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The governance of University knowledge transfer

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Abstract

Universities have long been involved in knowledge transfer activities. Yet the last 30 years have seen major changes in the governance of university-industry interactions. Knowledge transfer has become a strategic issue: as a source of funding for university research and, (rightly or wrongly) as a policy tool for economic development. Universities vary enormously in the extent to which they promote and succeed in commercializing academic research. The identification of clear-cut models of governance for university-industry interactions and knowledge transfer processes is not straightforward. The purpose of this work is to analyse university knowledge transfer models and assess recent developments in the literature on intellectual property rights, spin-offs and research collaborations. The paper also addresses the role played by university knowledge transfer organizations in promoting commercialization of research results.

Key words: European Universities, Knowledge Transfer, Governance, Intellectual Property, Knowledge Transfer Organization

JEL: I23, O3

1. Introduction

The last 30 years have witnessed a slow but continuous process of reorganization of European universities. The process started in the UK in the early 1980s and spread to the continent, beginning with the Netherlands and the Scandinavian countries, and more recently, southern European countries such as France and Italy. The rise of the ‘knowledge-based economy’ has increased the visibility among policy-makers, scholars, and business managers of those institutions that create and disseminate knowledge (Geuna, 1999). The massification of higher education, the increased scale (and scope) of university research and the more important role of knowledge in the production process have transformed small elite institutions, managed by academic peers in a collegial way, into large multi-task organizations in need of new governance structures to manage all the tasks and roles of these institutions today.

One aspect of this transformation, the focus of this paper, is the governance of knowledge transfer (KT) activities. Universities have always been involved in KT (or third stream) activities; they are not something new, something that has been “somehow” discovered in recent years, as argued by scholars in the Triple Helix or Mode Two traditions (Etzkowitz and Leydesdorff, 2000; Gibbons et al., 1994), who propose the idea of a new academic revolution characterized by universities becoming involved in KT activities. We can trace interactions between university professors (not necessarily with the universities themselves) and companies back to the development of the chemical industry in the nineteenth century (Meyer-Thurow, 1982). However, what it is new is the institutionalization of university-industry linkages through the direct involvement of the university. It would be incorrect to talk of an academic revolution because a real “second academic revolution” (the first being the introduction of research together with teaching in the early 19th century – see the Humboldtian transformation) would imply that everyone employed in a university is involved in both research and teaching, and third stream activities, which is far from the reality in most universities around the world. While some academic staff are heavily involved with companies through university offices devoted to KT, a significant number of academic staff are concerned only with teaching and research. What has changed is the type of activities (in response to new demands) and their relative importance and, therefore, the need to support, manage and organize them in

a more efficient way. In other words, the scale and complexity of the universities' activities has increased, moving from what we could define as "craft" production to something moving in the direction of "industrial" production, though only in a limited number of institutions we can really see the hallmarks of industrial production: a) standardisation of output, b) rigorous division of labour, and c) application of labour saving (or augmenting) capital. This has brought the need for an improved governance system that can cope with both the increased size and complexity and the highly specific and diversified group based production.

KT has become a strategic issue; it is a potential source of funding for university research and, (rightly or wrongly) has become a policy tool for economic development. While some countries are rethinking the roles of their research institutions (and their research funding) within national innovation systems – and especially with respect to industrial research institutes (and their core funding) (Arnold et al., 2006), there is substantial agreement about the increasing political pressures on universities to raise research funding from industry and contribute actively to economic development. This is because university research is seen as being able to promote local knowledge spillovers (Breschi and Lissoni, 2001; Calderini and Scellato, 2005; Feldman and Desrochers, 2003) and lead to regional innovation processes (Jaffe, 1989; Varga, 1998). In this context, it has been demonstrated that, for example, the growth of industrial laboratories is positively and significantly correlated with the extent of local university research (Furman and MacGarvie, 2007).

In recent years, many papers have examined various aspects of university-industry relationships. This literature has moved from being a niche strand to a dynamic field, with contributions from scholars in science and innovation studies (the original domain), sociology, business studies, economics, history, etc. KT activities have moved from mainly comprising research agreements with firms, to the current view that KT is mainly technology transfer (TT) and is focused especially on assessing and protecting intellectual property (IP), and making it available to industry.

It is not the aim of this paper to provide a review of the KT literature.¹ We discuss only those aspects that, in our judgement, are relevant for understanding the current governance of KT in universities. As will be discussed more thoroughly in the next section, there are various forms of KT activities, ranging from collaborative research projects involving universities and companies (e.g. research contracts), intellectual property rights (IPR) and spin-offs, labour and student mobility, consultancy, etc., as well as “soft” forms of KT, such as attendance at conferences and creation of electronic networks. Despite this diversity in the ways knowledge is exchanged with business actors, university governance of KT is found basically only in two main areas, which are analysed in this paper: IPR and spin-offs, and research contracts. In this paper, we analyse models of university KT and assess recent developments in the literature in the area of IPR, spin-offs and research collaborations. We extend the analysis to include the role played by university knowledge transfer organisations (KTO) in these transfer processes, as the KT initiatives in the areas addressed here are often implemented with the support of these institutions. Of course, most university knowledge is transferred via traditional channels such as exchange of human resources, publishing, consulting, conferences. However, these types of KT activities have not been institutionalized and little attention has been paid to their management and governance. Furthermore, there is scant evidence in the literature on how to deal with them and on the real necessity to institutionalize their management.

The remainder of this article is organized as follows. Section 2 provides a critical discussion of the models and institutions of university KT. Section 3 discusses in detail the evidence presented in the recent literature on the governance of university KT, paying particular attention to the organization of IPR and spin-offs. The concluding remarks summarize our findings.

¹ See, among others, the following special issues for references: *Science and Public Policy* 21, 1994; *STI Review* 23, 1999; *Research Policy* 29(2), 2000; *Management Science* 48, 2002; *International Journal of Industrial Organization* 21, 2003; *Economics of Innovation and New Technology* 16(2), 2007; *Industrial and Corporate Change* 16, 2007; *Oxford Review of Economic Policy* 23(4), 2007; *Journal of Economic Behavior & Organization* 63(4), 2007.

2. Models and institutions of university KT

The identification of clear-cut models for the governance of university-industry interactions and KT processes is not straightforward. However, it is possible to propose an oversimplified typology that, by focusing on the institutionalization of KT activities, distinguishes between the old model of governance of KT which existed before the advent of the so-called knowledge economy, and the new model.

In the old model, governance of KT activities was shaped by the personal relationships between academic researchers and industry and government (local or national). There were no (or very few) dedicated KTOs (the first KTO in Europe was probably the one established in Katholieke Universiteit Leuven in Belgium in 1973). Scientists, mainly due to their personal contacts (some of them developed during their university study years) developed networks of interactions with companies and government and acted, on a personal basis, as advisers and problem solvers; the university was not involved in these activities. Industry supported university research, usually through endowments and gifts rather than specific project contracts. In both the US and in Europe, large companies with R&D laboratories devoted to basic research (e.g. Bell Labs in the US, but also CSELT in Italy and ICI in the UK), played a special role, and academic researchers often collaborated with company scientists.

In 1975, the National Science Foundation, the agency supporting basic research in US universities, established in the US the first set of University-Industry Cooperative Research Centers (UICRCs); these organizations were intended to be the locus of university-industry interaction. This was the first step towards the institutionalization (and increased governance) of direct KT to industry as a missions of the university. The launch in the UK of the Alvey programme to foster university-industry relationships in the Information Technology (IT) area, in the early 1980s, was the first policy action in Europe, and was followed by a variety of other schemes in the UK and other EU countries.²

² The 1980s and 1990s saw the creation in all EU countries (in different years) of a large number of organizations, such as KTO, science parks and incubators, based in universities, that aimed at facilitating the transfer of academic knowledge to the economy.

The new model of KT stemmed from the assumption that the old model was not efficient for providing the knowledge needed by the new knowledge-based economy (Etzkowitz, 1983). The proponents of and policies supporting this view were focused on the professionalization of KT as the third main university activity. Clearly, this move has to be understood within the historical context of: (1) a reduced drive to finance university research for military reasons (for the US especially, the fall of the Berlin wall meant a significant reduction in US military spending in universities, though the trend started before); (2) the move towards reduced and more efficient intervention of government in the economy (the development of new public management views of government action); (3) government budget constraints due to the cap imposed by the new view on the role of the state, the introduction of the Euro and the high spending on health and pensions; (4) the push for an increase in the number of Higher Education (HE) students thought to be essential for the knowledge economy. In this context, government was willing to pay for the teaching related part of the universities' activities, but not the traditional "40% research" part automatically associated with teaching positions in most European HE systems. As a consequence, universities were encouraged to find other sources of funding to cover their research costs in the form of direct research funding from organizations, such as research councils and non-for-profit organisations (see the role of the Wellcome Trust in UK and Bank Foundations in Italy), and from third stream activities (which includes all the services, contracts and other activities that universities carry out for private commercial organizations or individuals to raise money). These sources of funding became an important part of the universities' total budgets in the UK, and are becoming increasingly so in the other EU countries (see, e.g. the recent introduction of direct research funding in Italy –PRIN- and the creation of the *Agence Nationale de la Recherche* in France).

The very simple characterization presented here oversimplifies the multiplicity of specific models of interaction among different countries (history and institutions matter a lot in this area as, until recently, universities were considered in Europe and Asia (not Canada and the US) to be national organizations), industries, technologies, firms (e.g. size and type) and universities.

Universities, like companies, vary enormously in the extent to which they engage in and experiment with new mechanisms to promote the commercialization of academic research, and in the extent to which they succeed in generating additional income from third stream activities. Many questions have been raised about the underlying reasons for this cross-institutional variety, and from a science and technology policy perspective, it is imperative to be better informed about them. Some of this variance can be explained by a specific country effect. The UK was the first to develop such policy and has made intensive efforts to create incentives for universities to carry out systematic interaction with business and society, while in Italy, for example, it is only in recent years that these kinds of policies have been introduced (at least at national level). However, within countries we can find high levels of heterogeneity in the approaches taken by universities to interact with business and society, firm, university and individual researcher characteristics are important in explaining the variety of models.

It is widely accepted that firms rely on several sources of knowledge in order to develop innovation activity and that university research contributes significantly to industrial innovation (Mansfield, 1995). Confirming this, in IBM's survey of chief executive officers (CEO) (IBM Global Business Services, 2006) around 13% of CEOs from 20 different industries and 11 geographic regions, pointed to academia as the most significant source of innovative ideas. From the university perspective, we know that KT between universities and industry takes place through a variety of mechanisms (D'Este and Patel, 2007; Muscio, 2008). These mechanisms range from recruitment of university graduates, to personnel exchanges, cooperative joint research, contract research, consulting, patents and publications, licensing, spin-off companies, and industry funded laboratories and other physical facilities, and also includes informal contacts such as meetings and conferences. D'Este and Patel (2007) show that the individual characteristics of researchers have a stronger impact than the characteristics of their departments or universities on the variety and frequency of interactions with industry. Researchers' previous experience of collaborative research and higher academic status have a significant and positive impact on the variety of interactions with industry. The quality of departmental research, on the other hand, has no impact on the probability of engaging in a variety of interactions. Elfenbein (2007) provides evidence that academic reputation impacts on the likelihood of

signing licensing agreements, but finds no evidence that an inventor's academic reputation affects the inferences made by potential licensees about the technology's value.

From the business perspective, Cohen et al. (2002) and Arundel and Geuna (2004) show that firms rely on a variety of sources of information on public research outputs, and also that there is no single source rated as most important by a majority of firms.³ Clearly, the firm size and industrial sector are major factors explaining the type and level of interaction (Laursen and Salter 2004; Mohnen and Hoareau 2003; Fontana et al. 2006), with larger firms generally having spare resources to invest or deploy in various type of interactions with university researchers, while the resources and capacity for small and medium sized enterprises (SME) to be directly involved with academics may be limited. Furthermore, the degree of complementarity between academic research and industrial application is a key factor in fostering interaction with industry. This is likely to depend on the composition of the local industrial structure and on the existence of a critical mass of firms in the area. Calderini et al. (2007) underline that policy related to university funding, which includes the possibility for university to increase industry funding, should keep in mind that the final outcome will depend on the characteristics of both the local scientific institutions and the local industry.

2.1 KTOs in the governance of KT

KTOs are becoming important (though not always effective) agents in KT processes, in the case of university collaborations with both large companies and SME. Under the broad heading of KTOs can be subsumed a large and varied set of institutions such as: the traditional university or public research centre TT office (TTO) found in Spain and the UK; the private research organization (PRO) holding companies found in Sweden; the TT companies (TTC) found in Israel; and targeted research centres such as the Fraunhofer Institutes in Germany and TNO in The Netherlands. In some

³ E.g., in Arundel and Geuna (2004), "publications" as the method for learning about public research outputs is rated as most important by the largest proportion of firms, 24%, closely followed by "hiring trained staff", 21%, and "informal contacts", 18%. While the figures presented are weighted and unweighted by R&D, the results show an *evenly* distributed importance for the different channels for learning about public research outputs. The figures in this text refer to the unweighted results.

countries, for example Italy (IPI, 2005), several kinds of KTOs coexist. Generally, TTOs are set up within universities or other public research institutes as adjuncts to pre-existing KTOs such as the holding companies in Sweden. In recent years, there has been a substantial increase in public and private investment in KTOs (Link and Scott, 2007).

The diversity in the institutional organization of public research in the EU countries has generated the high level of variety in KTOs. Restricting our analysis to those KTOs that are owned by, associated or affiliated with a university, we can conclude that KTOs have evolved in terms of their aims and objectives. Currently, TTOs tend to be focused mainly on the exploitation of IPRs via licensing or the creation of spin-offs. Historically, in a number of EU countries, Technology Liaison Offices (TLOs) or Industry Liaison Offices (ILOs) have been active in supporting university-industry interactions via contract research or consultancy, and were responsible for a broad set of activities and interactions with society at large. While some of these organizations have been transformed in TTOs others have maintained their original role. The missions of many KTOs include bridging between universities and industry, and not just marketing the results of university research, but also collecting business needs, especially at the local level. Finally, although there is some indication of a convergence across countries towards the model of TTOs based within universities and focused on IPRs, there is still much variety in the organization, aims and work of KTOs.⁴ And, although much current policy attention is devoted to IPR related issues it is important to acknowledge that contract research and consultancy are still dominant in the KT process⁵.

Since the mid 1990s, the number of KTOs in Europe and the US has increased dramatically (see the AURIL and Proton surveys for Europe, and the AUTM surveys for the US). In some countries (e.g. Belgium, Israel and the US), a few university established KTOs in the 1960s and 1970s. But it was not until the late 1980s and early

⁴ The coexistence of various type of KTOs is exemplified by the case of the UK where there are two professional associations: AURIL (Association for University Research and Industry Links) and UNICO (The University Companies Association). The former includes organizations concerned in general with knowledge transfer, while the latter tend to be more representative of TTOs focused on exploitation of IPRs and creation of spin-offs.

⁵ See, for example, the results of the UK Higher Education-Business and Community Interaction (HE-BCI) survey and Muscio, 2008.

1990s that KTOs began to be established in a large number of universities. In France, Spain and the UK the foundations of KTOs began in the mid-late 1980s, resulting in the formation of two national associations by the early 1990s. However, in France and Spain large national research organizations, such as CNRS, CSIC, CEA, INRA, INSERM and INRIA, KTOs have been active (and assessed) for several years. In Germany, the Fraunhofer Institute has played a dominant role in the transfer of knowledge since its foundation in 1949, however, or consequently, universities in Germany did not develop a strong system of KT and the establishment of KTOs in this country is recent. Sweden developed its own particular system, based on Holding Companies and Incubators and Science Parks, from the early 1990s, and it is only recently that some universities have begun to institute more traditional TTOs. In Italy, university KT activity through formalized KTOs, developed in the mid to late 1990s. And in Greece, although there is some longstanding KT activity, the first formal KTO was only funded in 2002. Finally, in the Eastern European countries, such as the Czech Republic, Estonia and Hungary,⁶ the organization of KT activities by universities through the creation of a few formal university KTOs, is a new phenomenon.

In most European countries with active KTOs there is an association or network of KTOs working to support the transfer of best practice across members, to develop training support and international connections, to influence national and European policy and to collect data on the performance of its members. Some of these associations such as the AURIL (UK), CURIE (France), NetVal (Italy), RedOtri (Spain) are members of the ProTon network, which links the various national associations at European level. Similarly, some of the national associations more oriented to IPR management, such as UNICO (UK), are members of ASTTP (Association of European Science and Technology Transfer Professionals). These associations have been collecting information on the activities of European KTOs, and universities more generally, especially in the last few years, while the AUTM has been conducting surveys in the US and Canada since the mid 1990s.

⁶ Similar to Germany, in Hungary KT activities are assigned to the Bay Zoltan Institute.

It should be noted that patent data collected by KTO associations refer to university-owned patents, but do not include university-invented patents (i.e. patents owned by a company or an individual with at least one university inventor). Confirming the results of Geuna and Nesta (2003, 2006) and Lissoni et al (2007), Crespi et al. 2006 show that university-owned patents account only for less than 20% of the total patenting activity of universities in Europe (80% of patents with an academic inventor are not owned by the university) and, therefore, is under-representative of the contribution of universities to the innovative process.

3. The governance of university KT

The heterogeneity among universities in terms of their engagement in KT activities and the success/failure of these activities indicate that, apart from the differential amounts of resources devoted to supporting TTO's goals, the governance of university–industry interactions influences both their frequency and their success.

Governance of KT is not new. In the last 30 years the US and European countries have attempted to develop “the right” infrastructural/organizational support to ease the exchange of knowledge between universities and companies. More than 30 years of mostly failure (but some success) in policies aiming to support KT have highlighted the difficulties inherent in the development of a successful organizational set up for the transfer of knowledge (and technology) from universities to businesses and society.

Universities have always made a significant contribution to economic development; however, the scale of current university research and the increased reliance on knowledge in the production process have created strong incentives for a more efficient way of transferring the discoveries made in academia to the business world. The partially tacit nature of knowledge and the difficulty involved in pricing it⁷ have complicated the design of a governance structure that creates the right incentives for

⁷ Arora et al. (2002) provide evidence that some minor forms of a market for technology based on licensing university patents has begun to develop in the US and in Europe.

academics to improve KT without damaging the traditional role of the university as knowledge producer and a locus of higher education.

The case of Johns Hopkins University, examined by Feldman and Desrochers (2003), illustrates the problems related to managing the conflicting goals of a founding mission to support curiosity-driven research, and an increasing focus on commercializing research activities. While the university goals of “creating knowledge for its own sake” and “disseminating knowledge” are the policy rationale for publicly funded (basic) research, a disregard for applied work (and its potentially successful commercial outcomes) may render some university departments redundant (as Feldman and Desrochers, 2003 shows), in the sense that some departments may lose touch with the practical problems, leading them to fall behind relative to the leading university departments in their discipline.

Some authors consider that the pendulum has swung too far in the direction of policies encouraging commercialization, to the point of endangering the open-science culture of universities and their reputation for good basic research (David, 2004; Nelson, 2004; Geuna and Nesta, 2006). For instance, Colyvas et al. (2002) argue that the conditions that would seem to justify the introduction of policies allowing academic institutions to retain the titles to patents derived from publicly funded research and development, and permit exclusive licensing of publicly funded research to encourage commercialization (i.e. the Bayh-Dole Act), are not always evident. In particular, a proportion of university-assigned patents involve inventions that are neither embryonic (since those inventions did not require significant further development to reach commercialization) nor a signal to industry (since these inventions were known about by people in industry before the universities began to market them). Though Colyvas et al.’s (2002) study is based on a small sample of inventions, it raises concerns about the extent to which policies promoting KT, while perhaps effective (but for only an handful of institutions) for increasing university revenues, may not be implemented in a way that maximizes the dissemination of knowledge from university to industry. Accordingly, Litan et al. (2007) found that in too many cases, university managers of US TTOs have adopted policies that encourage TTOs to become bottlenecks rather than facilitators of innovation dissemination. The authors are concerned with what they define as the ‘revenue

maximization model of technology transfer', which rewards university TTOs based on the revenues they generate rather than on the volume of inventions that universities transfer to industry. However, it has also been demonstrated that interactions between academic institutions and industry have positive effects on university researchers and could contribute substantially to improving their research performance (Gulbrandsen and Smeby, 2005). In fact, interaction between university and industry does not mean just transferring knowledge from the former to the latter: KT works in both directions. University scientists report that interacting with industry enables them to conduct better basic research, and to adopt a different perspective, which can sometimes be the inspiration for innovative research (Siegel et al., 2003). Moreover, one should consider how the development of TT as a professional field also opens new career perspectives to university employees and university students (Siegel et al., 2007). Finally, the question of whether stronger connections between university and industry are challenging the culture of open science in universities, and shifting attention away from basic research to applied, deserves further study. Within this crucial and current debate, KT managers at universities must be aware of the conflict between promoting university–industry partnerships in a situation where potentially successful pre-competitive university research is in danger of not being developed or commercialized by industry, and ensuring that when innovations are financed with public funds their dissemination is not being constrained by private interests.

In order to enhance the effectiveness of managers in universities and industry in the process of KT, Siegel et al. (2003) offer a set of recommendations (based on interviews with US university scientists and administrators and industry managers). One of the problems they highlight is the difficulty of bridging the cultural gap between university and industry. They recommend that people hired by university (industry) to manage KT should have a background in industry (university). This is a fundamental step in reducing the cognitive distance between managers and academics. Also, universities should be more flexible in negotiating agreements, and should avoid royalty maximization if this is likely to impede further collaborative work. Forums, workshops and informal meetings seem to be effective ways of facilitating interactions and exchanging information about current research interests, and, over the medium term, could form the basis for more formal collaboration and foster social networks of faculty and industrialists. As Murray (2004) shows, the

contribution made by university scientists to entrepreneurial firms is not just their personal scientific and technical knowledge and problem solving skills; it is also their social capital, that is, the social network that university scientists have built up during their careers. Murray (2004) argues that the social capital brought by university scientists contributes to integrating industry into the scientific community, and to establishing trust and long-term links.

Another issue is the rewards faculty receive for their participation in KT activities. There are a variety of mechanisms used to reward faculty for these activities, including consideration of patents and licences in promotions and tenure negotiations, and allowing faculty members a larger share (relative to that retained by the department/university) of licensing or equity revenues. However, as Friedman and Silberman (2003) show, greater pecuniary rewards to university inventors (as measured by the amount of royalty income they receive personally) are not significantly associated with the probability of achieving commercializable outputs. More research is needed into incentive structures that might be effective in stimulating involvement in KT activities, and establishing what is the relationship between a particular incentive structure and the volume of commercializable outcomes, taking into account that KT is much more than patenting.

3.1 Academic patenting, licensing and spin-off

Despite the evidence supporting the relevance of tacit knowledge flows (Grant and Gregory, 1997) and informal contacts between academia and industry (Bozeman et al. 1995) for the purpose of KT, most of the empirical evidence on university activities related to KT to industry, focuses on three types of mechanisms: patents (and invention disclosures), licences (royalties) and spin-offs. As Agrawal and Henderson (2002) note, there are a number of reasons why data on patents, licences and spin-offs are being used increasingly as a measure of university output: on the one hand, these university outputs are expected to be commercially useful and to generate important streams of income for the university (although in most cases they do not), and on the other hand, there is an increasing availability of data collected by university TTOs in the US and in Europe, which systematically include information on these types of outputs.

However, while a focus on patents, licensing and spin-offs as mechanisms of KT from universities to industry is understandable, it produces only an incomplete picture. Firstly, only a small fraction of the research conducted at universities can be codified in patents. As the NUBS (2003) report shows, based on data from 125 UK higher education institutions (HEI) for the year 2002, 45% of HEIs made no new patent applications (the mean number of patent application per HEI was 9) and 67% of HEI did not have a patent issued in 2002. Secondly, and equally important, the patenting channel accounts for only a small fraction of the overall knowledge transferred to industry. Cohen et al. (2002) show that only 17% of R&D performing firms consider patents as an at least moderately important source of public knowledge, and patenting cannot be considered to be representative of the channels conveying knowledge from the university to industry. Thus, as Agrawal and Henderson (2002: 45) argue “too great a focus on patenting may seriously misrepresent the nature of the impact of the university on the private sector”.

Most recent years have seen an increased reliance on academic IPR and spin-offs to try to efficiently/effectively transfer knowledge from universities, although very little positive empirical support has been found for these methods (Crespi et al., 2006). In fact, Antonelli (2008) argues that for the university system to work effectively non-exclusivity of IPR on the results of the research performed under contract is necessary. Rightly or wrongly, some EU countries (e.g. Denmark and Germany) have introduced Bayh-Dole act-like regulation, which assigns the IPR on academic research to the university, and removes professorial rights.

There are a few theoretical works that try to develop analytical models to explain the reasons for and implications of patenting scientific research (Hellmann, 2007; Mazzoleni, 2005; Thursby et al., 2007; Thursby and Thursby, 2007). Crespi et al. (2006) develop a set of empirical tests to assess whether the predictions in the theoretical literature and the assumptions in the normative policy literature on the higher efficiency of academic patenting as a mechanism of KT, can be validated, in the case of a sample of academic inventors in six EU countries. They find some evidence of higher levels of licensing for university-owned patents, but no evidence to support higher levels of use or commercialization, casting doubt on the theoretical

models and policy assumptions. Crespi et al. also point out that while in the US university-invented patents are a minority, in the EU they represent the large majority, indicating that European companies have developed interaction mechanisms with universities that are different from those used by US companies to access knowledge.

An increasing number of papers use data from European universities to complement the available literature based on US observations: Thursby and Thursby (2002) examine the patterns of invention disclosure (from university researchers to TTOs), patent applications, and licences from universities; Feldman et al. (2002) examine equity positions in companies as payment for the use of university IP; Di Gregorio and Shane (2003) examine the frequency of establishment of new firms to exploit university-assigned IP; Friedman and Silberman (2003) investigate the number of licences and level of licensing income generated by universities; and Bercovitz and Feldman (2004) investigate the faculty patterns of invention disclosure to TTOs .

Some of the more recent literature provides some insights into: (1) what are the characteristics of academic inventors and what is the relationship between patenting and publishing (Azoulay et al. 2007; Breschi et al. 2007; Carayol, 2007; Gulbrandsen and Smeby, 2005; Van Looy et al., 2006)⁸; and (2) what is the impact of university research patenting on the research practices of academic and industry scientists (Murray and Stern, 2007; Murray, 2005; Valentin and Jensen 2006).

These studies focus on understanding the complementarity or substitution effect between publishing and patenting and clearly show that those academic researchers (in both the US and Europe) involved in patenting are also very active in publishing. Some of the papers present strong evidence of a complementarity effect between the two research outputs, while others find little evidence of any substitution effect. There is some weak evidence of a non-linear inverted u-shaped relationship (see also Crespi et al., 2008). Overall, the evidence indicates that high quality university scientists are also active in patenting; and patenting may be preceded by higher than normal scientific productivity (in the US) or followed by a flurry of publications (such as in the Italian case). Life-cycle effects are present.

⁸ See also the Special Issue of *Economics of Innovation and New Technology* 16(2), 2007.

Murray (2005) and Murray and Stern (2007) present an institutional analysis of whether the increase in academic patenting is affecting the use and production of science. Murray and Stern provide some evidence that patenting may induce a modest decrease in the use/diffusion of scientific research and, consequently, result in future reduced production of new knowledge. Murray (2005) also highlights how the privatization of scientific ideas via patenting and licensing has not resulted in a complete privatization of the research area because academic scientists' resistance to and robust reliance on the norms of "open science" have created a hybrid economy in which both company and academic inventors use patents to protect and exchange their new knowledge. This new situation may be less efficient than the previous reliance on pure "open science" because of the transaction costs associated with patenting.

The paper by Valentin and Jensen (2006) constitutes a wake-up call to those policy makers who believed that the introduction of Bayh-Dole type regulation in the European context would be the solution to the supposed lack of contribution of universities to economic development. This paper clearly shows that since the law changed in January 2000, allowing the university right of ownership of a patent associated with an invention by a university researcher, there has been a steep decrease in the number of Danish academic inventors involved in patents by dedicated biotechnology firms (DBFs). The authors argue that this decreased contribution is because the new regulation, which requires some form of rational contracting to manage the property right, has created a disincentive for collaboration in early stage research where identification of shares or rights is more difficult.

Finally, Feldman et al. (2007) conducted a study on the history of how the Stanford University liaison office managed the patenting and licensing of the first major biotechnology process patent, the Cohen-Boyer patent for recombinant DNA (USPTO #4,2337,224; December 1980). The paper convincingly shows that non-exclusive licensing is the most suitable approach to maximize the diffusion and use of a process patent, such as the Cohen-Boyer patent which covers a fundamental new platform technology. The recombinant DNA technology resulted in the production of 2,442 known products and the foundation of hundreds of small biotech firms. These insights

are only partially confirmed by Bercovitz and Feldman (2007), who show that universities are the preferred partners of companies where there are concerns about the perceived ability to fully appropriate the results.

Licensing performance is the direct focus of analysis in another set of studies. For example, on the basis of a large, detailed panel sample of 110 US universities, Chukumba and Jensen (2005) examine how the characteristics of academic inventors, TTOs and universities affect licensing performance. One notable result is that, contrary to the UK case (Chapple et al. 2005), the older the TTO the higher is its performance. In contrast to previous findings, the presence of a medical school seems not to affect licensing. Some evidence is provided to support the view that “good science is useful science”, as the quality of academic researchers is shown to be positively related to licensing, and it is the quality of the engineering (not the biomedical) faculty that is especially important. Chukumba and Jensen also found evidence of a positive relationship between the importance of industry funding and the licensing agreement signed. Another study, based on AUTM data, confirms the centrality of human capital. Markman et al. (2005) present convincing evidence that the participation of academic inventors is a critical determinant of the speed of commercialization.

Finally, there are several recent studies on the UK context that focus on understanding the relative performance of TTOs (Chapple et al. 2005), their impact on the creation of spin-off companies (Lockett and Wright, 2005) and their potential role in second-order spin-off activities (Leitche and Harrison, 2005). The results of these studies indicate that UK TTOs have low levels of efficiency, very heterogeneous performance and decreasing returns to scale (perhaps due to the fact that the larger TTOs are generalists rather than specialists). Some evidence was found for the need for TT officers to have appropriate capabilities (business skills), confirming the prediction that well developed third stream activities in universities will require significant investment (Geuna and Nesta, 2003, 2006). Some of the results of these papers support the view that in certain UK regions it may be efficient to develop regionally-based, sector focused TTOs with broader responsibilities, including second-order spin-off activities.

Overall, there is substantial agreement in the literature that the analysis of university patenting, licensing and spin-off activities does not provide a complete picture of the extent and dynamics of university KT. However an increasing amount of effort is being spent on regulating and improving universities;’ management of these activities and there is an extensive literature on their effects on university research. Possibly, better patenting and spin-off practices could complement research performance and sustain university finances (at least in the case of a minority of universities). What we do not know is whether the focus of university KT practices on regulating these activities has a negative trade-off on the university’s capacity to establish collaboration with industry and become peers in local development processes. More than a decade ago Mansfield (1995) provided evidence that companies are prepared to trade faculty quality against geographic proximity, particularly in the case of applied R&D.

4. Conclusions

The scale of current university research, and the increased reliance on knowledge in the production process, have created strong incentives to develop a more efficient way of transferring the discoveries made in academia to the business world. In the last 30 years universities have changed in terms of the activities they carry out, the role they play within national innovation systems, and their governance of KT activities. At the same time as the remit of universities has been expanding to include a more market-oriented direction. Competition between research institutes and universities for public as well as private contracts, has increased, resulting in an inevitable change to the division of labour in knowledge production among universities, industry and applied research institutes.

Increasingly, universities are complementing their teaching and research activities with third stream activities oriented more towards having a direct socio-economic impact. However, university-industry interaction does not involve only transferring knowledge from the former to the latter; it also helps academics to conduct better research and provides improved understanding of research applications in industry.

Universities vary enormously in the extent to which they are involved in the commercialization of academic research and in the extent to which they succeed in generating additional income from third stream activities. Universities are investing (and are encouraged to invest) vast resources to protect their IP and to use patenting to generate additional income to fund their activities. In most cases these activities have resulted in a net loss. They have, however, allowed universities to formalize arrangements with industry and negotiate better terms for their interactions with companies. But, they do not fully capture the intensity of KT activities. KT occurs in a variety of forms and its relevance should not be underestimated in terms of the capability to leverage innovation activity in companies and sustain those industries where the use of patents is limited.

In several European countries and the US, a number of initiatives have been aimed at developing efficient infrastructures to ease the transfer of knowledge between universities and companies. However, the diversity in the institutionalization of public research across the EU countries has resulted in the heterogeneity in KT institutions, such as TTOs, and the activities they perform. In some cases, national coordination of KTOs has had beneficial effects in terms of knowledge dissemination and networking, in other not. In other cases, empirical evidence suggests that it may be efficient to develop regionally-based sector-specific KTOs. However, even in countries where there is no central coordination of KTOs' activities, efforts are being made to monitor their knowledge diffusion activities. The diversity in the approach adopted for KT from universities to industry, proves that, despite the availability of extensive evidence on what institutions do and how KT is achieved, it is not possible to produce a common formula for KT institutions and for how far universities should go in 'governing' KT processes. The picture becomes even more complicated if we consider the efforts extended by many universities in taking control of KT activities (sometimes against the resistance of faculty), to generate a range of initiatives aimed at increasing their level of interaction with industry.

Academia is rapidly increasing its involvement in the innovation process, mostly through spontaneous, endogenous KT initiatives. Many governments are promoting university-industry collaborations and creating bridging institutions to try to reduce the cultural gap between these two agents. However, the governance and management

of university–industry interactions can positively and negatively influence KT processes greatly, and needs to be monitored. Indeed, the rapid evolution of university KT activities needs to be supported by the implementation of best practice in regulating university–industry interactions, diffusing research results via KTOs beyond the local level, and promoting best practice in the management of KT. Despite the radical differences among the different university systems in Europe, much can be done in terms of exchange of best practice to avoid expensive mistakes that could jeopardize universities’ capabilities to respond to companies’ needs for knowledge-intensive services.

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