

Table 6. Parameter estimation (standardized structural coefficient) and variance explained (R^2)

	Standardized structural coefficient	Variance explained (R^2)
H1: Social embeddedness → TTO performance	0.199*	
H2: Internal embeddedness → TTO performance	0.290**	
H3: Marketing capabilities → TTO performance	0.228**	
H4: Patent portfolio management → TTO performance	-0.078 ns	
TTO performance		0.23

Note(s): * $p < 0.05$; ** $p < 0.01$. ns = not significant

TTO performance is also supported by the data ($b = 0.22$ and $p < 0.01$). Although it has received less attention in the context of UITT, and TTOs specifically, marketing capabilities' impact on firm performance was found to be positive in various industries and studies (Kamboj and Rahman, 2015; Jaisinghani *et al.*, 2019). The positive result may be explained by scientists' basic research outcomes – often being motivated by pure scientific curiosity – combined with TTOs' capabilities to effectively market research outcomes and improve TTO performance (Perkmann *et al.*, 2013; Swamidass and Vulasa, 2009). The empirical results do not support the fourth hypothesis ($b = -0.07$ and n.s.) that strict patent portfolio management has a positive effect on TTO performance. Contrary to the preliminary hypotheses, our results tend to confirm that a strong focus on patent portfolio management may even reduce TTO efficiency, as suggested by studies proposing a more holistic approach to examining the performance of TTOs (Molas-Gallart and Castro-Martinez, 2007; Secundo *et al.*, 2016).

The fifth hypothesis states that strict patent portfolio management has a weaker effect on opinions regarding the performance of TTOs among Japanese TTOs than among European TTOs. To reveal whether geographical origins (Japan or Europe) have a moderating effect on the relationship between patent portfolio management and the assessment of TTOs, we carried out a multi-group moderation test. We examined through critical ratios (z -scores) whether strict patent portfolio management determines the performance of TTOs to significantly different extents in the case of Japanese and European TTOs (Byrne, 2010).

The results presented in Table 7 show that strict patent portfolio management has a significant negative effect ($b = -0.302$ and $p < 0.05$) on TTO performance in Europe but has no significant effect on Japan ($b = 0.055$, ns), and that the difference between the two groups is significant ($p < 0.10$). According to Hypothesis 5, strict TTO patent portfolio management in Japan has a weaker effect on opinions regarding TTO performance than it does in Europe. Our results do not confirm this hypothesis; thus, H5 is rejected.

6. Conclusions and contributions

6.1 Response to research questions and synthesis of findings

The primary goal of this study is to enrich the technology transfer literature by suggesting an intangible, perception-based operationalization of TTO performance by capturing relevant but yet not investigated factors that influence performance and by highlighting the importance of region-specific differences. More specifically, we aim to answer the following research questions: (1) what factors influence intangible, perception-based TTO performance, and (2) does the role of patent portfolio management contribute to TTO performance differently in Europe than in Japan?

The conceptual starting point of our study is that in addition to traditional first and second missions of teaching and academic research, universities increasingly need to take part in the

Connection studied	European TTOs ($n = 77$)		Japanese TTOs ($n = 104$)		Significance level of the difference between European and Japanese TTOs
	Std. beta	Sig. level	Std. beta	Sig. level	z -score
H5: Patent portfolio management → TTO performance	-0.302	0.012	0.055	0.705	1.894*

Note(s): z -score significance: 0.01 level if it is greater than 2.58, 0.05 level if greater than 1.96 and 0.10 level if greater than 1.65 (Byrne, 2010). * $p < 0.05$

Table 7.
Geographical
connections of patent
portfolio management
and marketing
approach

generation, use, application and exploitation of knowledge outside academic environments as catalysts of societal and economic innovation (Molas-Gallart and Castro-Martínez, 2007). This new task, often labeled as the third mission, puts universities in an original position, and many of them have set up TTOs to facilitate technology transfer. TTO performance is often evaluated by output-oriented tangible metrics; however, as recent research points out, the legitimacy of intangible metrics is unquestionable, as these metrics provide a more nuanced picture of TTO efficiency (De Beer *et al.*, 2017; Secundo *et al.*, 2016).

Our study proposes a new perception-based scale for capturing intangible TTO performance and empirically validates this scale on a sample of various TTO stakeholders, such as TTO heads, TTO employees and university researchers. Our findings suggest that four factors—social embeddedness, internal embeddedness, marketing capabilities and patent portfolio management—all of which are related to the knowledge-based view explain 23% of the variance in TTO performance. The most important variable is the internal embeddedness of the TTO (i.e. the TTO is in possession of accurate information on innovations available within the university, there are scientific products and services that can be sold to industrial partners and the TTO is generally accepted as the exploiter of university inventions within the university). Our results indicate that the effect of patenting practices (e.g. only technologies with high business potential are worth patenting) on TTO performance is contingent on the region in which the TTO operates. In Europe, strict patenting practices have a significant negative effect on TTO performance. However, in Japan, where universities were prohibited from commercializing IP until 1998 and where TTOs have only played a role in technology transfer since 2004, strict patenting has no significant effect on TTO performance.

6.2 Theoretical contributions

This research enhances our understanding of how the environment/region of operation moderates the factors that affect TTO performance. More specifically, our empirical study of 18 countries in Europe and Japan provides robust evidence on the differential effect of patent portfolio management on TTO performance. Our findings in the European sub-sample, which suggest that strict patent portfolio management has a negative effect on TTO performance, provide an important contribution to the UITT literature. Former studies did not specifically look at the direct link between TTO performance and patenting practices; however, Siegel *et al.* (2003) point out that 80% of their respondents expressed dissatisfaction with TTOs exercising their IP rights too aggressively and being too concerned with a very narrow focus on the legal aspects of licensing. In Japan, however, where – compared with international standards – TTO income is largely derived from patent licensing (Ito *et al.*, 2016), and patenting rates are higher (Walsh and Huang, 2014), TTO stakeholders seem to be neutral toward the strictness of TTO patent portfolio management when evaluating its performance.

In contrast to prior research, which has typically associated sales or profitability (market impact), or the number of the university's patent applications (Clarysse *et al.*, 2011; Zaichenko, 2018; Sellenthin, 2009) with TTO performance primarily, we find that perception-based intangible metrics of TTO performance can be used and validated in a multi-country, multi-stakeholder context. This is an important finding for the UITT literature and supports recent new avenues for other capability-based intangible TTO performance metrics (e.g. Muscio, 2010; De Beer *et al.*, 2017; Secundo *et al.*, 2016).

Extant studies of performance metrics in the context of universities highlight the importance of management and strategy, such as transparency, description of objectives, quality of plans, etc. (Angiola *et al.*, 2018). Studies on TTO performance, however, place more emphasis on understanding the roles of individuals in this process by uncovering the

confidence of academics in TTOs, the TTO managers' industry background (Muscio, 2010) or the experience with the patenting system (Sellenthin, 2009), while factors related to the organization and the relationship between the university and other actors remain unexplored. As a theoretical contribution, by applying the knowledge-based view as a conceptual lens, this study highlights the roles of marketing capabilities, patent portfolio management and internal embeddedness as organizational factors and social embeddedness as an interorganizational factor in enhancing TTO performance.

6.3 Managerial contributions

This study might be of interest to both university management and TTO members. The former is interested in finding ways to foster the technology transfer process and raise its effectiveness, while the latter group seeks the means to improve the performance and legitimacy of the TTO.

We found that the internal embeddedness of the TTO and thereby its direct relationship with researchers as well as its possession of adequate information on university technologies are all important for stakeholder expectations. They underlie the significance of the scientific identity of the TTO. This means that it is not sufficient to merely fulfill industrial criteria; legitimacy in the eyes of the researchers is also essential for performance; thus, establishing personal contacts is crucial. Therefore, our first recommendation for university management is to support events that facilitate personal interactions between TTO staff and university researchers. Such events may include innovation days and innovation clubs. The former represents more formal ways for UITT managers and researchers to establish contact, while the latter represents more informal ones.

Our second managerial implication is based on the result that a business identity also proves to be important in terms of the performance of a TTO, which necessitates appropriate marketing activities. These are particularly expensive activities – especially regular visits to international partnering events – but we would like to draw university decision-makers' attention to the fact that this is still essential for effective TTO activity. Stakeholders rightly expect that one of the most market-oriented organizational units at the university builds an actual business-like image and engages in substantive marketing activities.

Our third recommendation is addressed to TTO managers and directors. The most insightful result of our research is the negative (or neutral in the case of Japan) assessment regarding strict patent portfolio management, traditionally viewed as a core activity of TTOs. On the one hand, we found that strict TTO patent portfolio management has no significant effect on stakeholders' opinions in the total sample. On the other hand, the European subsample showed that strict patent portfolio management has a negative effect on the assessment of TTO performance. It seems that stakeholders expect more than simple patent administration. Strict patent regulation can easily lead to restricting the TTO in its scope of action in terms of both portfolio and available resources. As far as this is concerned, we advise TTO managers to focus more on an effective application of marketing tools besides, or even instead of, portfolio revision and screening. This approach involves a more efficient exploration of new research results and an easy-to-access on/offline presentation of portfolios.

Another important finding is that, in addition to business aspects, the relevance of social aspects is also noted, as social embeddedness proved to be a criterion for high-performance university technology transfer. Our fourth recommendation is for university managers to maintain a closer relationship with the local community and to consider social aspects, though this often contradicts the exclusivity granted by a patent. Maintaining social ties also represents a change in approach since it requires decision-makers to engage in more holistic thinking that covers several stakeholders instead of mere business partners, which is also closely linked to the fulfillment of universities' third mission.

7. Limitations and future research directions

As with any research, this study has several limitations that offer potential avenues for further research. Our study offers a multi-continent perspective and, on a more general level, highlights the importance of moderators in modeling the factors that affect the process of UITT. Further research may warrant examining the difference in perceptions among various technology transfer stakeholders. For example, the factors that affect TTO performance may be different from the perspective of a researcher than that of a TTO manager or employee.

Although empirical evidence of this study suggests that the contextual setting of the UITT moderates the role of important factors, some countries and regions that can provide contexts for studying UITT are as of yet missing from the literature. For example, the process of UITT is well studied in Europe, but even on this continent, we can find regions that are terra incognita. While countries of “old” Europe, such as the United Kingdom, Spain, France and Italy, are the focus of researchers (Tartari and Salter, 2015; Marzocchi *et al.*, 2017; Clarysse *et al.*, 2011; Tartari *et al.*, 2014; Forti *et al.*, 2013; Olaya Escobar *et al.*, 2017), we have very limited knowledge of the UITT in regions of “new” Europe, such as the countries of Central and Eastern Europe and the former Soviet Union. We hope that researchers will increasingly find opportunities to collect data from these regions, especially because academic-industry knowledge transfer is highly concentrated in Europe, with the top 10% of universities (mainly from “old” Europe) accounting for almost 90% of all revenue (Gerbin and Drnovsek, 2016). Hence, our extant knowledge on UITT in Europe is derived from studies on more industrialized regions, while less is known about the specific features of UITT in lower industrial output regions.

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Appendix

Construct and definition	Items
<i>TTO performance</i> : the degree to which TTOs is perceived as being able to effectively commercialize technologies	(1 = fully disagree and 5 = fully agree) (1) TTOs are achieved high performance from a business point of view (2) Majority of university patents are applied by the industry with the assistance of TTO (3) Many intellectual properties are commercialized with the assistance of TTO
<i>Social embeddedness</i> : TTOs active collaboration in value creation with external stakeholders	(1 = fully disagree and 5 = fully agree) (1) The interests of the local communities are taken into account in the university technology transfer (2) Universities take part in open innovation processes with the assistance of TTOs (3) There is a society control over the university innovation process
<i>Internal embeddedness</i> : TTOs active collaboration in value creation with internal stakeholders, such as researchers	(1 = fully disagree and 5 = fully agree) (1) TTOs actively collaborate with researchers during technology transfer processes (2) The TTO is aware of all the exploitable technologies at the university (3) The TTO is aware of all the scientific services and devices that can be capitalized by industrial partners
<i>Marketing capabilities</i> : the extent to which a TTO is able to perform marketing tasks related to technology transfer	(1 = fully disagree and 5 = fully agree) (1) TTOs frequently visit international partnering events (2) The TTO has a user-friendly online knowledge map (or patent portfolio) (3) The brochures of the TTO on the university are business conform (4) The homepage of the TTO is business conform
<i>Patent portfolio management</i> : Strict patent portfolio management of the TTO is defined as the TTOs' preference for keeping only those technologies within the portfolio that has significant business potential	(1 = fully disagree and 5 = fully agree) (1) TTOs cancel patents that do not generate any interest from the industry within 3–4 years (2) TTOs patent only those technologies that have significant business potential (3) TTOs patent only those technologies that generate financial income to the university

Table A1.
Measurement
constructs

About the authors

Szabolcs Pronay is an associate professor at the Faculty of Economics and Business Administration at the University of Szeged. He holds a PhD degree on the topic of brand symbolism and brand loyalty and habilitated on the topic of B2B and B2C consumption communities. Szabolcs Pronay is the lecturer of several BA and MA marketing courses (including Consumer behavior, Pricing and Branding). He teaches these courses both in Hungarian and English.

Tamara Keszey is an Associate Professor and Head of the Marketing Management Department at the Corvinus University of Budapest, Hungary. She holds a Ph.D. in management sciences from the Corvinus University of Budapest. Her teaching and research interests cover customer cocreation, innovation and consumer adoption of innovations. Prior to her academic career, she had been working as

a senior IT consultant at KPMG Hungary. Tamara Keszezy is the corresponding author and can be contacted at: tamara.keszezy@uni-corvinus.hu

Norbert Buzás is an Associate Professor and head of the Department of Health Economics at Faculty of Medicine, University of Szeged. He holds a Ph.D. in Chemistry, a Master in Physics, Environmental Management and Business Administration. He was the founding director of the Directorate of Innovation Management and Technology Transfer at the University of Szeged. Dr. Buzás' research interest covers responsible innovation, science-to-business marketing, cocreation and behavioral economics in healthcare. He has about 100 publications, including 20 books and book chapters.

Takayuki Sakai is a Professor in the Graduate School of Science, Technology and Innovation at Kobe University, Japan and an advisor to the Kobe city government venture support consortium. Priorly, he worked a Professor at Tokushima University, president of Techno Network Shikoku (SHIKOKU TLO), the technology transfer office of the Shikoku Region and director of the Kansai Technology Transfer Organization (Kansai TLO) of Kyoto University. He has also served as assistant director of the Enterprise and Commercialization Division of Ritsumeikan University. Dr. Sakai was a visiting scholar at Cornell University's Center for Technology Enterprise and Commercialization.

Dr Kensuke Inai is an Associate Professor and deputy general director of the Center for Research Administration & Collaboration at the Tokushima University, Japan. He holds a Ph.D. in Engineering from the Tokushima University. His research interest covers technology transfer, industry-academia-government collaboration and academic entrepreneurship.