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Learning in university technology transfer offices: transactions-focused and relations-focused approaches to commercialization of academic research

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ABSTRACT

University Technology Transfer Offices (TTOs) need a wide range of abilities to facilitate commercial exploitation of research outputs; however, we know relatively little about how these important abilities are developed and refined over time. We draw on practice-based studies of learning to create a novel conceptualization of learning processes and their outcomes in TTOs and show that this conceptualization of learning provides new empirical insights into how learning in TTOs shapes their commercialization practice. We investigate learning-in-practice in case studies of six UK TTOs and find two approaches to commercialization, namely transactions-focused practice and relations-focused practice. We find that both practices co-exist and co-evolve in some TTOs while other TTOs are predominantly transactions-focused. For the latter the development of a relations-focused approach is difficult, but possible if there is strategic direction and if sources of inertia are removed by TTO directors. Given that evolving practice cannot be fully explained by informal learning processes, we suggest that so far separate streams of practice-based literature on learning and strategizing should be brought together. The implications for further investigations of TTO abilities and some recommendations for policy and practice are discussed.

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1. Introduction

It is widely accepted in science, technology and innovation studies 'that the innovative capacity of a nation depends not only on the strength of individual "players" (firms, universities, government research laboratories) but perhaps more importantly on the links between those actors' (Morlacchi and Martin, 2009, p. 578). Well-functioning links between universities and firms can stimulate economic growth (Mansfield, 1991; for a review see Salter and Martin, 2001) and help to solve societal problems. These benefits may be delivered through the commercialization of technologies resulting from academic research.

Some universities are relatively better than others at transferring technologies into practice (Cardozo et al., 2011; Chapple et al., 2005; Link and Siegel, 2005; Siegel et al., 2008; Thursby and Thursby, 2002). Universities' commercialization performance depends partly on the abilities of their respective Technology Transfer Offices (TTOs) to facilitate exploitation of academic inventions in commercial applications (e.g. Lockett and Wright, 2005; Markman et al., 2005a; Siegel et al., 2004). Different theoretical concepts have been used to

express what TTOs are *able* to do, such as 'capabilities' (e.g. George, 2005; Lockett and Wright, 2005; Markman et al., 2005a; Rasmussen and Jarl, 2010), 'expertise' (Swamidass and Vulasa, 2009), 'experience' (Link and Siegel, 2005; Siegel et al., 2008; Thursby and Thursby, 2002) 'competence' (Alexander and Martin, 2013; Siegel et al., 2007a) and 'practices' (Debackere and Veugelers, 2005a; Resende et al., 2013). These studies reveal a range of abilities that have a positive effect on the university's technology transfer (TT) performance, including the ability to evaluate technological inventions, to secure Intellectual Property Rights (IPRs), to identify commercial partners and to establish new ventures for commercial exploitation of academic inventions. Other studies show that TTOs can constitute barriers to efficient and effective TT, through aggressive IPRs or bureaucracy, for example (Siegel et al., 2003b). Thus, university TTOs can be 'bottlenecks' to or 'facilitators of innovation dissemination' (Litan et al., 2008), and how TTO abilities develop is an important topic that has been under-researched.

Scholars argue that TT managers learn by experimenting and failing (Debackere and Veugelers, 2005b; Zheng et al., 2013), and by sharing knowledge across TTOs (Cardozo et al., 2011). However, our understanding of *how* these learning processes contribute to development of TTO abilities is limited and, to our knowledge, there are no studies systematically investigating how the practices of university TTOs are developed and refined over time. It should

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not be assumed that more experimentation and failure, or more knowledge sharing across TTOs will lead to more effective approaches to commercialization. The link between TTO learning processes and learning outcomes needs to be better understood.

This study draws on practice-based studies of learning to create a novel conceptualization of learning processes and their outcomes in TTOs and addresses two research questions: What do TTOs learn? And, How do they learn? We believe that the practice-based view on learning, which to our knowledge, has not been applied to study university TTOs, could provide new and valuable insights. Drawing on practice-based studies of learning and knowing in other professional services (see [Amin and Roberts, 2008](#) on professional knowing), we theorize about how learning shapes commercialization practices: we identify the learning processes that might result in incremental or radical changes to commercialization practice, and posit that these changes will depend on the existing practices since the existing practice is a medium for learning as well as a source of inertia.

We investigate learning-in-practice in case studies of six UK TTOs and find two approaches to commercialization, namely transactions-focused practice and relations-focused practice. Some TTOs mostly perform and learn to improve on transactions-focused practice. In these TTOs the development of a relations-focused approach through informal situated learning is difficult, but not impossible if there is strategic direction and sources of inertia are removed. Other TTOs perform predominantly relations-focused practice, but adopt transactions-focused practice in relation to technologies that are more market-ready. In these TTOs both approaches to commercialization can co-evolve through informal situated learning. The findings from this study illustrate how path-dependency emerges and is overcome.

This article makes a conceptual and empirical contribution to the literature on university-industry TT. The article introduces a novel conceptualization of how learning occurs in TTOs, and how the learning processes involved shape learning outcomes, and shows that this conceptualization of learning is useful and provides new empirical insights into how learning in TTOs shapes their commercialization practice. The study also contributes conceptually to practice-based theory of organizational knowledge and learning. Specifically, we show that, to understand how practice evolves we need to consider employees' informal situated learning as well as more strategic management practice, and we call for bringing together the so far separate streams of practice-based learning literature and practice-based studies of strategizing ([Jarzabkowski, 2003](#); [Johnson et al., 2003](#); [Pye and Pettigrew, 2006](#); [Whittington et al., 2006](#)). The article concludes with a discussion of some implications of our findings for the development of effective practices and policies.

2. Literature review

This section summarizes current understanding of university TTOs' abilities embedded in practice and learning in TTOs. First, we review previous studies looking at the effect of different TTO abilities on TT performance and discuss what can be inferred from these studies about what TTOs learn (learning outcomes). Second, we review the few studies that shed light on learning processes in TTOs and, we point out that they say little about the learning outcomes. We conclude that there are no studies that investigated systematically the effects of learning in TTOs on commercialization practices.

While acknowledging that the remit of a TTO will likely vary over time, we discuss the abilities required for five key aspects of the TTO role: encouraging disclosure of potentially commercializable inventions, managing the university's Intellectual Property,

identifying licensees and/or investors, securing resources for IP development and exploitation, intermediating among scientists, firms, and university administrators. Commercialization practice is defined here as the set of activities performed by TTO staff in order to fulfil the TTO's role.

Encouraging university faculty to disclose potentially commercializable inventions ([Jensen et al., 2003](#)) has not been studied explicitly although some authors refer to some aspects of it. [Thursby and Thursby \(2002\)](#) argue that the propensity of faculty to disclose their inventions is influenced by the policies and practices of central university administration. To encourage invention disclosure, TTOs need to be able to develop or facilitate the development of effective policies and practices related to royalty sharing ([Baldini, 2010](#); [Friedman and Silberman, 2003](#)), 'self-licensing' ([Panagopoulos and Carayannis, 2013](#)), academic promotion ([Siegel et al., 2007b](#)) and proactive search. The ability to search proactively for commercializable inventions is important because the sooner the TTO can be apprised of a potential commercialization opportunity, the more time it has to assess the invention and develop an exploitation plan. Proactive search by TTOs is sometimes considered to be controversial because it might influence research choices, for example, by shifting efforts from basic to applied research. It is locally negotiated within each TTO what approach to encouraging invention disclosures is acceptable.

TTOs are also considered 'guardian[s] of the university's intellectual property' ([Siegel et al., 2003a](#), p. 31). The ability to manage Intellectual Property (IP) has been described as 'IP capability' ([Degroof and Roberts, 2004](#)), and involves assessment of the IP along several dimensions, and securing of and maintaining IPR protection. The TTO must be able to assess ownership of the invention, which requires information on how the research that spawned the invention was funded, who was involved, and whether there is any background IP. The TTO needs an ability to perform a technological assessment, which 'requires the ability to assess the extent to which research results are stable and/or sufficiently developed to lead to industrial exploitation' ([Ndonzuau et al., 2002](#), p. 284). The TT manager often needs to work closely with the academic inventors and relevant external partners since TTOs are unlikely to have expertise in all areas of the university's research. Finally, the TTO must be able to 'verify the extent to which there might be a viable market' for an academic invention ([Ndonzuau et al., 2002](#), p.284) and to estimate its potential commercial value. This involves assessing the dynamics of the marketplace, for example, whether the company commercializing the invention will have the freedom to operate in the marketplace without infringing any existing patent rights ([Lockett and Wright, 2005](#)). IP valuation also entails estimation of market size, and the value that the invention potentially will add to the firm's existing range of products, services and processes. This can be difficult in the case of a radically new technology for which there is no defined market. The patentability of an invention can be assessed without a thorough commercial assessment; an invention is patentable if it is capable of industrial application. However, since the value of a patent depends on the scope of its claims, it is desirable to understand the commercial value of the technology and the dynamics of the prospective marketplace before drafting the patent claims. Understanding the technology's value is useful also for licensing and spin-out activity. The choice between necessary and optional activities leaves room for interpretations of how competently to manage the protection and assessment of university IP.

The TTO's remit also includes informing companies about inventions and expertise in the academic community in order to identify licensees and investors for university spin-out companies ([Macho-Stadler et al., 2007](#); [Siegel et al., 2003a](#)). Although a few

studies analyse TTOs' marketing abilities, the specific ability to market academic inventions is not well defined. Markman et al.'s (2005a) assumption that more competent TTOs approach fewer companies to identify suitable licensees, is somehow at odds with Powers and McDougall's (2005, p.1030) concern that the fit between technology and licensee may be inferior if TTOs 'rely on rubrics of convenience' and sign licensing agreements with companies that have already expressed an interest in the technology, and/or which are convenient to contact, and/or are preferred by the academic faculty. Also, what constitutes good timing is open to interpretation - when is it too early or too late to contact industry? Early identification of licensees is desirable so that 'the precise terms of a patent can be customized to the commercial interests of the licensee' (Graff et al., 2002, p.99), which increases the chance of closing a licensing deal. The concurrence of marketing and patenting, although desirable for the purposes of identifying a licensee, is not compulsory for patenting.

The TTO's responsibility also includes helping to secure the human and financial resources required to create spin-out companies and provide company formation expertise (O'Shea et al., 2005). This support ranges from help with applications for external funds, to assistance in writing a preliminary business plan, to recruitment of management for the spin-out (Clarysse et al., 2005). Lockett and Wright (2005) show that business development capability is beneficial for spin-out formation. Their operational definition of this capability, however, encompasses a range of abilities which here are discussed individually for clarity.

The TTO is also responsible for mediating between academics, commercial organizations and university administrators, for example, to 'mitigate conflict caused by palpable differences in the[ir] motives, incentives, and organizational cultures' (Siegel et al., 2003a, p.36). The abilities involved have not been thoroughly investigated but TTOs that have a good understanding of the motives of both sides appear to be successful in facilitating successful collaboration between academia and industry (Ankrah et al., 2013). Since TTOs are involved in negotiating licensing contracts (e.g. Thursby et al., 2001) and equity agreements (e.g. O'Shea et al., 2005), they must be able to settle any accompanying conflicts. The TTO represents the university's interests in these negotiations and TT managers interpret what these interests are and how best to serve them. Should TTO managers aim to maximize the financial gains from a licence or to broaden collaboration with the licensee? The former could lead to conflicts over expected royalty rates; the latter could incorporate sponsored collaborative research in the licence deal and lead to subsequent conflicts over research direction and ownership of future IP (Markman et al., 2005b). Again, the approach to mitigating conflicts is up to TT managers. Finally, it should be noted that although the ability to mitigate conflicts is crucial during licence and equity agreement negotiations, it may also be needed in other situations.

The literature referred to above discusses a wide range of TTO activities and abilities that make knowledge transfer more effective and efficient, but says relatively little about how these abilities are developed. Very few studies elucidate the process of learning in university TTOs, and these few tell us little about how learning processes shape TTO abilities embedded in practice. Some scholars refer tangentially to the nature of the learning within organizational boundaries. For instance, Debackere and Veugelers (2005b, p. 339) note that TTOs learn 'how to optimize the various transfer mechanisms and monitoring processes through experimentation'. Similarly, Mowery et al. (2002), after examining changes in commercialization performance, argue that TTOs learn about patenting by doing it. The findings in Zheng et al. (2013) suggest that groups of TT managers who are relatively successful at securing licensing deals learn from failure, which allows them to

improve successive licensing performance. Other studies show that the learning process in TTOs can span organizational boundaries. Cardozo et al. (2011) refer to know-how being shared across TTOs through publications and professional contacts. However, Cardozo and colleagues do not expand on the effect on TTO practices.

In summary, past studies reveal a range of important abilities embedded in TTO practice and the types of social interactions through which learning occurs but not how these learning processes shape TTO practice. Our study contributes to the literature on university-industry TT by elucidating how learning in TTOs shapes their commercialization practice. The next section introduces the theoretical framework that guides our analysis.

3. Conceptual framework: practice-based view of learning

Since most studies of TTO abilities employ the concept of 'capability' or 'competence', we begin this section by justifying our choice of a practice-based view of knowing and learning, specifically situated learning theory, over the dynamic capabilities framework (Teece and Pisano, 1994; Teece et al., 1997). The term 'knowing' is favoured in practice-based literature to the more conventional 'knowledge' or 'ability' (Amin and Roberts, 2008; Blackler, 1995; Gherardi, 2000; Orlikowski, 2002) to highlight that knowing is part of practice (or action) as opposed to knowledge, which is often understood as an 'object' possessed by individuals or groups (Cook and Brown, 1999). Next, drawing on the insights from practice-based studies, we develop a framework for the analysis of how learning shapes organizational practice.

We argue that, in comparison to the capability framework, situated learning theory (Brown and Duguid, 1991, 2001; Lave and Wenger, 1991; Wenger, 1998) has two main advantages which make it more suitable for an analysis of learning processes and their outcomes in university TTOs. Firstly, a practice-based conceptualization of knowledge in organizations is free from normative assumptions. In accepting that changes to capabilities result partly from learning, attention focuses on the positive outcomes of learning - capabilities as a source of competitive advantage, by definition, are positive. Consequently, many studies of TTO capabilities assume implicitly that all TTOs aim to develop the same capabilities for the commercialization of academic research, and that some have made more progress than others. This assumption arguably obstructs our understanding of TTO abilities because it directs the researcher's attention to the abilities TTOs are supposed to have rather than those that actually exist. In contrast to the capability framework, a practice-based view of learning assumes that changes in practice resulting from learning can be beneficial or dysfunctional in relation to organizational goals. Both beneficial and dysfunctional work practices might be considered sufficient or adequate by those performing the work. According to this view the 'knowing' (or abilities) is embedded in practice and can be deduced from observing the 'doing' (Orlikowski, 2002) since 'knowing' and 'doing' are considered inseparable elements of practice (Gherardi, 2000). Our analysis follows this principle.

Secondly, situated learning theory provides an arguably better explanation of the learning process. The capabilities framework is useful for explaining which knowledge assets enhance organizational performance, but sheds less light on how important capabilities are developed. The development of capabilities has been explained in relation to other capabilities - as dynamic capability (Teece and Pisano, 1994; Teece et al., 1997). This explanation is problematic because it ignores the original source of the capability (Collis, 1994). Abell et al. (2008, p. 490) note that the concept of dynamic capabilities is 'useful shorthand for complicated repetitive patterns of individual action and coordinated interaction', and

that explanations of the origins of capabilities could be improved by a focus on the actions of individuals and the interactions among individuals. The practice-based view of learning includes a conceptual framework for the analysis of such actions and interactions and offers helpful theoretical mechanisms to link learning processes to changes in organizational practice. In the remaining part of this section we develop our conceptual framework derived from practice-based studies of learning. We present three arguments about how learning shapes organizational practice.

3.1. Existing practice shapes learning outcomes

The practice-based view of learning conceptualizes evolving practice as the outcome of learning-in-practice (Wenger, 1998). We argue that the existing practice shapes the outcomes of learning for two reasons.

First, the existing practice is the learning medium as learning takes place through participation in social practice (Lave and Wenger, 1991) and consequently what individuals already know and do affects what they learn and what changes they make. Second, the existing practice can be a source of inertia. The existing practice reflects the local 'regime of competence' – the socially-negotiated ways of competent performance of joint work activities – and the local 'world view' – that is, understanding how the work fits within the broader picture (Wenger, 1998). As 'regimes of competence' and practices co-evolve (Wenger, 1998) changes to practice and changes to the regime of competence need to happen concurrently. The existing practice can become a source of inertia as the individuals who enact it might resist changes which they see as undermining their competence and existing ways of working (Mørk et al., 2008, 2010). The practice-based view of knowledge and learning recognizes the situated and socially-negotiated nature of competence (Wenger, 1998) and thus this source of inertia is specific to a given organizational context.

We assume that changes made to commercialization practice are shaped by a TTO's existing practice that is the medium for learning and a source of inertia. What TT managers already know and do will affect what they learn and what changes they make. In Section 2 we have argued that the competent conduct of commercialization tasks is open to interpretation, and the understanding of what constitutes a competent approach may vary across TTOs. Recognizing the socially-negotiated nature of competence, we assume that TTOs develop ways of working that their staff believe are competent, but which in reality may be relatively ineffective in stimulating innovation. TT managers interpret their organizational and institutional contexts, and learn to develop their practice in line with their understanding of what should be done. Their existing 'regimes of competence' and practices co-evolve (Wenger, 1998), however, the development of activities that do not fit with the existing regime of competence may be difficult. TT managers may resist more radical changes which they see as undermining their competence and existing ways of working. However, as competence is locally defined, changes considered to be threatening in some TTOs may be seen as well-fitting with the existing 'regime of competence' and 'world view' in other TTOs. Section 3.2 conceptualizes learning processes that can lead to incremental and more radical changes to commercialization practice.

3.2. Situated learning shapes organizational practice

The practice-based perspective assumes that work practices are reproduced and transformed through situated learning (Wenger, 1998).

Situated learning within organizational boundaries takes place in local CoPs (Brown and Duguid, 1991; Lave and Wenger, 1991;

Wenger, 1998). CoP members learn by *participating in social practice*, that is, through interactions with others in a shared activity, in a particular social and historical context (Lave and Wenger, 1991). Knowledge is socially constructed during these interactions, through the active process of meaning construction and meaning inference (Boland and Tenkasi, 1995). We assume that TTO staff learn in CoPs, that is, through interactions within informal groupings of individuals involved in commercialization practice.

According to the practice-based view, inter-organizational learning can take place through 'networks of practice' (NoPs) (Brown and Duguid, 2001; Tagliaventi and Mattarelli, 2006). Brown and Duguid (2001) coined the term NoPs to describe the network of loosely connected people who engage in the same or very similar practice, but are dispersed geographically. In such networks, knowledge is shared relatively easily because of the overlapping knowledge bases of the individuals involved (Knorr-Cetina, 1999). We assume that TTO staff learn in NoPs, that is, through interactions with TT managers based in other TTOs.

Professional knowing in TTOs is similar to professional knowing in other professional services because specialized declarative knowledge is learned through education and training, and tacit understanding is acquired through interactions with co-workers in specific work settings (Amin and Roberts, 2008). Therefore, we expect that the effects of situated learning on practice in TTOs will be similar to those in other professional services, that is, learning through interactions within the COPs and NOPs will tend to result in incremental changes to practice (Amin and Roberts, 2008; Faulconbridge, 2007). Incremental or minor change is defined here as change to an existing activity that it is believed will help to achieve better the activity's objective (i.e. the object (goal) at which the activity is directed (Leontiev, 1979).

Unlike other professional services, such as education or health-care, the practice of TT managers is not subject to very strong regulatory frameworks or professional standards; although efforts are being made to develop such institutional frameworks (e.g. the Alliance of Technology Transfer Professionals – an international professional accreditation body for TT professionals – was launched in 2010). Thus, there is a possibility that in the absence of these external sources of inertia, situated learning in CoPs and NoPs will lead not only to incremental but also to more radical changes to TTOs' practices.

Previous studies show that in professional services more significant or radical changes tend to result from learning across CoPs (Amin and Roberts, 2008; Nooteboom, 2008; Scarbrough and Swan, 2008). Major or radical change to practice is defined here as the addition of a new activity, or significantly altered performance of an existing activity, which redirects that activity towards a different objective. In the context of TTOs, learning across CoPs could take place in interactions of TT managers with other professionals such as patent attorneys, venture capitalists and academics. Sharing knowledge across CoPs may be less straightforward than learning in CoPs and NoPs because different practices entail different languages (or professional jargon), values, norms and general worldviews (Brown and Duguid, 2001). Nonetheless, interactions across CoPs provide opportunities for cross-fertilization of ideas, discovery of different ways of working (Tagliaventi and Mattarelli, 2006), and expansion of or alterations to the regime of competence.

In summary, we create a novel, practice-based conceptualization of learning processes in TTOs. To our knowledge, this study is the first to adopt a practice-based view on learning and knowledge in university TTOs. Theodorakopoulos et al. (2012), Theodorakopoulou et al. (2014) show that the concept of CoP helps to explain how barriers to university-industry knowledge transfer can be overcome. We believe that this lens will provide new insights on how learning shapes

commercialization practice in TTOs. Drawing on the practice-based literature, we posited that learning outcomes in TTOs will depend on the existing practice as this practice is a medium for learning and a source of inertia. We propose also that incremental improvements that fit well with the existing practice and the regime of competence will result from learning in CoPs and NoPs while more innovative approaches will be developed through learning across CoPs. However, we recognize that learning may well result in more significant change to practice, given that the practice of TTOs is not heavily regulated and standardized.

4. Methods

4.1. Case study selection

Six cases were selected to interrogate our conceptual framework about learning in TTOs, which was derived on the basis of past practice-based studies of professional services. The selected cases are six university TTOs in the UK, one of the countries in Europe with fairly advanced infrastructures to support university-industry TT, which makes it an appropriate empirical context for this study. Our case selection strategy is aimed at identifying contrasting cases (Yin, 2009). We aimed to select cases with incremental changes and cases with more radical changes to practice to allow for theoretical replication – that is, to verify whether different outcomes occur through different learning processes (Yin, 2009). We wanted also to identify several cases of each type to enable literal replication of results, that is, to verify whether the same outcomes occurred through similar learning processes (Yin, 2009). Yin (2009) suggests that case selection should be based on a replication logic, that is, one should think of multiple cases as multiple experiments. This means that a second (and a third, and so on) case-study should either reveal another aspect of the studied phenomenon or corroborate the findings from the first case-studies: “This is far different from a mistaken analogy in the past which incorrectly considered multiple cases to be similar to the multiple respondents in a survey (or to the multiple subjects within an experiment) – that is to follow a “sampling” design.” (Yin, 2009).

Since there is no publicly available information on changes to TTOs' practice, we use changes to commercialization performance as an imperfect approximation for changes to TTO practice, to guide the selection of cases. Information on commercialization performance was collected from the Higher Education – Business and Community Interaction surveys published by the UK Higher Education Funding Council for England (until 2009) and the Higher Education Statistics Agency (from 2010). Based on the assumption that different patterns of changes in commercialization performance are related to different changes in commercialization practice, we looked at two measures of performance: number of inventions disclosed by academics to the TTO, and the number of licence contracts arranged by the TTO. Since the number of internal invention disclosures is strongly correlated with the number of patent applications, it can be assumed that changes in the number of disclosed inventions will be related to significant changes to identification of commercializable inventions and management of IP. Changes in the number of completed licensing deals are believed to be associated with significant changes to marketing of academic inventions, identifying licensees and negotiating licence contracts with established and start-up companies. We selected cases with high performance improvements in both areas (cases A and B – assumed to have some radical changes to practice), cases with low performance improvements in both areas (cases E and F – assumed to have predominantly incremental changes to practice) and cases with low performance

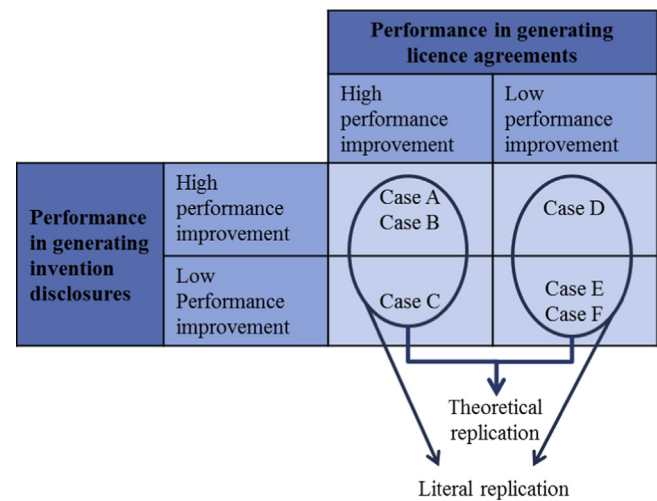


Fig. 1. Case study selection.

improvement in one area of practice, but high in another (cases C and D – assumed to have a mix of incremental and more radical changes).

Although change in commercialization performance is a very rough proxy for changes in commercialization practice, the above case selection strategy proved quite effective since we identified contrasting cases: cases with predominantly incremental changes to practice (E, F, D) and cases with incremental as well as more radical changes to commercialization practice (cases A, B, C). The selected cases are also characterized by different existing practices. The group of selected cases is therefore argued to provide sufficient empirical material for interrogating our conceptual framework shedding light on the learning processes shaping TTO practices. Fig. 1 depicts the replication logic used in the following analysis.

4.2. Data collection and analysis

The analysis is based on data collected from semi-structured interviews with staff in the selected TTOs and information from relevant documents (e.g. TTO's website, internal practice guidelines, policies and strategy documents). Operational definitions of the key concepts (practice, change in practice, learning in and across CoPs, learning in NoPs) were created, and interview questions designed to address each concept (see Weckowska, 2013). Different interview protocols were prepared to guide the conversations with TTO directors and TTO staff. Following three pilot interviews the protocols were adjusted to ensure clarity and manage time constraints.

A total of 34 one-to-one interviews were conducted: 32 face-to-face at the respective TTOs and two by telephone, between December 2010 and May 2011. Interviews lasted around 1.5 h, and were digitally recorded and transcribed. The interviews focused on current work practices, learning and changes to practice that had occurred since 2005.

Data analysis followed the ‘explanation building’ technique (Yin, 2009) and was completed with the help of NVivo, a computer-assisted tool for qualitative data analysis, which was used to code the textual data and to make connections between the explanands (learning processes) and the explanandum (learning outcomes). We first analysed whether the respondents learnt through situated learning in CoPs, NOPs or across COPs, using a deductive coding scheme. Groups in the selected TTOs that were

Table 1
The characteristics of transactions-focused and relations-focused commercialization practices.

Transactions-focused commercialization practice		Five aspects of a TTO's role	Relations-focused commercialization practice	
Knowing aspect of practice	Doing aspect of practice		Doing aspect of practice	Knowing aspect of practice
Knowing how to recognize commercializable research outputs	Waiting to be informed by academics; raising awareness among academics of support for research commercialization	1. Inducing disclosure of potentially commercializable inventions	TTO staff develops close relations with academics to keep on top of progress in academic research and identify early opportunities for commercialization	Knowing how to identify research with the potential to yield commercializable outputs
Knowing how to assess appropriability of potential revenues	Focus on assessing patentability; assessment of IP ownership; technological assessment; desk-based market research to speculate about potential applications and financial returns	2. Managing the university's Intellectual Property	Focus on assessing the commercial viability of inventions; assessment of IP ownership; technological assessment; assessment of patentability; assessment of IP value; early desk-based market research to identify the players in the relevant industry and market dynamics+early interactions with companies that launched products based on similar technologies in order to estimate the value that the university's technology can add to a product and understand the market dynamics	Knowing how to assess appropriability and commercial viability of academic inventions
Knowing how to help secure financial resources for IP development	Help with identify funding for further development of inventions; mentoring academics during commercialization process, helping academics to become entrepreneurs	3. Securing resources for IP development and exploitation	Help with identifying funding for further development of inventions (e.g. proof-of-concept work, seed funding); mentoring academics during commercialization process, identifying surrogate entrepreneurs to run spin-outs;	Knowing how to help secure financial and human resources for IP development and exploitation
Knowing how to identify 'buyers' for university's IP	Online and off-line distribution of marketing materials; reliance on contacts of academics whenever possible; 'first come, first served' approach; prevailing one-way communication	4. Identifying licensees and/or investors	Online and off-line distribution of marketing materials; identification of potential licensees through the use of an academic's contacts and by means of extensive market research; talks with a number of potential licensees; prevailing two-way communication	Knowing how to identify partners for the academics
Knowing how to make one-off transactions with commercial organizations	Focus on maximizing financial gains from IP exploitation; protecting interests of the University; retaining IP ownership whenever possible	5. Intermediating among scientists, firms, and university administrators	Focus on maximizing opportunities for research collaborations; licensing as 'hooks for research contracts'; securing a win-win deal while protecting interests of the University; On-going management of the relation with a licensee or a university-owned spin-out	Knowing how to build partnerships between a university and commercial organizations

Note: Smaller TTOs do not perform all activities typical for their dominant practice.

characterized by 'mutual engagement' in joint practice, 'negotiation of the joint practice' and 'shared repertoire of practice' (Wenger, 1998) were identified as COPS. These theoretical concepts were used as codes. Next we examined whether respondents or their colleagues learnt from TT managers based in other TTOs and from other professionals, using the respective codes 'interactions within NOP' and 'interactions across COPS'. Following this, learning outcomes, that is, changes to commercialization practice, were examined for each TTO. We developed a more inductive coding scheme to identify *what* work activities were performed in a TTO (codes are presented in Table 1, column 3), *how* each activity was performed (Table 1 columns 2 and 4) and the *changes to what and how* activities were performed. NVivo was used to retrieve the codes characterizing practice in each TTO, and cross-case comparison identified relations-focused and transaction-focused approaches to commercialization practice. We next identified the learning processes that shaped the changes to practice. NVivo was used to identify textual data that was coded as situated learning in COPS, NOPs or across COPS and simultaneously as change to practice. Each change was investigated in detail and descriptions of how changes to practice emerged were prepared (see Weckowska, 2013). The last step was comparison of learning processes across cases. In accordance with Yin's (2009) recommendations, each case was treated as a separate study, and cross-case comparison was aimed at theoretical and literal replication of the findings. The findings from the six case studies are discussed in Sections 5 and 6. The scope of this article does not allow to present

a case by case analysis of changes to practice in each TTO (available in Weckowska, 2013). Instead we offer the macro-level insights into how learning shapes commercialization practice gained from all six cases.

5. Existing practice: two approaches to commercialization

The analysis of work practices in the six TTOs reveals two approaches to the commercialization of research outputs: transactions-focused and relations-focused. We find that all six TTOs are capable of performing commercialization activities in a transaction-focused manner. This approach dominates in TTO D, E and F and is occasionally performed in TTOs A, B, C. The relations-focused practice was observed only in TTOs A, B and C. Table 1 summarizes the characteristics of transactions-focused and relations-focused commercialization practices.

In what follows we argue that these two approaches to research commercialization are related to different 'regimes of competence', that is, to differences in the understanding of what constitutes a competent action, and to different 'world views' – specifically, perspectives on the innovation process. As argued in Section 3.1, existing TTO practice and co-existing regimes of competence and 'world views' can shape learning outcomes because existing practice constitutes both the learning medium and a source of inertia.

5.1. Relations-focused commercialization practice

Relations-focused commercialization practice is focused on building relations among academics, commercial organizations and university TT managers. The practice is underpinned by a belief that competent pursuit of commercialization entails building and managing complex relations between stakeholders during all commercialization activities. As one TT manager put it: 'IP is a foundation stone of a business but it is not enough' ... 'our biggest push is to maintain a good professional relationship and respect one another' [2]. Through their relations with academics, TTOs are aware of on-going research that may spawn commercializable outputs. Therefore, they can 'identify areas of research that might be exploitable before you get to the point that the academic says – I am off to a conference, I need to take my intellectual property, file me a patent' [7]. Potential licensees and investors are approached at an early stage, and it is the opportunity to work with scientists on new technologies rather than the technology itself, that is highlighted in marketing. The relations with academics and potential licensees inform the TTO's patenting decisions. For example, information gathered during interactions with potential licensees is used to 'steer patent claims, etcetera. in terms of what is the real value, what people want'[3]. This shows that these TTOs are aware that commodities do not come ready-made, but rather are 'decontextualized, dissociated and detached' (Callon, 1998, p.19) and, therefore, it is the actors involved in these processes that shape the nature of the commodity and its value. The IP licences or assignments are seen as potential 'hooks for collaborative research'[2], that is, a starting point for long-term complex relations between academics and commercial organizations, with the purpose of co-creating new knowledge. They want to 'use ... intellectual assets in the broader sense to drive collaborative relationships with downstream partners who may then exploit that intellectual property'[7] and highlight that 'it isn't about pounding the other side into submission in negotiation' [2]. IP protection, assessment of an invention's commercial potential, and identification of licensees are fairly concurrent. The knowing in practice (or abilities) comprising the regime of competence associated with the relations-focused practice is presented in Table 1. Relations-focused commercialization practice seems to be underpinned by implicit assumptions that the innovation process is not linear, but interactive, that scientific discovery must match industry needs and capabilities, and that two-way communication between academia and industry and the collaboration of market and research and development experts are crucial. The same assumptions underpin the interactive or 'coupling' model of innovation described by Rothwell (1994). We observed that the relations-focused approach to commercialization was dominant in TTO A while TTOs B and C were learning to adopt it as their dominant approach. Nevertheless, on occasion, TT managers in all these TTOs performed transactions-focused practice, for example, when dealing with exploitation of IP embedded in more 'market-ready' products, such as software package or audio CDs.

5.2. Transactions-focused commercialization practice

Transactions-focused commercialization practice is characterized by treating the outputs of scientific research as tradeable products, and is focused on completing IP transactions, such as sales and licences. It is based on the belief shared by members of CoPs, that the competent pursuit of commercialization research entails commodification of scientific knowledge and successful sales and licences of IP. TT managers pursuing this practice highlighted the importance of skills for 'selling an idea to an external party'[21]. Once an academic discloses a commercializable research output, the TTO 'productizes' it by securing IPRs. The

product (e.g. patented technology) is then marketed to potential licensees and/or investors. One TTO manager explained that: 'when we have sufficient data I will then start to sell and promote the patent. When I have actually got the agreement from someone that they will buy the patent [X and Y] will help me put together the necessary agreements' [30]. Commercial organizations are perceived as 'buyers' and are not approached until the product is believed to be 'ready' because it is thought that the TTO must 'fully understand the economics of the new product and the scalability of it'[25] in order to be 'able to give them [potential licensees] a fuller picture so they have fewer questions to ask and fewer reasons to say no' [25]. The IP licence or assignment is seen as an end in itself. Clearly, the approach is linear – the specific commercialization activities (patenting, marketing, deal negotiations) are performed sequentially. There seems to be an implicit assumption that the outputs from one stage can be transferred to the next stage – from academic, to the TTO, to industry. In other words, the innovation process is assumed to be linear and scientific discovery in the university is assumed to be succeeded by technological development in companies with no need for feedback loops or complex long-term relations. This assumption underpins the early technology-push or science-push innovation model (Godin, 2006). Thus, transactions-focused commercialization practice is grounded in a linear understanding of innovation process. The knowing in practice (or abilities) comprising the regime of competence associated with the transactions-focused practice is presented in Table 1. As already mentioned, this approach to commercialization is performed occasionally by TTOs A, B and C to exploit IP embedded in more 'market-ready' products. However, in the other three cases, TTOs D, E and F, this approach dominates and is performed irrespective of the nature of the IP. In these TTOs, transactions-focused practice is the only medium for learning-in-practice and, thus, development of abilities to establish and manage relations with commercial organizations or identify commercial needs may be difficult. TT managers that adopt a transactions-focused approach need to acknowledge the insufficiency of their approach and to invest in developing different ways of identifying commercialization opportunities, managing IP and dealing with commercial organizations and academics. As the existing practice is a learning medium and a source of inertia we paid attention to it while analysing how learning processes shape commercialization practice. The results of this analysis are presented in the next section.

6. Learning processes shaping a TTO's commercialization practices

This section illustrates the social interactions through which TT managers learn to change existing practice(s). Following the replication logic discussed in Section 4.1 we verify whether different learning outcomes occur through different learning processes. Cases with similar learning outcomes are discussed together in Sections 6.1 and 6.2.

6.1. Cases with predominantly incremental changes to practice

In our case study analysis we have observed that TTOs D, E and F predominantly learnt to make minor changes to commercialization practice. It is worth noting that another common characteristic of these TTOs is a dominance of transactions-focused practice (see Section 5.2). Most changes observed in these TTOs fit well with the existing transactions-focused practice and entail performing it more efficiently, more systematically or more rigorously and, in one case, adding a new activity to the existing practice (see Table 2). These predominantly incremental improvements to

Table 2
Examples of learning in TTOs D, E, and F.

Minor changes	Major changes	
Changed performance of an existing activity to better achieve its objective	Performing a new activity as part of practice	Changed performance of an existing activity to achieve a different objective
<p>Learning in a CoP:</p> <ul style="list-style-type: none"> – How to identify more commercializable research outputs: periodic surveys (TTO F)^T and calls for invention disclosures (TTO E)^T – How to assess more systematically the patentability of academic inventions and inventors' motivations (TTO D)^T – How to protect university's interest in contract negotiations: introducing a template licence and shareholder agreements specifying non-negotiable terms related to warranties, liabilities, indemnities and publication rights (TTO E)^T – How to help academics to become entrepreneurs: mock board meetings (TTO E)^T – How to keep records of formal contracts with external parties (TTO D)^T – How to keep records of generated income (TTO D and TTO E)^T 	<p>Learning in a CoP:</p> <ul style="list-style-type: none"> – How to assess the patentability of academic inventions and inventors' motivations (TTO E previously outsourced the IP assessment)^T 	<p>Learning in a CoP: None</p>
<p>Learning in NoPs:</p> <ul style="list-style-type: none"> – How to identify more commercializable research outputs: drop-in sessions (TTO E)^T and analysing RAE scores (TTO F)^T – How to standardize estimations of invention's technical strengths, market size and the inventors' motivations based on desk-based online research: introducing COAP questionnaire (TTO F)^T – How to document IPR-related and financial aspects of commercialization projects in a systematic manner (TTO D)^T 	<p>Learning in NoPs: none</p>	<p>Learning in NoPs: none</p>
<p>Learning across CoPs: None</p>	<p>Learning across CoPs: None</p>	<p>Learning in across CoPs:</p> <ul style="list-style-type: none"> – How to recruit surrogate entrepreneurs instead of mentors for academics: an attempt to create 'virtual club' of surrogate entrepreneurs (TTO F)^R

^TApproach typical of transactions-focused practice.

^RApproach typical of relations-focused practice.

practice are informed by learning in CoPs in each of the TTOs and learning from NoPs, that is, from other TTOs, through participation in professional associations and informal networks.

Among the three TTOs with dominant transactions-focused practice, we observed only one attempt to develop a more relations-focused approach to exploiting IP. A newly hired spinout manager in TTO F had developed ideas for a different approach to identifying commercial management for spin-outs through interactions with non-academic entrepreneurs and venture capitalists. He wanted to develop a virtual 'club' of commercial entrepreneurs who might be interested in leading university spin-outs and could be contacted when opportunities arose. He commented that:

there are some great people out there who can help companies but when you try to bring them in to mentor academics it does not work that well because at the end of the day the academics have got full time job and I think that we need to change it that there is identified commercial lead that is really motivated and rewarded if they are interested in taking the project forward. ... I am sure there are better ways of describing it but it is a bit like a cooperation or partnership rather than strictly business and we need to keep testing what is acceptable and what is possible. It might be that I will be pushed back.[31]

The spin-out manager clearly realized that his ideas conflicted with the TTOs existing 'regime of competence' and he notes that implementation of these ideas would require a 'culture shift'[31]

not only in relation to company formation activities, but also in evaluation of IP and identification of licensees and investors. His ideas did not fit well with the existing regime of competence as they undermined the validity and sufficiency of the established ways of commercializing academic research in this TTO. They also received little attention and backing from other TT managers. As a newcomer, the spin-out manager had little power to implement his ideas and he had not been invited by the incumbent COP members to participate in assessing IP and developing IP exploitation plans. His efforts after a year had had little impact on the practice in TTO F.

These findings are consistent with observations of situated learning in the professional services sector where learning in CoPs and NOPs is associated mainly with incremental changes (Amin and Roberts, 2008; Faulconbridge, 2007). As in other professional services, learning across COPs has the potential to result in more radical changes to TTO's practices (Amin and Roberts, 2008; Mørk et al., 2010). However, in this case the incumbent COP members who invested in developing existing practices were a source of inertia and prevented the ideas from being implemented in practice.

6.2. Cases with incremental as well as more radical changes to commercialization practice

We have observed a mix of incremental and more radical changes in TTOs A, B and C. At the time of interviews TTO C and

Table 3
Examples of learning in TTO C and D.

Minor changes	Major changes	
Changed performance of an existing activity to better achieve its objective	Performing a new activity as part of practice	Changed performance of an existing activity to achieve a different objective
Learning in a CoP: – How to protect university's interest in contract negotiations: Introducing a template licence agreement specifying non-negotiable terms related to warranties, liabilities, indemnities and publication rights (TTO C) ^T	Learning in a CoP: – How to manage a relation with the licensee after signing a deal: Introduction of 'Partnering to Achieve More' software (TTO C) ^R	Learning in a CoP: – How to assess systematically and rigorously commercial viability of inventions rather than merely an appropriability: engaging early with potential customers (TTO B and C) ^R – How to identify a partner for development and exploitation of a technology: concurrent negotiations with multiple companies (TTO B, C) ^R – How to build good relations with commercial companies: handling IP issues in industry-sponsored research contracts in a business-friendly way (TTO C) ^R – How to build good relations with commercial companies: balancing competing interests and negotiating win-win licensing deals (TTO B) ^R
Learning in NoPs: None Learning across CoPs: – How to identify funding for follow-on development of academic inventions: contributions to creating an online portal listing up-to-date funding opportunities (TTO B) ^{T+R}	Learning in NoPs: None Learning across CoPs: None	Learning in NoPs: None Learning in across COPs: None

^TApproach typical of transactions-focused practice.

^RApproach typical of relations-focused practice.

Table 4
Examples of learning in TTO A.

Minor changes	Major changes	
Changed performance of an existing activity to better achieve its objective	Performing a new activity as part of practice	Changed performance of an existing activity to achieve a different objective
Learning in a CoP: – How to assess the technical and commercial aspects of inventions in a systematic and rigorous way: introduction of customized questionnaires ^R – How to manage relations with other universities: creating templates for external revenue sharing agreements in inter-institutional situation of jointly owned IP ^R	Learning in a CoP: – How to protect and exploit intellectual assets other than patents e.g. know-how, biological materials, copyrights ^T – How to demonstrate the commercial value of inventions in marketing flyers ^R	Learning in a CoP: None
Learning in NoPs: – How to market inventions online jointly with other TTOs: creation of online portal ^R	Learning in NoPs: – How to audit licensees to ensure that the received royalties are correct ^T – How to manage a relation with the spin-out: managing equity in spin-outs and setting up a fund for follow-on investments in spin-out ^R	Learning in NoPs: None
Learning across CoPs: – Revising licensing contract templates to keep them up to date with commercial law ^T	Learning across CoPs: None	Learning in across COPs: – How to build good relations with commercial companies: securing a win-win deal by protecting the university's interest without including causes in contracts that can limit spin out's growth ^R

^T Approach typical of transactions-focused practice.

^R Approach typical of relations-focused practice.

D were learning to complement their transactions-focused practice with a more relations-focused approach. TTO A had already well-established co-existing relations-focused and transactions-focused practices.

Developing a relations-focused approach in TTOs B and C where a transaction-focused approach previously prevailed entails significantly altered performance of some existing activities (see Table 3). For example, changing the approach to assessing the commercial viability of academic inventions by moving away from

a practice where TT managers 'take this technological IP from the academic, understand it, patent it and then ... try to market it and engage the commercial community more independently'[17], towards an approach where 'commercial vision, a business case' are developed before 'putting significant amount of time and money into patenting and protecting the technology'[17] by 'starting that dialogue very early'[17] with potential customers to assess inventions' commercial viability. Developing relations-focused practice involves learning new approaches to identifying

partners, and negotiating and managing partnerships. TT managers captured the nature of these changes while explaining what was learnt in their TTOs: 'you shouldn't just sell it [IP] for whatever you can sell it for. You should find a real partnership. There should be a real partnership with the licensee, not just "Whoever! Catch!", which is how it always used to be'[8] and 'Rather than just give them the licence and wait for the royalties to come in, we stay very closely involved in the development [of an invention]'[17].

TTOs B and C illustrate that learning to radically alter the performance of some existing activities can take place within internal COPs. The observed changes were not informed by interactions across CoPs or within NoPs. This was an unexpected observation since previous studies show that more innovative changes to practice in professional services typically are attributed to informal learning across COPs (Amin and Roberts, 2008). It is important to highlight that learning in COPs underpinning the development of relations-focused practice is not bottom-up. The development of a relations-focused approach in TTOs where a transaction-focused approach had prevailed requires significant changes to the 'regime of competence' and to the understanding of the innovation process. It requires TT managers to alter their understanding of competent action. It is inevitable that incumbent CoP members will not voluntarily abandon their prevailing views and beliefs. TTO directors played a very important role in stimulating and shaping the learning that had led to developing the new, relations-focused approach. They set the strategic direction for the changes and employed various tactics to remove the forces of inertia, including firing most members of an existing CoP, firing the members most resistant to changes, removing procedures that reinforced the old way of working and re-negotiating the work practices considered acceptable.

Interestingly, while the new approach was learnt, the CoP members in TTOs C and B continued evolving the transactions-focused practice. They learnt, through interactions within COPs and also across CoPs, to make improvements to activities typical of transactions-focused practice. Moreover, once TT managers in TTO C learnt to perform some activities in a relations-focused manner they improved their relations-focused practice with the addition of the new activity of post-deal management of the relation with the licensee. These cases show that informal situated learning plays an important role in continuous improvements to old ways of working and evolution of newly developed ways of working.

TTO A with well-established co-existing relations-focused and transactions-focused practices displayed very dynamic informal learning processes (see Table 4). Most observed practice changes related to improving relations-focused practice because this approach dominated since the TTO deals mainly with very early stage technologies for which a transactions-focused approach is deemed inappropriate. TT managers learnt to make changes to their commercialization practice consistent with their existing 'regime of competence' and with their understanding of the innovation process, however, (unlike in TTOs with only transactions-focused practice) this means that both approaches to commercialization evolve. TT managers learn, through interactions in CoPs, NoPs and across COPs, to develop both types of practice.

The close relations between TT managers and academics, patent agents, entrepreneurs and venture capitalists, enable learning about others' points of view and inspire TT managers to make changes to their approaches to IP commercialization. Unlike in TTO F, sparked by interactions across COPs the ideas for making existing activities more relations-focused were implemented in practice. This was possible because both transactions-focused and relations-focused approaches were accepted as competent ways of commercializing the outputs of academic research in specific

circumstances, and the sources of inertia present, for example, in TTO F were not present in this TTO.

7. Discussion

This study creates a novel, practice-based conceptualization of learning processes in TTOs and produces new insights into how learning shapes commercialization practice in TTOs.

The conceptual framework directed our attention to existing TTO practices because this existing practice is a learning medium and a source of inertia. Our examination of TTO practices contributes new empirical insights to the literature. Specifically, we reveal that TTOs take transactions-focused and relations-focused approaches to commercialization practice. We found TTOs where these approaches co-exist - where TT managers follow a relations-focused approach to commercializing early stage technologies and a transaction-focused approach to more 'market ready' inventions, and learn to co-evolve both approaches. However, we also found TTOs that were only transaction-focused and evolved their practice through learning; for these TTOs it is difficult to develop relations-focused practice through informal learning. While recent studies have paid attention to heterogeneity of approaches across different public TT organizations (Landry et al., 2013), our findings reveal differences in practices among university TTOs, which deserves further investigation. Moreover, the presence of different approaches to commercialization challenges the assumptions in the literature that IP commercialization, by default, entails low levels of relational involvement (Alexander and Martin, 2013; Perkmann and Walsh, 2007). The strong focus on the transactional aspects of research commercialization may be overstated in the literature and perhaps perpetuated unnecessarily in practice. IP transactions are often an element of more complex relations among firms pursuing open innovation and there is no reason to suppose that this would not apply also to relations between universities and firms.

The novel conceptualization of learning in TTOs allows us also to produce new insights into how learning processes in TTOs shape their commercialization practices. The very few studies elucidating the process of learning in university TTOs suggest TTOs learn internally 'through experimentation' (Debackere and Veugelers, 2005b) or 'by doing' (Mowery et al., 2002), and externally through interactions with other TTOs (Cardozo et al., 2011). Our findings provide support for these suggestions, and add to the literature on learning in TTOs by revealing the effects of these intra- and inter-organizational learning processes on TTO practice. We find that informal interactions in COPs and NOPs mainly help to evolve existing activities and inform the development of new activities that fit with the existing practice and regime of competence (supported by all the cases). Changing the approach to an existing activity in order to achieve a different objective (e.g. changing the marketing approach to identify a partner rather than a buyer) is quite difficult. We find that interactions across COPs, namely with commercial organizations, can spark ideas for changing the approach to an existing activity and making the practice more business friendly. However, applying these ideas in TTOs with dominant transactions-focused practice can be problematic if the new approach does not fit with the existing regime of competence; thus, some COP members resist change and persist in existing ways of working (e.g. TTO F). Such ideas might be implemented in TTOs with dominant relations-focused practice because they fit with the existing regime of competence (e.g. case A). This makes development of relations-focused activities in TTOs with predominantly transactions-focused practice rather problematic, but not impossible. We found that learning to implement a fairly radical change

to the performance of an existing activity can occur in internal COPs if there is good strategic direction, and if some sources of inertia are removed by TTO senior management (e.g. cases B and C). These findings provide new insights into how learning processes shape learning outcomes, and constitute an empirical contribution to the literature on university TTOs.

In turn, these new insights reveal why and when the transition to an 'entrepreneurial university' (Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2000) might be difficult. Etzkowitz (2003) argues that a 'traditional university', operating under a purely linear model of innovation, evolves first into a 'transitional entrepreneurial university', based on the assisted linear model, and subsequently into a 'fully-fledged entrepreneurial university', in line with the interactive model of innovation that includes a two-way flow between the research and the economic and social spheres. Although the first transition step is relatively easily accomplished by setting up a university TTO, implementation of the second transition step arguably requires relations-focused commercialization practice, which, if transactions-focused practice dominates, is difficult to develop without strategic input from the TTO directors. Although serious concerns have been raised over a top-down push towards the entrepreneurial university (Philpott et al., 2011), we find that a top-down approach that enables and guides situated learning may be necessary to develop relations-focused practices in TTOs that previously focused on IP transactions.

Our study contributes also to the practice-based literature. Our findings are consistent with Amin and Roberts's (2008) observation that professional communities are capable of radical change, but more likely to pursue incremental change. Most observed changes to practice informed by situated learning are incremental, and fit well with the existing 'regime of competence'. Previous practice-based studies highlight the importance of interactions across COPs for innovative changes to practice in professional services sectors. While our findings corroborate this, we find also that more radical changes can result from learning in COPs when strategic direction is provided and the sources of inertia are strategically removed. This might be possible because TTO practice is less heavily regulated and less standardized than health care or education services for example, and thus is more malleable. The insights from our research show that, in some cases, evolving practice cannot be fully explained by informal learning processes, and that formal strategic actions within the organization must be taken into account to explain how changes to practice unfold. In practice-based studies, situated learning (Amin and Roberts, 2008; Koliba and Gajda, 2009; Ranmuthugala et al., 2011) and strategizing (Jarzabkowski, 2003; Johnson et al., 2003; Pye and Pettigrew, 2006; Seidl and Whittington, 2014; Whittington et al., 2006) tend to be treated separately. Our research suggests that combining these literature streams would provide a more complete explanation of how changes to practice come about. Recent practice-based studies examining evolving practices show a growing interest in the role of institutional context (Hotho et al., 2014; Gherardi and Perrotta, 2011). While we recognize it as a fruitful research avenue we also call for studies of the wider organizational context in which knowing, learning and practice take place.

8. Conclusions

This article makes a conceptual and empirical contribution to the literature on university-industry TT. The article introduces a novel conceptualization of how learning occurs in TTOs, and how the learning processes involved shape learning outcomes, by drawing on practice-based approaches. The practice-based tradition is well rooted in organization studies (Brown and Duguid, 1991, 2001), but very few studies so far have employed this theoretical approach

to examine university-industry TT (Theodorakopoulos et al., 2012; Theodorakopoulou et al., 2014). So far, much of the theorizing around TTO abilities builds on a capabilities-based understanding (e.g. Lockett and Wright, 2005), which is useful, but lacks the theoretical apparatus required to differentiate among the different learning processes and the mechanisms linking learning processes to changes in organizational practice. These mechanisms have received scant attention in the TTO literature, which tends to focus on the effects of TTO practices on TT performance (Lockett and Wright, 2005; Markman et al., 2005a). Our study shows that a practice-based conceptualization of learning in university TTOs is useful and provides new empirical insights into how learning processes in TTOs shape their commercialization practice.

This study contributes also to practice-based theory. Specifically, we show that evolving practices cannot be fully explained by informal learning processes. In order to understand how practice evolves, informal learning has to be examined alongside strategic management practices. We call for a conceptualization of organizational change that builds on practice-based studies of learning and practice-based studies of strategizing, which, in the past, have tended to develop along separate paths. Such a framework would help to advance our understanding of the processes through which organizational practices evolve.

The insights from our study allow us to make suggestions for further research. First, the empirical findings could be used to inform future quantitative studies that examine the determinants of university TT performance. The present study does not examine the relation between learning outcomes and TT performance. However, it should be noted that TTOs where relations-focused practice dominates, but coexists with transactions-focused practice, exhibit higher growth in number of licensing deals between 2002/03 and 2008/09 than TTOs with dominant transactions-focused commercialization practices (see Section 4.1). Our research is based on only six cases and is not focused on the consequences of a transactions-focused approach on commercialization performance; however, there are several potentially worrying consequences of our findings. For example, the lack of effort to understand the value of inventions associated with transactions-focused practice may have negative impacts in the form of over- or underestimation of an invention's value. Also, the focus on one-off transactions rather than long term relations could lead to missed opportunities for collaborative projects that might generate new commercially-useful knowledge. This suggests that more flexible TTOs able to apply the most suitable approach to commercialization may display superior performance in the exploitation of academic inventions through licensing, compared to TTOs with dominant transactions-focused commercialization practice. Future work could examine whether prevalence of transactions-focused commercialization practice in a university TTO hinders science-based innovation.

Second, our findings suggest that, in order to avoid type-one errors, researchers examining the determinants of university TT performance need to investigate more than one (cap)ability at a time. We show that the abilities related to a particular type of commercialization practice typically co-occur, and constitute a coherent set. Thus, studies focusing mostly on single (cap)abilities (e.g. Lockett and Wright, 2005; Markman et al., 2005a) may overestimate its importance for TT performance. Third, the conceptual approach used in this study has the potential to shed light on some under-researched aspects of university-industry relations. For example, the concept of NoPs might be useful to study how good and bad commercialization practices spread over time and space. Know-how related to technology transfer may flow through existing networks, such as university groupings (e.g. Russell Group), or through new regional networks that emerge based on the physical proximity of some TTOs. The prominence of

different networks and their impacts on local practices are not well understood. Future work could apply the concept of CoP to examine relations between academics, university administrators, TT managers and firm managers. In particular, investigating how cognitive and normative barriers between different stakeholders are overcome might be a fruitful avenue for research.

Finally, our findings have some implications for policy and practice. Given the importance of social learning, university and TTO management should create environments conducive to the emergence of CoPs and NoPs. This includes provision of space and time for social interactions (e.g. by co-locating staff involved in commercialization), ensuring continuity of relations (e.g. by reducing staff turn-over), allowing staff to make decisions about work practices on the basis of their learning, and encouraging them to develop and maintain networks of contacts with their peers in other TTOs. University and TTO management should try to strike a balance between providing autonomy and space for informal learning, and directing the development of practice. Strategic direction is particularly important for the development of relations-focused approaches in TTOs where transactions-focused commercialization practice prevails.

Although locally defined 'regimes of competence' are unavoidable in an emerging profession, much can be done to improve the understanding of competent pursuit of commercialization activities across TTOs. For example, in order to improve uniformity of practice across TTOs the Alliance of Technology Transfer Professionals could focus on elucidating the interactive nature of the innovation process and the role of universities in national and regional innovation systems as opposed to teaching only the 'what' and 'how' of the everyday work activities of TT managers. In addition, governments could provide funding for programmes to support knowledge sharing across university TTOs. An example here, is the Beacon Scheme for local government in the UK, introduced in 1999, to identify good practice and innovative services in local government and support peer-to-peer learning among local councils.

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Annex. List of interviewees

Position of an interviewee	Code
Case study A	
Director of TTO A	1
Head of licensing and company formation division	2
Licensing manager	3
Business development manager 1	4
Business development manager 2	5
Marketing manager	6
Case study B	
Director of a TTO B	7
Licensing manager	8
IP manager 1	9
IP manager 2	10
Former business development manager	11

Case study C	
Director of a TTO C	12
IP manager	13
Contract manager	14
Business development manager	15
Research enterprise coordinator	16
Innovation advisor	17
Case study D	
Director of a TTO D	18
IP manager	19
Contract manager	20
Business development manager 1	21
Business development manager 2	22
Case study E	
Director of a TTO E	23
Senior administrator	24
Senior business development manager	25
Business development manager 1	26
Business development manager 2	27
Academic	28
Case study F	
Senior manager on behalf of a TTO director	29
Licensing manager	30
Spin-out manager	31
Business development manager 1	32
Business development manager 2	33
Marketing manager	34

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