How to commercialise university-generated knowledge internationally? A comparative analysis of contingent institutional conditions

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Abstract
Our paper sets out to explore the contingent institutional conditions that underpin knowledge transfer, and particularly commercialisation, from universities to enterprises across national borders. We explore the phenomenon in four technology-focused and research leading (in the national context) universities in Estonia, India, Portugal and the UK. We argue that participants in interactions (despite the fact that they maintain their core operations in different institutional fields) possess common knowledge bases, and shared norms and cognitive frameworks. In many cases however, the emergence of organisational rules to facilitate interactions do not lead to the institutionalisation of the processes at work: restricting the scope of both existing interactions and their advancement and offering a central role to nonpracticing entities. The paper advances university-led pooling of intellectual property (geographically or sectorally) as an alternative for institutionalisation.

Index Terms: Commercialisation; Internationalisation; Knowledge Transfer; Institutions

1. Introduction

The central locus of innovation has become increasingly international and dependent upon linkages between different types of organisations and sources of knowledge (Heitor, 2015). This is partly because of the offshoring of corporate R&D facilities (Karlsson et al., 2006), leading to increased international technological collaborations often as part of global innovation networks (Gassler and Nones, 2008; Li, 2010). These are enabled by the low cost and global proliferation of ICTs that enable more distributed innovation processes (Schwaag et al., 2010). At the same time, universities, viewed as sources of competitive edge that can advance innovation through the commercialisation of knowledge generated by the academic community (Wilson, 2012), are increasingly globally-engaged: through rapidly growing numbers of international co-publications, cross-border patenting, and human (scientific) capital mobility (OECD, 2008).

The exploitation of opportunities that come from the international transfer of university-generated knowledge requires participants, i.e. universities and enterprises, to interact effectively outside the institutional terrain (the terms that will be used hereafter is field) of their core operations, education and research in the case of the former and business venturing in the case of the latter. More specifically participants must interact in institutional fields differentiated by: i) type of organisation that tend to give rise to differences in goals, interests and time horizons informing R&D behaviour of participants in the interaction (Siegel et al., 2003), and ii) country, which influences prevailing regulatory regimes, and a broad range of cultural characteristics (language, religion and other) (Ionascu et al., 2004: 4). Interacting across fields is influenced by sectoral characteristics (as will be discussed in more detail in the following Section): as the effects of between-country institutional differences may vary on account of sector specificities, whilst between-types-of-organisation differences may be shaped by sectoral systems (Malerba, 2005).

The underlying assumption of existing literature is that interacting across institutional fields is important in influencing the incidence and direction of international knowledge transfer (Malik, 2013). Institutions provide boundaries to the interactions, and influence (or according to some scholars determine) choices: facilitating more frequent interaction between participants in the field than with those outside (Scott, 1995). The challenge of interacting across fields may be persistent as institutions are path-dependent, as a result of their evolution in historical time in distinct organisational, sectoral and country contexts (Hodgson, 1988). Thus, in the main, interacting across institutional fields[1], in the case of our paper transferring university-generated knowledge internationally, may be less frequent even if opportunities

[1] The institutional field is a key concept used in our paper. It is defined as 'a community of organisations that partakes of a common meaning system, and whose participants interact more frequently with one another than with actors outside the field' (Scott, 1995, p. 56).

exist in bridging such fields (Burt, 2004). Within this intellectual context our paper sets out to *explore the contingent institutional conditions that could foster the international transfer of university-generated knowledge, and particularly commercialisation, to enterprises.*

The importance of the institutional context (organisational, sectoral and country) prompted us to adopt a comparative approach. Thus, we focus on four national contexts: the UK, Portugal, Estonia and India that vary considerably in terms of historical trajectories, embeddedness of intellectual property (hereafter IP) relating regulation, and knowledge generating capabilities (discussed in more detail in the third Section of the paper). Within each national context we selected one university: focusing on those that possess strong knowledge generating capabilities, and are viewed as leading (nationally) in knowledge transfer (hereafter KT). In each of these organisational contexts we identified two cases of international commercialisation. Deciphering these cases placed emphasis not only at national and organisational institutional factors but also at the implications of sectoral systems (using influences particularly pertinent for the purposes of our study, such as the type of knowledge involved).

The rest of our paper is organised as follows. The next Section engages with the literature on university-industry KT and institutional theoretical constructs. Then we proceed to explain the desgin of the study, data collection, the analysis processes deployed, and limitations. The fourth Section compares the eight cases of international interaction with enterprises, whilst Section five focuses squarely on the analysis of institutional factors. The penultimate Section discusses our findings and develops propositions. Finally, the paper presents some final conclusions and explores implications for future research.

2. The literature

2.1 The internationalisation of knowledge transfer in context

In order to understand the nature of the transfers involved and position our research in the existing body of literature we decided to advance a typology of KT internationalisation. This combines two criteria: i) the nature of the knowledge transfer activity with that of ii) the type of internationalisation. The former draws on the ideas of Perkmann et al. (2013) who advanced an increasingly influential divide between academic engagement and commercialisation. It includes 'formal activities such as collaborative research, contract research and consulting, as well as informal activities like providing ad hoc advice and networking with practitioners' (Perkmann et al., 2013: 424). Commercialisation is defined in this context as 'the patenting and licensing of inventions as well as academic entrepreneurship' (Perkmann et al., 2013: 423). This divide is also reflected upon the degree of the user (i.e. the enterprise) involvement in the process of knowledge generation. Thus, commercialisation revolves around knowledge generated from research that is academically driven, publicly funded, and subsequently owned by the University. The second criterion draws from Jin et al. (2011) who distinguish between i) direct linkages between universities and enterprises operating in different national settings, and ii) indirect ones (for example relationships with (invariably) a multinational through its domestic subsidiary, or those established with foreign companies through universities operating in the same (as the knowledge user) national context. Our paper focuses on the top right-hand corner of Table 1: exploring direct international commercialisation. This invariably involve the development of a new relationship, touching upon a novel area of research in institutional theory as will be discussed in the sub-Section below, as the enterprise is usually not involved in the generation of knowledge.

Insert Table 1 about here

2.2 Institutional theory

The type of interaction explored in our paper is of particular interest conceptually for institutional theory: on account of a gradual shift in emphasis from within to between institutional settings. More specifically, this stream of institutionalist thinking poses the question: 'how social choices are shaped, mediated and channeled by the institutional environment' (Wooten & Hoffman, 2008: 130)? Thus, action is not defined by the actor but influenced (or even determined) by a perspective that is common to a group of participants in the interaction. Analysis focuses overwhelmingly within an institutional field. This emphasis on the integrity (though not necessarily the boundaries) of the field underpinned the charge that it over-emphasises homogeneity of the actors involved in specific institutional fields (Wooten & Hoffman, 2008). This, in turn, is viewed as leading to a form of 'institutional determinism': where actors act out institutionally prescribed actions leading to stability and inertia.

More recently however, there is increased acknowledgment of situations where individuals from different institutional fields interact. This constitutes a shift in emphasis away from actors who occupy positions that bridge different fields, enjoy exposure to the institutions that characterise the different fields, are able to distance themselves from these and 'transpose', 'transplant' and 'recombine' institutions across fields (Sahlin and Wedlin, 2008). Instead research focused increasingly on interactions taking place in the boundaries of institutional fields. Boundary work involves creating, expanding, reinforcing, blurring, opening and crossing social boundaries between fields across time, space and levels (Helfen, 2015). The outcome may be the reproduction of the field or the introduction of change in institutions

(Gawer & Phillips, 2013). More recently, research focused on interstitial spaces, i.e. 'small-scale settings where individuals positioned in different fields interact occasionally and informally around common activities to which they devote limited time' (Furnari, 2014: 440), exploring the initial emergence of new practices that may eventually become institutionalised. Our inquiry focuses on interactions that, like boundary work and interstitial spaces, take place between institutional fields, thus, involving no common/shared institutional basis. In fact, participants maintain their core activities in different institutional fields: namely market ones in the case of enterprises and open science in universities. However, and unlike boundary work, these interactions are developed 'de novo' (as shown in Table 1). These interactions differ from interstitial places in that they are invariably formal (involving contractual arrangements between participants).

Existing research on the contingent institutional factors that underpin the transfer of university-generated knowledge in general (Bjerregaard, 2010; Hsu et al, 2015), and particularly internationally (Malik, 2013), has remained relatively detached from these debates, with the exception of Taheri and Geenhuizen (2016). Probably the most coherent treatise of institutional factors is that of Bjerregaard (2010): who draws from Scott's conceptualisation of institutions. This paper follows on this tradition as it allows for the exploration of institutions from the extremely fine grained (i.e. within one organisation) to broad grained (i.e. nationally or even transnationally). Thus, we tapped into the ideas of Scott who distinguished between 'cultural-cognitive, normative and regulative elements that, together with associated activities and resources, provide stability and meaning to social life' (Scott, 1995: 33). Regulative elements emphasise rule setting and sanctioning, whilst normative elements contain an evaluative and obligatory dimension. Lastly, cultural/cognitive factors involve shared conceptions and frames through which meaning is understood (Powell, 2007). These three elements form a continuum

moving ‘from the conscious to the unconscious from the legally enforced to the taken for granted’ (Hoffman, 1997: 36). In the following sub-Section we will try to disaggregate institutional factors further: combining insights from institutional theory (in the tradition of Scott) and empirical evidence from the KT literature.

2.3 Institutional factors

Regulations are established at different levels and shape behaviours through their provisions, inspection of conformity with the rules and the imposition of the sanctions and rewards involved (Scott, 2013). They are not merely means of restricting behaviour, but also enabling and incentivising actors as well as establishing certainties (for example through the conferment of rights) that may facilitate interaction. The logic that drives the development of a regulation is an instrumental one: individuals develop the rule they believe that will advance their interests, and comply with it in order to reap rewards and avoid sanctions. Institutional theorists acknowledge the importance of macro-level regulations as manifested in law and implemented in courts, professional statutes, and prerogative of public agencies (DiMaggio, 1988). However, there is also recognition of procedures created within organisations, in part to conform with macro-level regulations but also in order to institutionalise existing practices that are viewed as important in attaining success (DiMaggio, 1988). Thus, we will distinguish here between regulative institutional influences originating from national regulation and organisational rules and procedures.

There is a voluminous body of literature exploring regulations at different levels in university-industry KT in general and commercialisation in particular. At the national level, this goes back to the introduction of Bayh-Dole Act that ‘allowed universities to own the patents arising from federal research grants’ (Grimaldi et al., 2011: 1046). These regulations governing the

ownership of university-generated research outcomes underpinned an emerging consensus of academic opinion regarding a move away from ‘open science’ rules to a ‘model, where the identification, protection and exploitation of intellectual property is central (Murray & Stern, 2007). However, there is also recognition in the accumulated literature of the differential effect of national rules in specific sectoral systems. In an influential contribution, Malerba (2005) illustrates the importance of strong patent protection in chemicals, influencing the architecture of the sector, whereas in software the centrality of IPRs has been greatly affected by the open source movement. In the latter context, standards (and their development and the actors involved in the process) play an increasingly important role.

There is also research into the development of rules at the organisational level, particularly from the point of view of knowledge providing organisations, regarding commercialisation. This research revolves around the proliferation of technology transfer offices (Phan & Siegel, 2006) and the associated set of rules and implementation mechanisms encouraging disclosure and academic entrepreneurship (Grimaldi et al., 2011). Of particular relevance is the development of rules that incentivise academics not only to disclose but also to lead IP exploitation, and the internalisation of these regulations by academics (Bjerregaard, 2010). More recently, there has been increased emphasis placed on the role of organisations that provide a rule-governed context for interactions: nonpracticing entities (defined as organisations that own and often assert IPRs but do not practice, in the sense of directly exploiting, the knowledge covered by the IPRs (Meurer and Bessen, 2014)). They generate or (more often) acquire protected knowledge with the aim of securing licensing income through commercialisation. Advocates of nonpracticing entities view them as potentially efficient middlemen, connecting those who invent but whose inventions have not been deployed (such as universities) with those who can produce an innovation from that invention (Spulper 2012).

Critics argue that they discourage innovation by generating excessive social costs through frivolous litigation (Meurer and Bessen, 2014). Organisational rules are influenced at least in part by sectoral systems. For example, in engineering the nature of the knowledge involved means that early Technology Transfer Officer (hereafter TTO) engagement with enterprises is important: underpinning the development of rules to facilitate this (Mosey and Wright, 2007). Instead, the knowledge involved in biological sciences, necessitates early involvement of equity investors though the advancement of institutionalised solutions: university managed equity funds (Croce et al., 2014).

Normative institutions introduce a prescriptive and obligatory dimension in actor behaviour. Thus, they identify the appropriate goals and actions that can be pursued by actors occupying specific positions within a field. They underpin expectations that other actors hold about the behaviours linked with a specific position and may become internalised (Scott, 2013). Like regulations they are also restricting and enabling. The central logic of normative institutions is appropriateness: i.e. 'given the situation and my position within it what is the appropriate behaviour for me to carry out?' Existing research distinguishes into two types of norm: descriptive and injunctive (Cialdini, Reno & Kallgren, 1990). The former informs individuals of what is being done within an institutional field. It describes the prevalence of a certain behaviour and thus encourages the adoption of that behaviour since prevalence implies usefulness in managing social life. Injunctive norms are related to the evaluation, by those within the institutional field, of a certain behaviour. It involves approval or disapproval, and functions as pressure on an individual to perform or not perform a behaviour.

The bulk of research on university-industry KT in general and commercialisation in particular focuses upon injunctive norms. More specifically, in the case of knowledge providers at the

organisational level research norms are viewed as central: thus, aligning KT activities (and commercialisation in particular) with research (through generating revenue and ease funding pressures on research) (Welsh et al., 2008). At the individual level, academics that occupy the knowledge provider position subscribe to traditional and scientific norms (Perkmann et al., 2013). Diverse manifestations of this are apparent in career-progression (Lam, 2007), the importance attached to non-monetary objectives (Azagra-Caro et al., 2008). There is some evidence that doing so impacts adversely on involvement in commercialisation (Krabel & Mueller, 2009). Interestingly, however, academics may also occupy a position as knowledge users (bridging fields) in instances where they lead or are involved in spin-off activity. This position necessitates the adoption of norms associated with the entrepreneurial act opening up the scope for incongruity and conflict with traditional scientific norms (Perkmann et al., 2013). Enterprises, in the literature, use knowledge generated in universities in order to secure financial gain (Siegel et al., 2003).

There is much less research exploring normative descriptive institutions in KT and commercialisation. Within universities there is evidence that academics are more likely to engage in commercialisation activities if departmental colleagues of the same rank adopt this type of behaviour (Bercovitz & Feldman, 2008). This argument is placed somewhat differently by Jain et al. (2009) who emphasise the importance of increased awareness, among academics, of commercialisation possibilities and actual involvement in this. From the point of view of both universities and enterprises Bjerregaard (2010) stresses the importance of a shared cultural micro-cosmos for collaboration. He goes on to argue that interaction may also facilitate a process of enterprise 'scientification' involving the adoption of 'open science' norms.

Existing institutional theory research places particular emphasis on cognitive-cultural institutional influences (such as language, religious and ideological ways of understanding the world and others). This is because pre-established cognitive frameworks (viewed here as an element of cognitive institutions), at least in the beginning, influence sharing of knowledge and learning process (Nooteboom et.al., 2007). Differences in cognitive frameworks may cause misunderstandings and conflict between participants (Inkpen & Tsang, 2005), and in that situation they may decide to restrict information exchange affecting negatively outcomes (Krause et al., 2007).

Research into KT and commercialisation appears to overlook the significance (or not as the case may be) of cognitive-cultural institutional differences. Thus, in this paper this will be captured in terms of the language used by participants, as identified by Malik (2013) in a exploring international KT and its cognitive frameworks. Another dimension of cognition that is particularly relevant for KT in general and commercialisation in particular, revolves around common knowledge bases (Lane & Lubatkin, 1998). Operationally this may be examined in terms of the commonality of patents owned by participants in the interaction. Knowledge bases are formed of mental models which are representation of the world that are shaped through interaction with other people and surroundings and used to control the world through making sense and anticipating events (Johnson-Laired, 1983). The argument goes that cognitive knowledge bases should be similar enough in order to communicate, understand and process scientific knowledge successfully but too much cognitive proximity have negative effects (Nooteboom, 2000). Hewitt-Dundas (2013) suggests that the transfer of university-generated knowledge is facilitated when enterprises have internal R&D capabilities. This view is moderated by Xu et al. (2011) who identify a differential effect between foreign owned and locally owned ones.

Sectoral systems are particularly important influences of knowledge bases. This is because the very nature of the knowledge involved in the transfer may vary considerably: with profound implications on institutions governing its transfer. For example in the case of the biotechnology industry the (scientific) knowledge involved is both abstract and codifiable making it relatively easy to protect through patents (Saviotti, 1998). In contrast, in sectors such as software where the knowledge involved is often tacit (as it is linked with a complex and diversified base) impacting adversely on the importance of IPRs such as patents (Aramand, 2008). Thus, sectoral systems impact upon cognitive institutional conditions influencing the commercialisation of university-generated knowledge internationally.

3. Methods

3.1 Research Design

The study was designed as comparative case research. This is because it allows for the exploration of a phenomenon (international commercialisation) within its real life context and comparison of findings across different cases (Yin, 2003). The national contexts selected were identified for their diversity in two important sets of factors, as suggested by Audretsch et al. (2014). Firstly, there was profound diversity in terms of institutional development: from advanced market (UK), to post-socialist (Estonia) and emerging (India) – as captured in Table 2. For example, the degree of protection of IPR varied profoundly between the UK, occupying the eighth position globally, and India, who is placed 71st. Similarly, there were significant differences in the degree to which institutions underpinned close collaboration between universities and industry: with the UK being 8th and India 47th. Secondly, there were considerable disparities in the knowledge generating capabilities of the four countries

examined here: ranging from one of the leading globally (UK), to an emerging leader (India), a medium-sized knowledge producer (Portugal), and a relatively small one (Estonia). However, on the measure of per scientist publications (to adjust for size) there are only modest differences in the position of countries, with Estonia (surprisingly) being best placed (Table 2).

Insert Table 2 about here

In order to identify instances of the phenomenon (international knowledge commercialisation) it was important to select organisational contexts that have a technological orientation, possess strong knowledge generating capabilities, and are viewed as leading in KT within their respective and profoundly different, as described in the next Section, national contexts. We selected the Indian Institute of Technology Delhi (IIT Delhi), Tallinn University of Technology (hereafter TUT), the University of Lisbon, and the University of Manchester. Table 3 provides an illustration of the technology focus of the key units of the Universities (Faculties) and international comparable data provided by SCImago[2]. The latter shows on two measures the very strong national position of the universities selected: i) research outputs, i.e. the rank position of the institution nationally in terms of papers published in scholarly journals indexed in SCOPUS, and ii) innovative knowledge, namely rank position of the institution nationally in terms of number of scientific publications from the institution cited in patents.

Insert Table 3 about here

[2] The choice of an international dataset was primarily for practical purposes: as it provided already comparable data. It is worth pointing out here that the data are weighted for size of institutions.

However, despite the common technological focus and the leading position occupied by the four organisational contexts selected, there were differences in their shape and size reflecting disparities in the national context and distinct historical organisational trajectories (Table 3). Knowledge production capabilities vary considerably between the universities concerned. In 2013 academics working at the University of Manchester produced more than 4,500 papers, which have been cited around 30,000 times in the following two years. The corresponding figures for the University of Lisbon were 2,500 and more than 6,600 respectively. However, in IIT Delhi there were just over 1,000 journal papers and 2,200 citations. Lastly, in TUT more than 300 papers were published in 2013, which were cited more than 800 times in the following years. The exploitation of knowledge generated by these universities is captured in terms of new patents granted. The University of Manchester stands out as it had a portfolio of some 513 patents in 2013. IIT Delhi and University of Lisbon had a portfolio of 103 and 139 respectively, whilst TUT held just 34 patents.

In order to capture the effects of sectoral systems we drew upon a relatively well-established divide from the existing body of literature (Asheim and Gertler, 2005; Malerba, 2005; Salavisa et al., 2012) that is relevant for the purposes of our study revolving around the type of knowledge involved and the relative position of universities in the processes at work. The first sectoral system involves science-based knowledge: i.e. it is driven by discoveries in universities based on deductive processes and formal models and appeals to abstract "know-why". Within this context, there is proximity between scientific principles and application, easy codification (thus IPRs are of considerable importance), and scope for exploitation across a wide range of industries (Salavisa et al., 2012). Examples of science-driven sectoral systems include biotechnology, pharmaceuticals and chemicals. The second sectoral system involves knowledge often, but not solely, generated for the purposes of introducing innovation, thus,

knowledge creation arises from specific problem solving through inductive processes of testing and experimentation. In this system tacit knowledge is of greater importance (undermining the centrality of patents and other forms of individual protection of intellectual property), whilst the knowledge is often applicable in a rather narrow sectoral setting. Exemplars of innovation-driven sectoral systems include software and electronics.

3.2 Data Collection and Analysis

The cases of international knowledge commercialisation were identified based on information received from well-informed individuals, mainly TTOs and university managers at each university. In our selection, we tried to include cases across sectoral systems, demonstrating a broad range of processes, i.e. licensing, spin-off and others, and very importantly instances of both success and failure (though the latter were more difficult to trace). Data richness was also an important consideration. Overall, nineteen such instances were identified in the four case study contexts: with eight of these selected (two from each University).

Primary data was collected from actors that were involved in knowledge commercialisation from different perspectives. Thus, we conducted a total of 47 interviews with five stakeholder groups: senior university managers (eight interviews), academics (sixteen), TTOs (nine), entrepreneurs (eight) and government officials (six). In terms of geography there were ten interviews conducted in Estonia, twelve in India, thirteen in Portugal and twelve in UK. Interviewees were selected through non-random purposeful sampling including criterion sampling and snowball sampling (Patton, 2002). There were two-stages in interview data collection. The first involved individuals with oversight of the process and direct involvement in the development of policies and practices supporting commercialisation (such as senior

academic leaders, TTOs, etc): they provided context and identified instances of the internationalisation of commercialisation. Secondly, there were academics and entrepreneurs that had been directly involved in the commercialisation of IP. The interview schedules consisted of four main sections of questions: knowledge production, KT (including international activities), actors and relationships, governance and management of KT. The interview schedule was similar for the five target groups with slight variations depending on the interviewee's profile. For example, in the case of government officials, emphasis was placed on the issues of governance and managing KT. The academics and entrepreneurs, on the other hand, were asked to describe more thoroughly their own experiences of international KT in the area of commercialisation of IP. The interviews were carried out in 2014 and lasted between one and one and a half hour each. In most cases the interviews were recorded and transcribed; in case the interviewee viewed the context as too sensitive notes were made of the interview.

In order to construct the case studies and particularly to capture institutional factors influencing international knowledge commercialisation secondary data sources were also used. These included national and university regulations, R&D reports, company web-pages, press-releases, and others. These sources of data covered: i) the context of commercialisation, such as national Research, Development and Innovation policy documents and analysis, university KT regulations, university R&D reports, and ii) case-specific ones: namely web-pages of enterprises, press-releases regarding commercialisation of IP, and information in databases (Scopus, Espacenet patent search).

The analysis of interview and documentary data consisted of a series of steps (with the help of 'peer debriefing'), searching for within-case similarities coupled with cross-case differences or in other words "the simplicity of the overall perspective" (Eisenhardt, 1989, p. 547). Each of these cases offers an opportunity to learn and integrates context analytically into the explanation rather than simply using context (as a description) to enhance understanding (Welch et al., 2011). As a first step, we thus used directed content analysis and coded the interview script data in terms of key themes identified in the literature in the previous Section (Hsieh and Shannon, 2005). In doing so, we used role-ordered matrices to compare views coming from different groups of interviewees (academics, entrepreneurs, TTOs and others), for each institutional pillar and factor. In a second step, we purposefully looked for patterns across cases, and collapsed the previous themes into two overarching ones. These were: cross-scale institutional factors and processes at work that result in successful commercialisation of IP (Miles et al., 2014). This led to a final reordering of the case study data that focused on institutional factors not only across pillars but also between actors within each pillar (underpinning success or failure).

3.2 Limitations

There are some apparent limitations in our research, linked with our data collection methods. Specifically, we focused on the same type of university context (technology-focused, leading research and KT), thus, we are unable to undertake comparisons between different types of university. Our findings may have been different if we have examined cases of knowledge user organisations: and country implications upon them. Lastly, and despite our efforts to explore cases of both success and failure, we identified a single instance of failure on account of institutional factors. Linked to this, we had to restrict ourselves on instances where an

interaction was established: and we were not able to examine interactions that floundered in the very early stages of the process.

4. The Case Contexts

The cases involved in this study are presented in Table 4. Half of these (Gamma, Zeta, Eta and Theta) were in a science-driven sectoral system, whilst the other half in an innovation-driven one. The other participant in the interactions is in most, but not all cases, a potential user-enterprise. Indeed, in two cases (Beta and Delta – both revolving around innovation-driven sectoral systems) the participant is what could be best described as a nonpracticing entity: accessing university owned knowledge with the aim of generating licensing income through its diffusion to user-enterprises. The nonpracticing entity involved in the case of Delta: has been successful in pooling tens of thousands of patents from universities and private inventors across the world. The nonpracticing entity involved in Beta tapped into university held IP primarily from post-socialist states (the Baltics, Poland, Russia, Ukraine) and China.

Insert Table 4 about here

The divide between user-enterprise and nonpracticing entities influences both the knowledge bases involved (as will be discussed below) as well the mechanisms used. In the case of the latter this takes the form of a strategic partnership regarding the exploitation of the IP, whereas in the case of the former mostly of a direct licensing agreement or spin-off: only in one case (Theta) involving a strategic partnership.

There are considerable disparities regarding the participant driving the interactions. In a number of instances this is the enterprise (user or nonpracticing) that aims to access the university owned knowledge: attracted by the research profile of individual academics (Alpha, Beta, Delta, Zeta). In other instances (Gamma, Zeta) the academic-inventor him or herself is pursuing the establishment of an international interaction. Interestingly, it is only in two cases (Eta and Theta) that the university is directly and proactively pursuing linkages with user-enterprises respectively located across national boundaries. As stated previously, the study pursued the inclusions of cases of both success and failure. Three cases can be characterised as a failure, one in Estonia (Beta), one in Portugal (Zeta) and one in the UK (Eta). Failure was manifested in different ways: break-up of the interaction, interruption of the pursuit of licensing, or withdrawal from the agreement. In one case (Beta) the reasons for failure revolve around the institutional dimension, and will be examined in more detail in the Section below. In the cases of Zeta and Eta outcomes fell short of initial participant expectations because of a change in the priorities of the multinational corporation (hereafter MNC) in the former case and poor results of early testing in the latter. These two cases constitute apt reminders that non-institutional factors may also be important in determining of the processes and the outcomes of international commercialisation of university-generated knowledge.

5. Analysis of institutional factors

5.1 Regulatory

Not unexpectedly, the geography of the interactions (Table 4) shows that university-generated knowledge is accessed from (when the process is driven by the enterprise) or diffused towards (when led by the university) settings that possess strong IP protection and enforcement. More specifically, users of knowledge are located in Finland, Singapore, UK, and the USA:

occupying positions one, two, eight and twenty respectively on the same IPR protection measure used in Table 2. This indicates that interactions are established when there is strong protection of IPR in the setting of the enterprise, irrespective of the fact that protection in the country where the university is located is modest or relatively weak.

At the organisational level, there is differential advancement of regulation governing international commercialisation. Indeed, in all four university settings there are rules governing such interactions. In the case of TUT and the University of Lisbon these rules are operationalised through autonomous departments (Innovation and Business Centre Mektory and the Projects, Entrepreneurship and Knowledge Transfer Office respectively) within the organisation. Moreover, in these settings international commercialisation is not pursued pro-actively. The small patent portfolio and the absence of patent families in TUT prevent the institutionalisation of practices that would facilitate international commercialisation: as articulated by the university's TTO who explained that 'so far the solution is researcher himself … the researcher has more contacts than all others and is more likely to find a buyer for its invention.' (TUT_TTO1). This is also the case in Portugal, where the internationalisation of the knowledge transfer has not yet been put in the priorities of the TTO. In the context of IIT Delhi and the University of Manchester organisational rules exist in the form of distinct wholly-owned university subsidiaries: the Foundation for Innovation and Technology Transfer (FITT) and University of Manchester Intellectual Property (UMIP). However, it is only in the case of the University of Manchester where there is explicit intend to 'be recognised internationally for the excellent quality, significant scale and the distinctiveness of [its] … work in the successful commercialisation of appropriate research … outputs' (UMIP, 2010, p. 10). This underpinned the identification of transnational IP income flows, and established rules for the advancement of institutionalised linkages particularly with intermediary and user enterprises

in the US, and to a lesser degree the EU, as key priorities, that underpinned 'a straightforward dialogue with prospective investors' (UoM_TTO1). Evidence of their importance is shown in the case of Theta, and to some degree Eta.

Similarly, there was differential advancement of organisational rules amongst the enterprises involved in the interactions. In the cases of the nonpracticing entities involved in Beta and Delta: these were well developed as they underpinned their core operations: i.e. to 'be one of the leading players globally in international IP commercialisation … through the world's largest international network of universities and research institutions' (TUT_E1). In these cases the volume of interactions involved meant that there was an institutionalisation of the processes at work. Developed organisational rules were also reported by enterprises' participants in the cases of Zeta, Eta and Theta (the former two being MNCs that often use university-generated knowledge in innovation). Organisational rules were less well developed in the remaining enterprise participants.

5.2 Normative

The prevalence of shared injunctive norms between knowledge producers and individuals in participant enterprises is an important influence in the success of commercialisation activities across national boundaries. Of particular importance, but not solely, are norms associated with what is widely understood as the 'science commons' (such as openness, community, mutual criticism and fair allocation of credit). For example, the senior academic from the University of Manchester involved in Eta stressed the importance of working with scientists within the knowledge using enterprise, but has also worked himself as Head of Research in the R&D facilities of a large multinational. Similarly, the chief executive officer of the US based

enterprise involved in Theta has held a number of positions in public R&D facilities in his country of origin. The challenges of misalignment are apparent in Beta, where academics had to work with commercially driven knowledge users: 'we had negotiations … for half a year … but when we reviewed the conditions of an agreement they proposed we noticed we would be paying a huge salary for the general manager and financial manager that they have the right to appoint … My way of thinking is not too greedy, but working for pennies for people I do not know, is not what I want. The researcher is also a bit crazy, wants to do his own things.' (TUT_A8). This impacted directly on the failure of the interaction. This was also the case in Delta.

As far as shared normative descriptive institutions are concerned, individuals occupying different positions operate in environments where commercialisation activities are commonplace. More specifically, the departments where the academic-inventors work demonstrate considerable incidence of commercially exploitable knowledge. In the case of Alpha and Beta (both coming from the same academic unit) there were three patents granted between 2010 and 2013, six in the case of Eta and eight in the case of Theta. Moreover, users (at the individual scale) work in enterprises that have considerable experience of engaging in commercialisation activities with universities. This may be linked to injunctive norms encouraging such activities, as shown in IIT-D where 'earlier good publications were one of the main criteria for your promotion … but now they give equal importance to how many patents you have filed and how much interaction you have with industries' (IITD_A2).

5.3 Cognitive

As identified in the literature, language constitutes an important cognitive influence. All eight cases examined here show linguistic alignment between participants in the interaction, re-

iterating the commonly held view that ‘the language of science is English’. Indeed, academics in these leading (nationally) universities, who have to publish internationally, are competent in the use of this medium of communication. This is also the case regarding individuals working in enterprises transacting externally and often internally (in the case of MNCs) in English.

Alignment is also apparent in the case of cognitive frameworks (captured here through the educational background of participants). This appears to be the case amongst the cases explored at the University of Manchester, for example in the case of Theta the CEO of the enterprise has been educated in a similar disciplinary setting as the academics that pioneered the knowledge output commercialised. Similar educational backgrounds are also apparent in all but two of the cases deciphered in this paper: for example in the case of Gamma from IIT Delhi stating that ‘it is easier for the larger firms to interact with university as the firm representatives themselves are scientists’ (IIT_TTO1). One case of difference is Epsilon: where the background of the persons involved in the spin-off was very different: cutting across scientific disciplines, namely engineering and management. This was seen as positive since it enabled complementarity. However, this case involved interactions around a fully-developed product, rather than knowledge that required advancement within the commercialisation process. Another instance of difference was that of Beta: between the academic and the investors (an instance where failure occurred).

In terms of common knowledge bases, in most of the cases examined in our paper the other participant in the interactions appears to possess patents in the same area where knowledge outputs are currently commercialised. For example in the case of Zeta the interaction between the academics and the MNC was facilitated by the deep technological knowledge the company had in the technology, expressed by a large portfolio of patents in that technological area. This

was to a lesser extent also the case at Alpha, as the enterprise was in the processes of applying for legal protection of its own IP in parallel with the patent licensing process with TUT. In the cases of Beta and Delta there was no knowledge base held by the nonpracticing entities.

6. Discussion

Evidence presented in our paper advances incrementally three arguments previously articulated in the literature. Firstly, it shows that the emergence of IP protection and enforcement arrangements that transcend national boundaries (following the TRIPS agreement in 1994), provide the institutional basis for cross-border commercialisation activities: even in instances where interactions break down (Beta) or results fall short of expectations (Theta). IP protection and enforcement appears to be particularly important in the national setting of the enterprise rather than that of the university, as illustrated by the cases coming from IIT Delhi. Secondly, and potentially related with the previous point, the effective protection of the university-generated IP is a significant consideration particularly amongst cases in science-driven sectoral systems. Interestingly, this takes somewhat different manifestations: sought from the university commercialisation venture in the cases of Eta and Theta and externally in the case of Gamma and Zeta. Lastly, the widespread use of English in scientific pursuits also facilitates interactions even in the case of Estonia, with its historical linkages with Soviet (and Russian language using) science.

The findings of our research also point towards some novel insights in this empirical context. Specifically, whilst the actual interactions created in order to facilitate the international commercialisation of university-generated knowledge are new, their formation in some cases involves organisations (nonpracticing entities) that aim (as their core operation) to occupy the

space between university and user-enterprise institutional fields. Their role is apparent in the cases of Beta and Delta, not surprisingly (on account of the more applicable nature of the knowledge involved) both revolving around innovation-driven sectoral systems. Whilst the involvement of nonpracticing entities does not ensure success, as shown in the former case, it is indicative of the innovation potential involved in the international commercialisation of university-generated knowledge.

Our findings point instead at a set of contingent institutional factors facilitating the international commercialisation of university-generated knowledge: common knowledge bases (organisationally) as well as injunctive and descriptive norms and cognitive frameworks (individually). Common knowledge bases are apparent in all but two of the cases (including those in science-driven sectoral systems where the knowledge transferred is codified) examined: Delta and Beta. Interestingly, the latter is a case where there was conflict and interaction break-up. Organisational knowledge bases, in turn, influence the scientific backgrounds of the individuals employed by participants in the interactions. Academics are employed by departments that are the repository of existing organisational knowledge. Similarly, researchers working in enterprises are concentrated in areas of past investment or future growth areas. This leads, as shown by all but two of the eight cases examined in our paper to shared cognitive frameworks (captured in terms of educational background). Beta had a negative outcome, whilst in the case of Epsilon the actual product had already been developed and differences in cognitive frameworks did not have detrimental effects. Moreover, scientists, who work either as academics in universities or lab researchers in enterprises, have been trained in academe, have been influenced by science commons norms. Indeed, in some instances as shown in the case of Eta lab researchers in enterprises participated in the science commons, through publication, to a degree that underpinned a career move across fields. Lastly,

academic-inventors worked in departments where the commercialisation of knowledge was commonplace, as shown by the incidence of patent activity. In fact, this poses the question (that merits further investigation) regarding the degree to which descriptive norms influence employment choices of academics, leading to concentrations of those capable of performing a more catalytic role in international commercialisation. Common knowledge bases, and shared norms and cognitive frameworks are the outcome of path-dependent trajectories: resulting from organisational decisions and investment and individual decisions about education and work experiences both unfolding through time. This underpins our paper's first proposition.

Proposition 1: New international commercialisation interactions are established between participants that possess, as a result of path-dependent trajectories, common organisational knowledge bases and shared individual (injunctive and descriptive) norms and cognitive frameworks.

The path-dependent nature of common knowledge bases and shared norms and cognitive frameworks means that they cannot be altered through action in the short- to medium-term. This restricts the scope for the development of new interactions only to those participants that meet the very specific institutional conditions described in Proposition 1. Moreover, the scope of existing interaction is very narrow: as it is invariably constructed around individual academic inventors (Alpha, Beta, Gamma, Epsilon, Zeta) and their knowledge generating capabilities, rather than those of a university as a whole. Thus, if an interaction fails (for example if the knowledge sought is bypassed as was the case with Zeta) the investment by both participants is lost (as there is no wider residual link). It is the advancement of organisational rules and an institutionalised process of pursuing international commercialisation, as those identified in the interstitial spaces research that can widen the scope for the international commercialisation of university-generated knowledge.

Organisational rules aimed at facilitating commercialisation have been created in all university and enterprise contexts examined here. However, institutionalisation of the processes at work occurs only in some of the cases. Institutionalisation is apparent in two cases originating from the University of Manchester, where organisational rules are complemented by a declaration of intend (articulated though UMIP) to achieve excellence in commercialisation internationally, focusing on transnational income streams. More importantly, however, it is linked to the strongest (by some considerable margin) knowledge generating capabilities (in terms of papers), the most visible research outputs (as measured in terms of citations and research H-Indices), and the greatest volume of IP (in numbers of patents) amongst the four organisational contexts examined here. Institutionalisation, from the point of view of nonpracticing entities is also evident in the cases in Beta and Delta. The enterprises involved also combine rule governed settings for the institutionalisation of interactions, and scale by pooling the IP of a number of universities and private inventors. However, in both of these instances the pooling of IP is not achieved in the context of common knowledge bases and shared injunctive norms. This underpins the development of the paper's second proposition.

Proposition 2: The institutionalisation of international commercialisation, either in universities or enterprises, is the outcome of the combined effect of organisational rules, strategic intend, and the volume of the IP held by the organisation.

7. Conclusions

7.1 Concluding Remarks

The point of departure of this paper was that the increased internationalisation of university-generated knowledge, facilitated through the global proliferation of ICTs and changing corporate R&D practices, can stimulate innovation in global networks and the advancement of solutions to global challenges (such as pollution, climate change, ageing population to name but a few). Our findings suggest that the realities of the national context and sectoral system,

have some but only modest impact in shaping interactions. Instead, we argue that the ability of participants (both universities and user-enterprises) to engage in new interactions that cut across the boundaries of institutional fields, is primarily on account of commonality in a number of institutional factors (knowledge bases, norms and cognitive frameworks). This is novel theoretically as it illustrates that broad institutional field analysis may conceal more complex organisational institutional realities. Empirically, it is useful as it identifies a set of contingent institutional factors (Proposition 1) that underpin new international commercialisation interactions. Interestingly, these factors, like institutional fields, are path-dependent.

New organisational rules have been developed by both university and enterprise participants to facilitate interactions. In fact, nonpracticing entities emerged as an important rule governed setting, bridging institutional fields. They acquired relevance, by virtue of the size of their own IP portfolio, in instances where individual universities possess limited knowledge generating capabilities and modest volume of protected knowledge (Proposition 2). They were able to institutionalise the processes at work: in the case of the smallest university contexts and innovation-driven sectoral systems. This is in sharp contrast with university-led institutionalisation, in large knowledge producing universities and science-driven systems. More importantly, however, limitations on the facilitating capacities of nonpracticing entities revolve around their nature regarding the contingent institutional factors (own knowledge base, injunctive norms and cognitive frameworks) that underpin success.

7.2 Implications for Practice and Research

Our findings have implications for organisational practice and research. Regarding the former, we advance a potential solution to the challenge confronting universities possessing relatively

modest, particularly if viewed globally, knowledge generating capabilities and volume of protected IP. This solution may take the form of a university-led organisation pooling university held IP either within defined geographical settings (for example a city, a region or small country like Estonia) or maintain research capabilities in specific sectoral systems (for example consumer electronics or digital imaging). Ownership of these entities by universities, as opposed to nonpracticing entities, augers well for the attainment of increased international commercialisation on account of the prevalence of shared injunctive norms with the academic knowledge producers and individuals working within user-enterprises.

Our paper has also implications for research. Firstly, the propositions developed here could be operationalised into quantitative variables: thus, offering scope for the conduct of research across a broader range of national and organisational contexts (indeed, a key limitation of our research - identified in the third Section - was the narrow, technology-focused and research leading, organisational context examined here). Secondly, the use of institutional theory, and particularly constructs exploring the space between institutional fields, could be particularly useful in deciphering the emergence of new rules, and their implications for institutionalisation processes. We believe that research in this context could also influence institutional theory. Lastly, we believe that there is scope for further research in examining the international commercialisation of university-generated knowledge from the perspective of nonpracticing entities. Apart from providing novel insights into the processes at work, their success in pooling IP could inform the creation of new university-led organisations aimed at commercialising IP.

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Table 1. Types and means of international KT coordination

	Academic engagement	**Commercialization**
Direct international linkage	Enterprise located internationally that participated in the production of the research outcome engages in its exploitation.	Enterprise located internationally develops a new relationship in order to access university generated and owned knowledge that is the result of curiosity driven research.
Indirect international linkage	Enterprise located internationally that participated through a subsidiary or national university in the production and the exploitation of research outcomes.	Enterprise located internationally develops through a subsidiary a new relationship in order to access university generated and owned knowledge that is the result of curiosity driven research

Table 2. The National Research, Development & Innovation Context, 2013 (rank order)

	Estonia	**India**	**Portugal**	**UK**
Number of publications*	62	7	26	3
Number of publications per scientist*	25	36	31	27
University-Industry Linkages[1]**	36	47	27	5
Intellectual Property Rights[2]**	31	71	38	8

* Scopus ** World Economic Forum

[1]Indicator capturing the degree to which businesses and universities collaborate on R&D (enterprise survey data)

[2] Indicator capturing the degree of protection of IPRs (enterprise survey data)

Table 3. Description of university and its commercialization activities in 2013

	IIT Delhi	**TUT**	**UoLis**	**UoMan**
Research outputs[1] (rank order nationally/total nationally)*	4/209	2/5	1/34	4/184
Innovative Knowledge[2] (rank order nationally/total nationally)*	3/209	2/5	1/34	4/184
Science & Technology based Faculties/Total Faculties**	11 out of 13	6 out of 8	9 out of 18	3 out of 4
Number of academics**	485	1155	3461	4555
Number of publications***	1066	308	2565	4619
Number of citations[3***]	2240	867	6691	29869
Citations per paper***	2.1	2.8	2.61	6.5
H-Index***	14	11	23	53
Total number of patents held ***	103	34	139	513

* Scimago ** University own data ***Scopus

[1] Total number of documents published in scholarly journals indexed in Scopus

[2] Scientific publication output from an institution cited in patents

[3] Citations in 2013-2014

Table 4. Overview of cases of direct internationalization of commercialization

Case	**HEI**	**Partner**	**Sectoral System**	**Process**	**Mechanism**	**Outcome**
Alpha	TUT	Finnish user-enterprise (SME)	Innovation driven	The enterprise sought technology complementing its own (own patents pursued simultaneously). Approached TUT after searching 'research markets', using academic	Licensing	Signing of licensing agreement; receipt of royalties

				networks (the SME being an academic spin-off itself) to establish contact. Licensing negotiations included the university (TTO), the academic-inventor and the representative of the enterprise and followed a standardised process: including concluding non-disclosure agreement, approving the business plan, etc.		
Beta	TUT (spin-off)	UK nonpracticing entity	Innovation driven	An intermediary-enterprise originating in the UK approached a spin-off from TUT, holding University IP, with the aim of investing in return for equity. Prolonged negotiations did not produce agreement as the owners of the spin-off did not want to lose majority ownership.	Strategic partnership	Break-up of interaction
Gamma	IIT Delhi	User-enterprises in the UK, USA and Australia	Science driven	Professors and students set up company to commercialize the IP generated. The company, building on the reputation of the researchers and alumni linkages, sought investment from venture capitalists and angel investors. Cambridge University's Ignite programme helped it form partnerships with pharmaceutical firms (one owned by IIT alumni) in US and UK.	Licensing	Signing of confidentiality agreement.
Delta	IIT Delhi	US nonpracticing entity Singapore subsidiary	Innovation driven	The Singapore based subsidiary office of a US intermediary enterprise that had memorandums of understanding with other IITs identified the potential technology available IIT Delhi and approach the Technology transfer office (FITT).The MNC agreed to pay the license fee and bear the patenting cost associated with this invention. A US patent was filed.	Strategic partnership	Signing of agreement; receipt of royalties
Epsilon	UoL (spin-off)	United Kingdom and Spain user-	Innovation driven	The spin-off company is internationalised through sourcing of production and	FDI, outsourcing of	Establishment of affiliates.

		enterprises (SMEs)		FDI. The internationalisation was a goal since the start-up and the company exported in its first year. The sourcing of production to a European and Asian country was not intentional but a necessity, since they have not found a Portuguese company interested in producing the product components.	production, establishing affiliates abroad	
Zeta	UoL	User-enterprise based in the UK (MNC)	Science driven	Multinational company pursued the potential of an invention (patented) created by academics. The academics consider that the effective protection of the university IP depends of it licensing to a large company that can register it worldwide and enforce the property rights. Negotiations to license the technology have begun and, at the same time, the enterprise funded a project so that the inventors could develop the technology further, since they had the relevant knowledge to do it.	Licensing of IP	Licensing process interrupted due to change in market positioning of the enterprise
Eta	UoM	US user-enterprise (MNC)	Science driven	The University of Manchester benefited from the transfer of a research team (and IP) from a UK based company (2007). University and research council funding led to the generation of new IP. UMIP, as part of its commercialisation activities, promoted this IP in the United States and was successful in establishing a licensing agreement with the company. The aim of this is to use IP in order to develop a new compound for the treatment of skin diseases.	Licensing of IP	Licensing agreement; pre-clinical trials; US company changed priorities away from this invention.
Theta	UoM	US based user-enterprise (SME)	Science driven	The University of Manchester is recognised as a global leader in the development of a new material. It established a strategic partnership with one US-based enterprise	Strategic partnership	Opening of European basis of company at Manchester.

				leading commercialisation of material. This involved the location of the European headquarters and production facilities of the enterprise in Manchester, joint development work (using material supplied by the company) and support for the commercialisation of the IP generated by the University.		