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# **The Flow of Knowledge from the Academic Research Base into the Economy: the Use and Effectiveness of Formal IPRs and “Soft IP” in UK Universities.**

A Report to the Strategy Advisory Board for Intellectual Property Policy (SABIP)  
This research was commissioned by SABIP as an independent input to evidence for policy, and is published by IPO



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## Executive Summary

Academics produce a wide range of intellectual property (IP) products, which can be transferred to industry, government and other external stakeholders in different ways. Models of IP transfer involve different roles played by technology transfer offices, scientists, external commercialisation companies and universities themselves.

Two comprehensive literature reviews recently commissioned by the Strategic Advisory Board for Intellectual Property Policy (SABIP) (Baghurst et al, 2009; Rogers et al, 2009) have emphasised that different models of IP transfer can be appropriate in different circumstances. They stressed the need for more extensive investigation into the nature, advantages, value and limitations of “soft” forms of intellectual property (IP) – such as copyright, open source, trademarks and design rights – in counterbalancing the predominant use of patents (or “hard IP”). Such research would provide a more complete picture of the full contribution made by university knowledge to industry and society.

Our report makes an original contribution to the understanding of different IP governance models of university-industry knowledge transfer. It also offers new analysis of the absolute and relative importance of “hard” and “soft” IP in the knowledge flows between universities and external stakeholders. Our focus is on processes of direct and indirect knowledge transfer from university to industry, government and society, and on their feedback to universities through knowledge and financial flows.

Our primary focus is on the use of formal intellectual property rights (IPRs) and “soft IP” as the new ideas and creative expressions developed by academic researchers are put into use. We do not aim to assess in great depth the *full* range of knowledge transfer processes in which universities engage, which include a much wider and very complex web of interactions between university, industry and the community (HEFCE, 2009, 2010a). Rather, this report contributes to a more thorough understanding of the subset of university knowledge exchange activities involving some explicit IP transactions. We do so through a theoretical and empirical investigation of the analytical framework developed by SABIP on the flows of knowledge between the universities’ research base and commercial and social use, and by proposing new ways to articulate this framework more fully.

We look in detail at 40 UK universities (26 % of the total) to investigate:

- how universities with different characteristics (history, age, size, region, research orientation) manage their knowledge flows with external agents (industry and government) with respect to the exchange of different types of “hard IP” (focus on patents and copyright<sup>1</sup>) and “soft IP” (focus on open source IP and technology with no patent protection);
- the strategic incentives or motivations underpinning these knowledge flows, and the IP governance structures through which they are accomplished; and finally,
- the obstacles hampering the quality of the interactions between universities and external agents, which prevent knowledge from flowing smoothly or effectively, and therefore impede performance.

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<sup>1</sup> While Baghurst et al (2009) include copyright among “soft IP”, in our empirical analysis we consider “soft” and “hard” IP according to the extent to which there are restrictions on using, sharing, copying and modifying it: we use the term “hard IP” for IP on which such restrictions are enforced by legal means (for example, proprietary IPRs such as patents and copyright), and “soft IP” for IP on which some or all of these restrictions are relaxed (for example, open source and non-patented innovations). This point is further considered in Section 2.2.

Evidence is based upon three main sources:

- A database of the IP strategies of UK universities, developed under Work Package 3.2 “An IPR Regime in Support of a Knowledge Based Economy”, part of the UKNOW (“Understanding the Relationship between Knowledge and Competitiveness in the Enlarging EU”) project of the EU 6th Framework Programme (contract number CIT 028519);
- Specific case studies in three different UK universities, including a research university with a strong orientation towards the social sciences (henceforth, University 1); a research university with a focus on the sciences, including medical (University 2), and a university that was a polytechnic and has a strong regional focus (University 3).
- We also collected expert views from academics, university knowledge transfer teams, government agents, research funding bodies and private sector enterprises. Those views were collected at a conference at Birkbeck College (June 29, 2010) entitled “Creating value from academic-commercial collaboration” [[www.bathwick.com/birkbeckevent](http://www.bathwick.com/birkbeckevent)]. It was attended by around 80 active participants, including 30 expert speakers leading the debate.

Overall, the results show that universities use a variety of IP (both “hard” and “soft”), and that different forms of IP are used in complementary ways.

Type and size of university matter. Older universities and former polytechnics tend to be the most active in the transfer of *all* forms of IP (patents, copyright, open source IP and technology with no protection). Larger universities tend to be more active in the transfer of patents, compared to other types of universities. Furthermore, the importance of the different models of IP transfer depends on numerous interdependent factors, including: the extent to which the university is research-intensive or more oriented to teaching, the nature of its knowledge base, its entrepreneurial culture and the competencies within its technology transfer office (TTO)

Knowledge flows between universities and external stakeholders in both directions. The process of knowledge transfer cannot be represented in linear terms, but is better understood as a system of relationships in which both universities and firms fully participate.

In particular, knowledge transfer (from universities to firms) is accomplished by intensive use of all forms of IP. Knowledge feedback (from commercial use to universities) is mainly pursued by using “soft IP” (open source and IP with no protection). Furthermore, universities sell or out-license “hard IP” (patents and copyright) mainly to raise income, although the success of this strategy is strongly debated in the literature.

The results also show that IP governance forms matter for the transfer process, in the sense that universities choose to use particular IP governance forms (selling, buying, licensing IP, open source etc) to achieve particular strategic objectives related to knowledge transfer processes from research base into use, creating awareness of research base in universities, knowledge feedback from use back into universities, and financial income.

Finally, institutional failures exist in all IP marketplaces, preventing knowledge from flowing smoothly and effectively. They occur most intensively in markets for patents and non-patented innovations, and include problems related to market search, market transparency and contract negotiation. However, all IP marketplaces report problems with assessing the economic value of IP.

There are implications for policy. Universities’ knowledge bases, research outcomes, organisational features and knowledge management strategies are diverse. This needs to be reflected in a variety of models stimulating knowledge flows, using both “hard” and “soft” IP and a range of IP governance structures. Policy instruments need to be flexible enough to allow universities to develop different approaches to the strategic management of their knowledge and financial flows.

Moreover, since universities produce a variety of research outputs, focusing too strictly on the patent instrument is likely to limit rather than maximise knowledge transfer. There is plenty of empirical evidence that patents are only effective for selected industries (particularly biotechnology and pharmaceuticals) while firms in most other industries rely on different IP models to manage their knowledge and innovate.

Finally, metrics used to measure universities' research and impact performance are an important driver of the universities' choice of knowledge transfer models (see e.g. Sorensen and Chambers, 2008, Kesan, 2009). So, it is important that those metrics are not biased on indicators measuring patenting and licensing activities, but that they encompass a wider variety of IP indicators, including some based on "soft IP".

# 1. Introduction: Universities as an Interactive Partner in our Economy

Interest in innovation and knowledge transfer from university to industry has flourished in the last two decades. The emphasis on the economic role of the university as a producer of knowledge that feeds into innovation processes builds on numerous theoretical developments since the 1980s, including: the economic debate on knowledge-driven economic growth (Lucas, 1988; Romer, 1990); the literature on the features of the “knowledge economy”, characterised by a faster rate of technological progress and the greater economic importance of knowledge industries, including the university sector (Quah, 1998); the economic geography debate, where universities are held to play a key role in regional economic development through collective learning processes (Lawton-Smith, 2007).

Recent research by Haskel and Wallis (2010), using UK data, suggests that investment in public research and development (R&D) produces significant productivity-enhancing knowledge spillovers to markets (unlike private investment in such intangibles). Furthermore, there is a significant direct effect of university research on corporate patents in some specific research areas (Jaffe, 1989) and knowledge spillovers are higher when universities and firms are located near to each other (Jaffe et al, 1993; Agrawal and Cockburn, 2003).

Universities are seen as key agents in a country’s national innovation system (Lundvall, 1992; Nelson, 1993), playing a crucial role in the production and dissemination of new knowledge. But the extent to which universities are successful in doing so is likely to depend upon the nature and quality of their knowledge transfer processes, as well as upon their organisational processes and strategies. These are influenced, at least in part, by public policies and regulatory frameworks.

Since the 1980s, policymakers in many countries have believed that formal IP protection, particularly through patents, copyright and trademarks, is required for university-produced knowledge to be transferred effectively. However, this model has recently come under intense criticism, with numerous researchers encouraging universities and policymakers to consider alternative models.

Based on empirical evidence from UK universities, our report contributes to this debate and provides new policy recommendations. In particular, section 2 provides an overview of the theoretical framework underpinning the current debate on academic patenting, identifying several key (interdependent) topics which are currently under-researched or which appear particularly problematic. Table 1 below (middle column) lists the main topics discussed in Section 2; these relate to several research questions (listed in the right column) which form the basis of the empirical analysis in Section 3. Section 4 offers our conclusions.

Table 1. Topics and research questions investigated

| <i>Section where discussed</i> | <i>Topic</i>  | <b>Research question (RQ) derived, discussed and presented in Section 3</b>   |
|--------------------------------|---|---|
| <b>Section 2.2</b>             | Expanding the analysis of knowledge flows from the research base into use: not only “hard” but also “soft” IP       | RQ1: <ul style="list-style-type: none"> <li>Do universities transfer different forms of IP (patents, copyright, open source, innovations with no protection), and if so do they use them as complementary or alternative?</li> <li>What specific IP governance forms do universities use more intensively when transferring IP?</li> </ul>  |
| <b>Section 2.2</b>             | Governing the flows of knowledge between the university system and external actors: different models of IP transfer | RQ2: <ul style="list-style-type: none"> <li>How - and to what extent - is the transfer of different forms of IP related to the universities' strategic management of their knowledge flows from the research base into use (and vice versa)?</li> </ul>   |
| <b>Section 2.3</b>             | Different models of involvement of the university in IP transfer  | RQ3: <ul style="list-style-type: none"> <li>Do universities with different organisational characteristics transfer different forms of IP and use different IP governance structures?</li> </ul> RQ4: <ul style="list-style-type: none"> <li>Do universities with different organisational characteristics seek different strategic benefits from the management of their IP?</li> </ul> |
| <b>Section 2.4</b>             | The roles and inefficiencies of IP marketplaces and IP governance forms   | RQ5: <ul style="list-style-type: none"> <li>What obstacles do universities encounter when transferring IP, which prevent them from effectively and efficiently manage their flows of knowledge between research base and commercial use?</li> </ul>   |

Methodologically, the research topics and related research questions (Sections 2.1 to 2.4) are discussed through a review of the economic literature, supported with evidence from interviews with (i) technology transfer managers at universities and (ii) other stakeholders:

(i) The three universities we interviewed were chosen to capture the diversity of institutions: a research university with a strong orientation towards the social sciences (university 1); a research university with a focus on the sciences, including medicine (university 2), and a former polytechnic with a strong regional focus (university 3). These interviews were carried out alongside the UKNOW survey (see further details below) which underpins the data of this project,

(ii) We also interviewed leading knowledge transfer researchers, university knowledge transfer teams, government agents, research funding bodies and private sector enterprises at a Birkbeck College conference entitled “Creating value from academic-commercial collaboration”, [[www.bathwick.com/birkbeckevent](http://www.bathwick.com/birkbeckevent)], co-organised by Birgitte Andersen (June 29th, 2010, - 80 participants, including 30 expert speakers leading the debate).

The results of these interviews are embedded in chapters 2 and 3.

The survey results are analysed in Section 3. They are based upon data collected through Work Package 3.2 “An IPR Regime in Support of a Knowledge Based Economy” which forms part of the UKNOW (“Understanding the Relationship between Knowledge and Competitiveness in the Enlarging EU”) project of the EU 6th Framework Programme (contract number CIT 028519); henceforth, we refer to it as the “UKNOW survey”. The data allow us to investigate the exploratory research questions linked to each topic (see Table 1).

**Summary of Section 1:**

- Universities are widely acknowledged to play an important role in the production and dissemination of new knowledge, but there is debate about the best methods of knowledge transfer.
- How knowledge transfer processes unfold in practice depends upon the nature, structure and quality of the interactions among the stakeholders, as well as the organisational characteristics (history, age, size, region, research orientation) and IP strategies of universities involved.
- Investigating some of these aspects in relation to the UK university system and its management of IP flows with other agents in the national innovation system is the main objective of this report.

## 2. Analytical Framework and Research Questions: Theoretical Focus and Empirical Review

### 2.1. *Governing the flows of knowledge between the research base and commercial use*

Innovations either result from the development of new knowledge or from the recombination of existing knowledge in new ways or both. Therefore, the conceptualisation of the economic properties of knowledge is important in explaining the incentives and problems in the creation of those new ideas and in their circulation.

When economists began to study knowledge as an economic good in the 1950s, they equated it with information - the symbolic representation of knowledge content. Information has the character of public good: it is “non-rival”, since more than one person can use it at the same time, and non-exclusive, since it can be shared easily and rapidly and it may be difficult to prevent potential free riders from accessing it (Arrow, 1962). Moreover, it is difficult to assess the value of information: the potential buyer cannot appreciate it without knowing its content, but once the content is disclosed, the buyer no longer needs to purchase it. As producers are unlikely to gain a full return on information that they generate, private firms are likely to under-invest in its generation: public intervention is therefore required to ensure that a socially efficient amount of information is produced (Arrow, 1962)

Scientific knowledge arguably possesses the features of public goods (Dasgupta and David, 1994, p. 493); basic research activities are particularly prone to market failure, since their outcomes are fundamentally uncertain and they tend to produce large externalities (Nelson, 1959).

To ensure that a socially efficient level of scientific knowledge is produced, particularly from basic research, the government can engage directly in knowledge production, making it freely available for use (as in the government research system), or offering public subsidies to academic institutions, requiring them openly to disseminate their findings in the public domain (as in the academic research system) (Dasgupta and David, 1994).<sup>2</sup> Both the government and the academic research systems imply a combination of public funding of research and free dissemination of its outcomes, because it is assumed that, once public funding has ensured a sufficient level of scientific knowledge production, there is no need for further interventions to facilitate the transfer of knowledge to potential users.<sup>3</sup>

Since 1980, numerous legislative reforms have been introduced (such as the Bayh-Dole Act in the US), which allow universities to patent the results of publicly-funded research. Their rationale was not to create incentives for innovation (since most university research activities are publicly-funded) but to ensure that universities engage in an efficient amount of knowledge transfer.

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2 This argument in favour of the public funding of academic science has been extremely influential in the US and Europe, especially throughout the second half of the 20<sup>th</sup> Century (Mowery, 1983; Crow and Tucker, 2001)

3 As information is completely codified, it flows easily and without cost among agents, even over large geographical distances; therefore, once information has been produced and placed in the public domain, it is assumed that there is no need to support its transmission.

According to legal and economics theoretical literature, IPRs enhance knowledge transfer in several ways:

- IPRs provide incentives to use and allocate resources for invention more productively (Posner, 1992): without IPR protection, innovation would be biased towards inventions that could be held secret with minimum preparatory investment; the enforcement of IPRs should encourage inventors to come up with the most competitive product or process;
- IPRs provide incentives to disclose ideas (Andersen, 2004): the filing of patents and copyrights in libraries provides immediate information to economic agents, who can incorporate them into their own knowledge bases even though they cannot directly exploit them for commercial purposes.
- IPRs make possible and incentivise “markets for information and technology” and knowledge diffusion: thanks to profit seeking inventors (individuals and firms), who can increase their profit as market expands, formal IPR protection is expected to increase the circulation of ideas through trade (Romer, 1990). In that way, licensing and trading of IPRs also lead to information and knowledge spillovers, as individuals and firms are learning about the new technology once it is adopted, speeding up knowledge diffusion (David and Olsen, 1992);
- It is assumed that IPR markets are efficient, and that the only provisions required to foster an efficient level of knowledge production and transfer are the presence of appropriate supporting institutions like clear rules of the game, effective enforcement mechanisms and the provision of sufficient information.

Over time, the number of university-owned patents has grown and universities have increasingly engaged in patent transactions (Geuna and Nesta, 2006). However, academic patenting activities have recently been heavily criticised. Many commentators now suggest that greater attention should be paid to alternative models of knowledge transfer.

Moreover, economists seem to have moved away from the conceptualisation of knowledge as information in favour of a broader approach. Now, knowledge is recognised as both “codified” – easily transmitted through publication or other defined media – and “tacit” – less easily transmitted ideas developed through habit, practice and culture. Knowledge is increasingly conceptualised as partly tacit, cumulative, only partially appropriable and situated in organisational routines and individual skills (Ryle, 1949; Polanyi, 1966; Cowan and van der Paal, 2000). These features of knowledge reduce its mobility and public good properties, since knowledge transmission does not take place instantly and without cost, but often requires purposeful interactions between economic agents (Chesbrough, 2003; Nooteboom, 2004).

Empirical evidence has confirmed that knowledge transfer is often accompanied by direct interactions, even when the knowledge being transferred is codified in documents such as publications or IPR contracts (Meyer-Kramer and Schmooch, 1998; Bozeman et al, 1995). This approach is consistent with the more systemic views of innovation that have emerged since the late 1980s, which emphasise interactions between different organisations and institutions in order to support innovation processes.

Table 2 below summarises the key steps in the evolution of the theoretical interpretation of knowledge, and relates each step to those mechanisms that guarantee the production of socially efficient amounts of knowledge and those that permit knowledge transfer.

*Table 2. Evolution in the theoretical understanding of knowledge and normative implications*

| <i>Assumptions</i>   | <i>Main theoretical references</i>   | <i>Reference period</i> | <i>Implications for knowledge production</i>   | <i>Implications for knowledge transfer</i>   |
|--|--|-------------------------|--|--|
| Knowledge as information   | Economics of information.<br>Linear model of innovation.   | Since 1950s             | Public funding of knowledge production in the government or academic research systems        | Free dissemination of research outcomes  |
| Knowledge as information   | Economics of information.<br>New institutional economics.  | Since 1970s             | Implementation of clear rules and effective enforcement mechanisms for the protection of IPR | Once IPRs are in place, markets for knowledge arise to guarantee the transfer of knowledge among economic agents |
| Knowledge as partly tacit, sticky, localised, specialised, cumulative, recombinant | Economics of knowledge.<br>Resource theory of the firm and other heterodox approaches to firm theory.<br>National systems of innovation. | Since 1980s             | Implementation of mechanisms to foster interactions among agents to produce new knowledge    | Implementation of mechanisms to foster interactions among agents to transfer existing knowledge                  |

These models are not strictly competitive. Published or patented ideas are often accompanied by interactions – such as meetings or seminars - while interactions between universities and other agents can subsequently lead to joint publications or patents. There is, however, some conflict between deciding to disseminate knowledge openly through publications and deciding to embed it in IPRs and transfer it to private economic agents at a price, as we discuss in the next Section 2.2.

Universities have been increasingly encouraged to protect their research outcomes through IPRs, instead of openly disseminating them, since IPRs enable them more effectively to transfer knowledge to industry through well functioning IPR markets. But, do these assumptions hold in practice? Thanks to the empirical analysis in Section 3, we can check whether IPRs are more effective than open channels as a means to make the best use of university research findings (see research question 2) and whether markets for IP function efficiently (see research question 5). This analysis will improve our understanding and contextualisation of the different models of knowledge transfer identified by the literature.

#### *Alternative focus areas*

At this stage, we should point out the limitations of our analysis.

First, it is widely acknowledged that universities primarily transfer knowledge to industry and society through their education mission, by increasing people’s skills; in turn, a better skilled workforce is not only related to increased productivity and innovativeness within firms, but also to a greater ability to access and absorb academic knowledge, which supports knowledge creation. In addition, academics engage in many interactions with external stakeholders which do not involve the

negotiation and transfer of IP, but which are nonetheless beneficial to local communities and the broader society (HEFCE, 2010a). These processes, although very important, remain outside the scope of our discussion.

Second, we look at the issue of enhancing knowledge and resource flows between the research base and commercial use only from the perspective of universities. There is a growing body of research analysing these issues from the perspective of firms, but this remains beyond the scope of our study. Studies of knowledge transfer between firms and universities have shown that for firms the most important channels in accessing university knowledge are the traditional “open science” ones (publications, conferences), followed by collaborative relationships (joint ventures, contract research, consultancies), and employment-based channels (graduate recruitment, secondments at universities, and the like). Use of university patents generally tends to rank lower in importance. This is confirmed by numerous empirical studies (Bruneel et al, 2009; Cohen et al, 2002; Mowery and Sampat, 2005), which have also pointed out that business interactions with universities depend upon: size (larger firms have more collaborations), R&D intensity (more R&D intensive firms collaborate more - absorptive capacity) and distance (though its importance differs for different industries).

Third, our empirical analysis looks at the flows of knowledge between universities and the commercial sector by analysing the transfer of different forms of intellectual property. It does not look at the nature of the relationship between these agents that provides the context for these transactions, focusing only on the characteristics of the transactions themselves. There is a large body of literature on the characteristics of collaborations between universities and firms that may give rise to the exchange of intellectual property. These include contract research (with the university or with individual researchers), joint ventures, consultancies, graduate recruitment, joint supervision of postgraduate students, professional secondments into industry or university, creation of academic spinouts.

Our qualitative interviews with universities have confirmed that the importance of these different relationships varies according to numerous interdependent factors, including the relative importance of research and teaching, the university’s knowledge base, its entrepreneurial culture and the competencies within the technology transfer office (TTO). Research-intensive universities are successful at obtaining grants from research councils and other public sources, and their research and grants office may manage a larger share of university income than their technology transfer office. By contrast, teaching-oriented universities may be induced to make up for their lack of research resources by being more commercially oriented, by developing a third stream agenda focused on innovation, the creation of new companies and the provision of services to businesses. Indeed, universities that are less research-intensive often receive more funds from industry than those which have a profile of research excellence (Geuna, 1999).

Teaching-oriented universities make the most of their more applied and “vocational” agenda by developing links with industry around specific technologies. This may give them an advantage over research universities, which tend to be engaged in more abstract research with fewer immediate commercial applications.

Different knowledge bases are also important in influencing the nature of universities’ relationships with businesses. Universities focused on the social sciences may obtain large scale government contracts to monitor the success of policy initiatives, for example, while engineering specialists are better able to obtain contracts from industry. Of the three universities that we interviewed, only that with medical, biological and pharmaceutical sciences faculties valued patents for knowledge transfer. The other two saw patenting as a potential by-product of other types of activity, but not an end in itself. In fact, neither of those universities has significant internal capacity to deal with IPRs; one entirely outsources its IPR activities to another university.

Our survey data allows only a limited investigation of the relationship between such organisation-specific factors and the transfer of different forms of IP.

### **Summary of Section 2.1:**

- The evolution in the theoretical understanding of information and knowledge has been reflected in policies for university-industry knowledge transfer: from the simple funding of basic research, to the implementation of IPRs on academic research outcomes, to the support of direct interactions between companies and universities.
- Our empirical analysis researches the flows of knowledge between universities and the commercial sector by analysing the transfer of different forms of IP (see also section 2.2), the strategic incentives (see also table 3) underpinning such transfers, and their effectiveness.
- Qualitative interviews and empirical studies have confirmed that the importance of the different types of relationships between university and industry that may give rise to IP (contract research, joint ventures, consultancies, graduate recruitment, joint supervision of postgraduate students, professional secondments, academic spinouts) varies according to numerous interdependent factors. These include the extent to which the university is research-intensive or more oriented to teaching, the university's knowledge base, its entrepreneurial culture and the competencies within the technology transfer office (TTO). The survey data at our disposal allows only a limited investigation into the relationship between such organisation-specific factors and the transfer of different forms of IP.

## ***2.2. Expanding the analysis: not only “hard” but also “soft” IP for strategic value seeking***

Different governance mechanisms can ensure that universities produce a socially efficient amount of knowledge and transfer it to the economy. Different mechanisms for knowledge dissemination produce different – and sometimes conflicting - incentives for knowledge production: the decision openly to disseminate a piece of scientific knowledge prevents the subsequent implementation of IPRs; and the potential economic rewards that can be gained from the sale and licensing of patents bring new incentives and objectives to the university's activities beyond its traditional public service mission.

In recent years, a large literature has examined the possible negative side-effects of patenting academic discoveries. It has been suggested that patenting can limit the freedom of scientific enquiry, change the nature of university research, create imbalances within the academic system and lead to conflicts with industry. Some critics have argued that commercialisation pressures could induce universities excessively to favour applied research at the expense of both basic research and education and training. This in turn would undermine the original economic rationale for the public funding of university research. From a dynamic perspective, it is feared that more applied research may even reduce the quality of both patents and academic publications, as patents replace publications as the primary means of disseminating new ideas (for a comprehensive review of the debate on the negative effects of university patenting, see Baldini, 2008). In the long term, some commentators worry that encouraging universities to divert resources from blue-skies basic research to more applied research may even slow down the rate of innovation in the economy (Florida, 1999).

It has also been argued that the production of highly applied knowledge may put universities in direct competition with industrial research, discouraging businesses from investing in their own research activities. University patenting may even reflect negatively on industry, due to restrictions on university-industry communications, delays to industrial innovation, loss of proprietary information, obstacles to new research fields and unreasonable cost increases (for discussion, see Baldini 2008). Another implication relates to the extent to which IPR-protected knowledge is used as an input in academic knowledge production activities. Mowery et al (2001) have argued that the increased privatisation of research results may raise the cost of using scientific knowledge and restrict its dissemination, especially as universities increasingly turn to the patenting of their basic scientific discoveries. It has been noted that patenting has restricted some disclosures, data sharing and previously widely available research tools (Blumenthal et al, 1986; National Research Council, 1997) and that these restrictions have led to less diversity in scientific experimentation (Murray et al, 2009).

At the same time, mitigating empirical evidence has shown that increased patenting of research outcomes has *not* led to a quantitative or qualitative decline in the knowledge produced by universities. Some studies have suggested that patenting and publication are complementary activities, with highly productive star scientists reaching high levels of both (Zucker and Darby, 1996). Others studies showed a positive relationship between intellectual eminence and success in research commercialisation (Elfenbein, 2007). It has been suggested that the increase in patenting activities by universities owes more to the emergence of scientific fields rich in potential commercial applications, such as biotechnology and ICT, than to the effect of legislative changes in themselves (Mowery et al., 2001). In fact, high levels of patenting are mainly confined to a few disciplinary fields (Henderson et al. 1998; Geuna and Nesta, 2006), and most knowledge dissemination from academia to industry still takes place through the traditional, non-protected “open science” channels (Meyer-Kramer and Smooch, 1998). Consequently, it has been argued that the effects of post-1980 patenting legislation, such as Bayh-Dole, have not been radical and that universities have not significantly altered their research behaviour (Rafferty, 2008).

Besides the theoretical arguments, the extent to which universities have been successful in reaping rewards from the privatisation of academic knowledge is controversial. Research has shown that very few universities make money from patents and licences (Charles and Conway, 2001; Bulut and Moschini, 2006), the direct costs of IPR usually exceed revenues (Charles and Conway, 2001) and many university technology transfer offices struggle to be profitable (Kenney, 1986). Collaborative research projects, including consultancies, also appear to be a more important source of income than licensing (D’Este and Perkmann, 2007).

According to Macdonald (2009), this lack of economic reward for universities may be explained by the fact that patenting does not work well in every economic sector. Although universities produce a wide variety of research output, they have all adopted a model of technology transfer that is typical of the pharmaceutical industry, one of the heaviest users of the patent system (Levin, 1986; Harabi, 1995). However, in most other industries (such as in software and electronics), firms exploit their technological advantage through trade secrets, marketing strategy and lead time, rather than patents (Klevorick et al., 1987). Consequently, university managers tend to overvalue patents, when they should be focusing on different procedures, methods and goals for different industries (Macdonald, 2009). Our qualitative interviews have confirmed that patents are not the primary IP transfer channel for most universities; the exception being the institution with a knowledge base including medical, biological and pharmaceutical sciences as well as engineering.

Another related complication is that not all the IP produced by universities is suitable for patenting. Baghurst et al (2009) distinguish between “hard” IP, which can be protected through patents, and “soft IP” which is generally not patented. Their examples of “soft IP” are: non-software copyrighted materials (articles, reports, books, lecture notes, presentations); software (source level code as well as executable programmes developed by researchers in the course of their research work);

materials (synthesised by researchers working in the fields of chemistry and materials); database rights; cell lines; new plant or animal varieties; registered and unregistered designs; photographs and videos; research questionnaires; and tacit knowledge (know-how), a class of “soft IP” which is hard to codify and transfer but which is nonetheless valuable to third parties. These forms of IP are especially important for those universities strong in the social sciences, arts and humanities. For example, our interviews revealed that firms in the creative industries are important partners for universities that have competencies in fields such as arts, crafts, design, computer science, education science and the humanities in general, but such interactions are unlikely to involve the exchange of formal IPRs. However, unlike Baghurst et al (2009), we have decided to classify copyright as a form of “hard IP” (on the grounds of its classification as a proprietary IP related to its ability to restrict use of IP) rather than as “soft IP”.

As Baghurst et al (2009) pointed out, despite the quantitative importance of “soft IP” for universities, the issues relating to its generation, identification, commercial exploitation and value are systematically under-explored. While there have been some studies on the complementary use of different forms of IP, these have generally involved industrial sectors rather than universities. Moreover, most studies on alternative IP protection mechanisms focus only on “hard IP”, looking at the role of trademarks, design registrations and copyright (Graham and Somaya, 2006; Ramello and Silva, 2006) but neglecting soft forms of IP. Only a few case studies have examined how software firms use both open source and patents as part of their commercial strategies (Campbell-Kelly and Garcia-Swartz, 2008). Moreover, most of the literature assumes that different IP protection mechanisms are distinctive rather than complementary, despite lack of evidence to support this assumption (Nelson, 2006; Teece, 2006).

A key contribution of our empirical analysis is that it builds a more reliable picture of the ways in which universities actually transfer IP, by focusing not only on the transfer of patents, but on a broader range of both “soft” and “hard” IP, to which the economic literature has so far paid little attention. We are also much more open to the complementary nature of different IP channels, and investigate how they operate in practice. By focusing on four broad forms of IP – patents, copyright, open source and non-patented innovations – our empirical analysis captures most forms of “hard” and “soft” IP that universities produce.

Numerous authors (including Sorensen and Chambers, 2008) assume that non-patented intellectual property (know-how etc) is transferred to industry as part of a university’s normal research and teaching activities. Instead, we explicitly asked universities about the transfer of non-patented knowledge through several specific governance forms: releasing non-patented innovations to private firms or to the public, using non-patented innovations, and collaborating with other universities with no patent restrictions. We also investigated open source software, an example of a class of IP where the innovation does not need to be patented for it to be successfully transferred into the public domain.

Table 3 lists the different forms of IP and the specific governance structures that have been investigated through the survey.

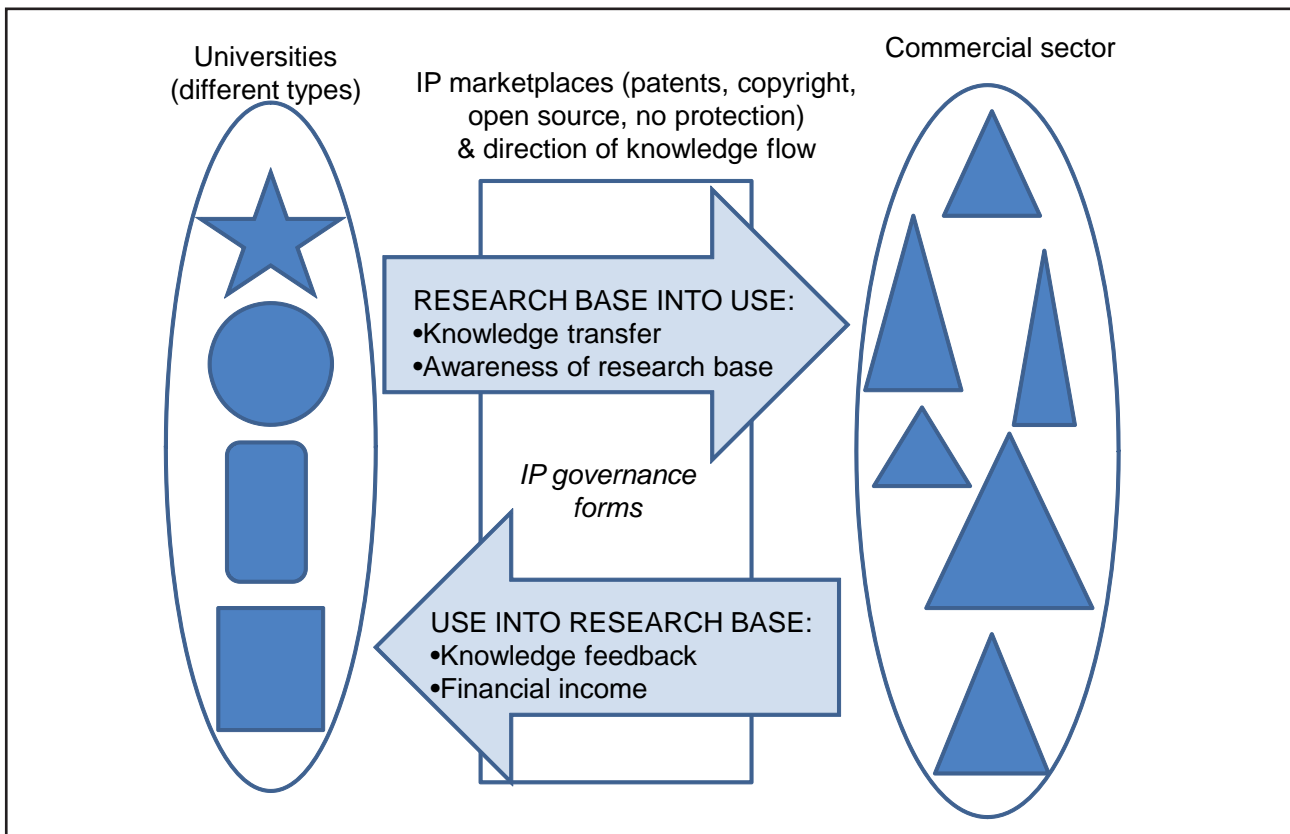
Table 3. Forms of IP and governance structures investigated through the survey

| <i>Forms of IP</i>  | <i>IP Governance structures</i>   |
|---|---|
| <u>Patents</u> as a tool for the protection of novel ideas                                    | <ul style="list-style-type: none"> <li>• Selling patents</li> <li>• Buying patents</li> <li>• Out-licensing patents</li> <li>• In-licensing patents</li> <li>• Cross licensing patents</li> <li>• Participation in patent pools</li> </ul>  |
| <u>Copyright</u> as a tool for the protection of original creative expressions                | <ul style="list-style-type: none"> <li>• Selling copyright</li> <li>• Buying copyright</li> <li>• Out-licensing copyright</li> <li>• In licensing copyright</li> </ul>  |
| <u>Open source</u> IP as a tool for the protection of original ideas and creative expressions | <ul style="list-style-type: none"> <li>• Participating in open source software development</li> <li>• Participating in open source pharmaceutical projects</li> <li>• Participating in other open source communities</li> </ul>   |
| <u>'Non patented'</u> innovations   | <ul style="list-style-type: none"> <li>• Releasing not patented product or process innovations to the public</li> <li>• Releasing not patented product or process innovations to private firms</li> <li>• Using not patented product or process innovations</li> <li>• Collaborating with universities without patent restrictions</li> </ul> |

Our objective can be stated in the first exploratory research question driving our empirical investigation: RQ1: Do universities transfer different forms of IP (patents, copyright, open source, innovations with no protection), and if so do they use them as complementary or alternative? What specific IP governance forms do universities use more intensively when transferring IP?

Different forms of IP (and specific governance structures for the exchange of IP; see Andersen and Konzelmann, 2008) can be related to the management of different flows of knowledge and financial resources from the academic research base into use, and vice versa, as illustrated in the following Figure 1.

Figure 1. Flows of knowledge and financial resources between the research base and the commercial sector



The empirical analysis in Section 3 investigates how the transfer of different forms of IP through different market governance structures relates to the strategic management of different flows of knowledge and financial resources between the research base and commercial use. These flows are interdependent and can take place simultaneously in the course of a single IP transaction. For example, a university can license a patent to receive income, to build relationships with industry and to signal its competencies to industry. Signalling, reputation enhancement and market development are ways in which the university can enhance awareness of its IP among the wider public, and are thus treated as a type of knowledge flow.

The universities that took part in our survey were asked to indicate what benefits (relating to different types of flows) they derive when transferring different forms of intellectual property. Table 4 below lists the 13 options presented, of which they were asked to indicate the five most important. The choice of specific options presented in the right-hand column was based on a thorough review of the economic literature on patents (reviewed in Andersen and Rossi, 2010).

Table 4. Flows investigated through the survey

| Direction of flow      | Type of flow               | Specific benefit  |
|------------------------|----------------------------|---|
| Research base into use | Knowledge transfer         | <ul style="list-style-type: none"> <li>• Building informal relationships with industry networks</li> <li>• Increasing ability to enter collaborative agreements</li> <li>• Giving something to the community</li> </ul>   |
|                        | Awareness of research base | <ul style="list-style-type: none"> <li>• Increasing market share</li> <li>• Professional recognition or brand recognition</li> <li>• Competitive signalling</li> </ul>  |
| Use into research base | Knowledge feedback         | <ul style="list-style-type: none"> <li>• Using the best inventions, innovations, creative expressions</li> <li>• Making or using compatible technology or creative expressions</li> <li>• Developing better technology or creative expressions</li> <li>• Benefiting from user or supplier involvement as a development strategy</li> </ul> |
|                        | Financial                  | <ul style="list-style-type: none"> <li>• Direct income from market transactions</li> <li>• Cost cutting</li> <li>• Increasing ability to raise venture capital</li> </ul>   |

Therefore, our second exploratory research question is: RQ2: How and to what extent is the transfer of different forms of IP related to the universities' strategic management of their knowledge flows from the research base into use (and vice versa)?

This question is designed to improve our understanding of the relative importance of “hard” and “soft” IP. In particular, it provides us with an indication of the use of “soft IP”, which is important since the performance of IP transfer initiatives is often monitored primarily by the numbers of disclosures, patents and spinout companies created, and this influences the direction of knowledge transfer activities. Our interviews confirm that the ways in which performance is measured and incentives are distributed by government influence knowledge transfer activities.

Consequently, it may be necessary to break down existing metrics to encourage the exploitation of “soft IP” (for example, by distinguishing between patentable disclosures and non-patentable disclosures) or create new ones (such as collecting information on registered designs, open source and non-patented innovations). Sorensen and Chambers (2008) suggest that academic Technology Transfer Offices (TTOs) need to refocus on the most important question for drivers of our global knowledge economy: “How well does a TTO facilitate access to knowledge protected by intellectual property of its faculty and institution?” Therefore, any metrics should be based on how well TTOs facilitate access to knowledge,<sup>4</sup> and should be balanced against income generation indicators. To be fair, the UK has gone further in addressing these issues than most other countries, thanks to initiatives such as the annual Higher Education – Business and Community Interaction Survey, which seeks to measure a wide variety of knowledge transfer channels and activities, not limited to the transfer of IP, using metrics updated on an ongoing basis.

Another key insight relates to the importance of bi-directional flows of knowledge between university and society in general, and the commercial sector in particular. It is still widely assumed that knowledge simply flows in one direction, from universities to industry or other users. But

4 For example, Sorensen and Chambers (2008) discuss metrics such as tracking the number of citations for a piece of research, and economic development metrics (for example measures of job creation, capital raised, spinout sales revenue etc), as well as involvement in open source innovations.

flows in both directions must be considered. Indeed, where these “feedback flows” of knowledge and financial resources are properly managed, they can enhance the university’s research and educational missions. Therefore, attention must be paid to the ways in which universities can strategically manage these processes in order to establish mutually reinforcing positive feedback processes between their education, research and knowledge transfer activities.

**Summary of Section 2.2:**

- Universities are increasingly encouraged to protect their research outcomes through IPRs, instead of openly disseminating findings. However, a large recent literature has examined the possible negative side-effects of the patenting of academic discoveries on issues such as the freedom of scientific enquiry, the nature of university research, the creation of academic imbalances and possible conflicts with industry.
- The extent to which universities have been successful in reaping rewards from the privatisation of academic knowledge is also controversial. A key explanation for the relative lack of financial success of many universities in exploiting the patent system is that it works better in pharmaceuticals than in many other industries.
- Universities produce a wide range of knowledge products, many of which are not suitable to be patented or which universities may choose not to patent. It is therefore important to investigate the relative importance and roles of “hard” IP (embedded in patents and registered copyright) and “soft” IP (such as open source IP and non-patented inventions). Despite the quantitative importance of “soft IP” for universities, there has been little study of issues relating to its generation, identification, commercial exploitation and value.
- The empirical analysis in Section 3 helps build a more reliable picture of the ways in which universities transfer IP, by focusing on a range of IP marketplaces relating to both “soft” and “hard” IP, by investigating to what extent they are used complementarily, and the extent to which they enhance four types of flows (related to knowledge circulation and financial resources) between the research base and commercial use.
- Our framework (see Figure 1 and subsequent discussion) also highlights the importance of bi-directional flows of knowledge between university and society in general, and the commercial sector in particular.

### **2.3. Different “models” of involvement of the university in IP transfer**

In their review of technology transfer offices (TTOs) at UK universities, Rogers et al (2009) find that they are useful in encouraging academics to disclose their inventions and promoting the commercialisation of the resulting IP. They support the successful commercialisation of university inventions by mediating between the different parties involved in the process: TTOs help reduce the uncertainty in inventions that originate from university research and create a more level playing field between academic inventors and potential industry clients. TTOs can play a crucial role in mediating between key representatives and building trust, particularly where commercialisation involves a significant transfer for tacit knowledge. Our interviewees stressed the importance for TTO staff of developing the specialised scientific knowledge and the communication skills that allow them to interact with both academics and industry managers and to “translate” between them.

The TTO model of IP transfer is not without its problems. In particular, we focus on two key issues highlighted by the literature: (i) the excessive homogenisation of the university IP transfer system, and (ii) the TTOs’ excessive focus on IP revenues at the expense of other important objectives, which may hamper rather than facilitate knowledge transfer to industry.

#### *(i) The excessive homogenisation of the university IP transfer system*

Studies of the university technology transfer system have identified several possible organisational configurations for knowledge transfer activities. Yusuf (2008) looks at the broad category of “knowledge intermediaries”, agents that can assist in the transfer of both codified and tacit knowledge, which is particularly important in the case of early stage technologies. The range of available intermediaries include the general-purpose intermediary, an example of which is the university itself; the specialised intermediary such as the technology licensing office; the financial intermediary such as the venture capitalist; and the institutional intermediary, which is often a public body.

Focusing only on technology transfer from university, Rogers et al (2009) present a typology of governance models that is useful in understanding how technology transfer operates (though, in practice, universities may use multiple models and the emphasis on each may change over time): the “Cambridge” Inventor-Ownership Model, based on the academics’ direct ownership of the IP originating from their research activities (as implemented in Cambridge prior to 2005); the In-house Model, where the university manages the entire technology transfer process through an internal organisation; the Stand-alone Company Model, where the university establishes a dedicated, independent limited company to act as a conduit between university research and business; and finally the Hybrid Model, where the university signs a long-term partnership agreement that grants a private company a share in the university’s IPRs (and income generated from their commercialisation) in exchange for advice, funding and expertise.

Along similar lines, Tang et al (2009) identified four different models of TTO organisation: an internal organisation wholly within the university structure (Type I); an organisation operating outside of the university, but reporting to the university (Type II); an external, generally non-profit making, commercial organisation wholly owned by the university but operating autonomously and reporting to a board for all decisions (Type III); and an external profit-making commercial organisation listed on the stock exchange (Type IV).

Despite this variety of organisational models (see HEFCE, 2010b, on the diversity in the infrastructure for knowledge exchange in the UK), the organisation of IP transfer activities within universities is not too dissimilar.

On the one hand, the variety of models may be decreasing over time, as the “Cambridge model” based on inventor ownership is being replaced by models based on the assignment of IPRs to the university. This has been a consequence of the increasing influence of the Bayh-Dole model of knowledge transfer (Mowery and Sampat, 2005). Although the Cambridge model suffers from lack of coordination and reduced incentives for universities to support academics in their entrepreneurial efforts, it also benefits from giving maximum incentives to academics and removing any negative effects of university involvement (an issue which we consider in more detail later). Some early evidence suggests that Cambridge’s transition to the Bayh-Dole model has actually reduced the number of spinouts from academic research, (Breznitz, 2008, ref. in Kenney and Patton, 2009). Recent evidence from Germany shows that since the adoption of a Bayh-Dole-like legislation for German universities, the overall patenting activity has not increased (von Ledebur, Buenstorf and Hummel, 2009). A similar result has also been found in Denmark since it introduced similar legislation, reflected particularly in the decline of collaborations with industry (Valentin and Jensen, 2007).

On the other hand, empirical evidence has revealed that strategies toward IP commercialisation do not differ significantly across the various organisational models (Rogers et al, 2009). These strategies are based on licensing, followed by spin-outs and/or equity holdings, and finally on consultancy. Whether internal or external to the university, the TTO is often established as a monopoly, centralising all university invention and commercialisation activities and requiring all academic staff to notify them of their discoveries and to delegate all rights to negotiate licenses on their behalf.

However, the diversity of IP products that universities generate and the diversity of industries and stakeholders with which they interact require more varied approaches to IP transfer. Tang et al. (2009) report that universities are aware of these problems. Their interviewees (from a stratified sample of 40 universities in the UK) pointed out that the government (1) needs to realise that university-industry engagement is a “segmented activity” – one size does not fit all; (2) is paying too much attention to the handful of the “great and the good” universities which patent a great deal; (3) policies continue to focus on science and technology and do not address the whole spectrum of disciplines, many of which do not patent. This is confirmed by our interviewees, who have highlighted the diversity of knowledge transfer models appropriate to different universities.

#### *(ii) TTOs’ excessive focus on IP revenues*

TTOs are also criticised for their focus on maximising revenues from the licensing of university-developed intellectual property (for example, by rewarding TTO offices and their personnel on the basis of the revenues they generate).

Litan et al (2007) suggest that the exclusive focus on revenue maximisation has induced some perverse behaviour by TTOs, which in some cases has led them to become hinder rather than facilitate the process of IP transfer. First, the emphasis on revenue maximisation has induced TTOs to dedicate the majority of financial and human resources to patent licensing, and minimal resources to non-patented innovations; this way, they maximise not output (the actual numbers of commercialised innovations) but revenue. Second, many TTOs focus their limited time and resources on the technologies that appear to promise the biggest and fastest payback. Technologies that might have longer-term potential or that might be highly useful to society as a whole, even if they return little or nothing in the way of licensing fees (such as research tools used mainly by other researchers), tend to be given low priority or to be overlooked entirely. Finally, although they are very focused on patenting, university managers are often naive users of the patent system, who are unaware that reaping its benefits requires using the system strategically, or simply lack the resources to do so (Macdonald, 2009).

Several solutions have been proposed.

Litan et al (2007) suggest that universities move to a model where they maximise the *volume* of the knowledge they transfer, rather than the *revenue* they produce. Ways to achieve this might include giving power to faculty members to negotiate license arrangements for entrepreneurial activities either themselves or using a third party, provided that they return some portion of their profits to the university (“free agency” model); implementing regional alliances between multiple universities that develop mechanisms for commercialisation, achieving economies of scale and sharing costs; using the web to facilitate commercialisation; relinquishing IPRs to academics and relying on their loyalty to donate some of the profits back to the university.

Kenney and Patton (2009) also suggest that the objective of maximising the volume of knowledge transferred (as opposed to revenue from licensing and sale of IP) could be accomplished by vesting IP ownership with the inventor, as in the Cambridge model: the inventor would be free to contract with the university technology licensing organisation (TLO) or any other entity that might assist in commercialisation. In return, the inventor would give the university a stake in any returns. An alternative would be to make all inventions immediately publicly available through a public domain strategy or a requirement that all inventions be licensed non-exclusively.

Our empirical analysis in Section 3 contributes to the debate on the effectiveness of different organisational configurations of IP transfer, by investigating how universities with different structural characteristics transfer different forms of IP (i.e. use different models of knowledge transfer, either more open dissemination or transfer of IPR) and how these impact their knowledge flows. We investigate the following research questions:

RQ3: Do universities with different organisational characteristics transfer different forms of IP and use different IP governance structures?

RQ4: Do universities with different organisational characteristics seek different strategic benefits from the management of their IP?

#### **Summary of Section 2.3:**

- Technology Transfer Offices (TTOs) can play a crucial role in mediating between universities and industry (or other external bodies) and in helping to build trust between them.
- Despite the variety of organisational models for the governance of university knowledge transfer, the organisation of IP transfer activities is fairly similar. Universities recognise the need for diversity in knowledge transfer. They believe that the government should pay more attention to disciplines where patenting is not relevant or applicable and to universities that don't rely on patents as their main model of IP transfer.
- TTOs and the metrics that are used to assess their performance (see Sorensen and Chambers, 2008 and Kesan, 2009) are excessively focused on maximising IP revenues for the universities, while the mission of most universities would suggest that they should focus on maximising the volume of IP transfer achieved.
- Our empirical analysis in Section 3 contributes to the debate on the effectiveness of different organisational configurations of technology transfer, by investigating how universities with different structural characteristics transfer different forms of IP and how these impact their knowledge flows.

## 2.4. Potential inefficiencies of IP marketplaces and IP governance forms

More attention needs to be paid to the quality of the IP marketplaces through which IP is transferred. A key assumption underlying legislation that encourages universities to patent their research outcomes is that IPR marketplaces function well. However, institutional economics teaches us that all markets are institutions characterised by specific norms and bargaining forms, where, for trade to take place, social relations need to be underpinned by trust and similar expectations (in relation to prices, contracts and other aspects) between buyer and seller (Hodgson 1988, 1999). Accordingly, IP marketplaces are platforms of social relations in which value is created. The understanding of IP marketplaces as institutions opens up the possibility that they may not function as smoothly as assumed when they are conceptualised as simple price-clearing mechanisms. In fact, numerous problems with the functioning of IP marketplaces have been identified by the empirical literature, usually relating to patents.

In Section 3, we investigate the obstacles that universities encounter when transferring IP in the marketplace, thus contributing new empirical evidence that enable us better to understand problems in technology markets and their implications for university knowledge transfer processes. Specifically, we asked universities what obstacles they experienced when transferring different forms of IP, which hampered the knowledge and financial resource flows between their research base and commercial use. Universities were given 14 potential obstacles (see Table 5) and asked to choose which five were most important. The choice of specific obstacles presented in the right-hand column was based on a thorough review of the institutional economic literature and of industry reports (IBM 2006), primarily focused on patents (reviewed in Andersen and Rossi, 2010, 2011).

Table 5. Obstacles investigated through the survey

| Type of obstacle         | Specific obstacle   |
|--------------------------|---|
| Search problems          | <ul style="list-style-type: none"> <li>• Difficulty in locating the owners of IP</li> <li>• Difficulty in locating the users of IP</li> <li>• Difficulty in finding the best IP</li> </ul>  |
| Lack of transparency     | <ul style="list-style-type: none"> <li>• Difficulty in assessing the degree of novelty/originality of the IP</li> <li>• Lack of clarity of the IP document</li> <li>• Difficulty in assessing the economic value of the IP</li> </ul>         |
| Contract negotiation     | <ul style="list-style-type: none"> <li>• Difficulty in negotiating a price for the IP</li> <li>• Difficulty in negotiating the terms, not related to price, of the contract</li> </ul>  |
| Contract enforcement     | <ul style="list-style-type: none"> <li>• Excessive cost of enforcing the contract</li> <li>• Problems, not related to cost, with enforcing the contract</li> <li>• Trust issues (opportunistic behaviour, free-riding, or similar)</li> </ul> |
| Regulation and practices | <ul style="list-style-type: none"> <li>• Different practices of firms</li> <li>• Regulations allow too exclusive rights</li> <li>• International IP regulations do not fit the needs of different local markets</li> </ul>                    |

The objective of the empirical analysis can be summarised in the following exploratory research question:

RQ5: What obstacles do universities encounter when transferring IP, which prevent them from effectively and efficiently manage their flows of knowledge between research base and commercial use?

**Summary of Section 2.4:**

- One of the key assumptions underlying legislation that encourage universities to patent their research outcomes is that IPR marketplaces function well: however, empirical studies have identified numerous problems that impair the efficiency of patent transactions.
- Drawing on our empirical analysis in Section 3, we investigate the obstacles that universities encounter when transferring IP in the marketplace, thus contributing new empirical evidence better to understand problems in markets for technology and their implications for university knowledge transfer processes.

## 3. Data, Analysis and Results: UK Universities

### 3.1. Data collection process

Our empirical analysis draws on a UKNOW survey database, developed at Birkbeck College by Prof. Birgitte Andersen and colleagues.<sup>5</sup> The data are described below.

We created a list of relevant institutions and their technology transfer offices by merging two lists: the 120 members of the University Companies Association (UNICO), which represents the technology exploitation companies of UK universities, and the 162 institutions that responded to the HEBCI 2004-05 and 2005-06 surveys (HEFCE, 2007), which includes all 133 universities in the UK, as well as some colleges of higher education and public research organisations (PROs). After correcting spellings and eliminating double entries, we had a final list of 169 different organisations. Respondents could answer the survey by: filling in the questionnaire online, returning an electronic copy by email or returning a copy by post or fax. We obtained 46 valid responses (a 27.2% response rate).

The survey was targeted at technology transfer offices (or their equivalent). These usually have a broad view of their institution's involvement in IP exchanges, since they manage many IP contracts. Consequently, they know the obstacles encountered when attempting to exchange such IP efficiently. They also understand the relative strategic advantages of the different forms of IP because of their dealings with the researchers.

For our report, the data analysis is limited to the share of the institutions in the sample that are universities or colleges of higher education (that is, PROs are excluded). This is because we want to focus our analysis on knowledge flows *within the university innovation system*.<sup>6</sup> Moreover, our additional variables drawn from HESA and HE-BCI databases (which we describe later) are generally not available for PROs. This allows us to perform a more in-depth and focused analysis. Excluding PROs leaves us with a total sample of 154 institutions, of which 40 responded to the survey (response rate 26%).

### 3.2. Structure of the survey

In our questions, we were particularly concerned with four IP marketplaces – those for patents and copyright (“hard” IP), and open source and non-patented innovations (“soft” IP). For each marketplace, we examined different IP governance structures, as detailed in Table 3 (Section 2.2).

A first set of questions allowed us to collect information on the extent and intensity with which universities participate in the various IP marketplaces and governance structures. Respondents were asked about their stock of patents owned and licensed, whether they engaged in each patent governance form, and the number of transactions in the previous two years. With respect to open source, non-patented innovations and copyright, universities were asked whether they engaged in each governance form, and the number of transactions in the previous two years.

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5 As described in the introductory chapter, data was collected (2007/08) through Work Package 3.2 “An IPR Regime in Support of a Knowledge Based Economy” which formed part of the UKNOW (“Understanding the Relationship between Knowledge and Competitiveness in the Enlarging EU”) project of the EU 6th Framework Programme.

6 PROs and universities are characterized by different economic incentives and resource allocation mechanisms. For example, in the former, research is organized by the state in relation to targeted objectives, while in the latter academics are free to pursue research targets of their own choice. In return for this financing, academics must provide educational services, which instead are not required from public research organization (PRO) staff (Foray and Lissoni, 2009).

The next set of questions referred to the strategic benefits that universities seek when trading IP. For each marketplace and governance form, universities were asked to tick up to five important strategic benefits, from the 13 options in Table 4 (Section 2.2). Universities were then asked to tick up to five of the most serious obstacles they encountered when transferring IP, from the list of 14 options in Table 5 (Section 2.4).

Finally, respondents were asked to provide some general information about their organisation: geographic location, ownership (independent or subsidiary), size (current number of employees, current yearly turnover), research intensity (yearly expenditure in R&D), geographic extension of the organisation's main market (domestic or international) and sector of activity.

Numerous additional variables relating to organisational characteristics were derived from other sources. The number of academic staff and total staff (academic, non-academic, atypical), the share of academic staff employed in scientific fields (engineering and technology, medicine and natural sciences), and the institution's income (disaggregated by source) were drawn from the Higher Education Statistics Agency's database (2007/08). We also included several variables, drawn from the HE-BCI survey (2007), relating to: the university's organisation of knowledge transfer activities;<sup>7</sup> its management of IP;<sup>8</sup> policy requiring staff to disclose inventions; policy rewarding staff for the intellectual property which they generate; the university's IP activities.<sup>9</sup> The share of research-active staff performing research rated 3\* and 4\* was derived from the 2008 UK Research Assessment Exercise (RAE).

### **3.3. Sample and respondents' characteristics**

Table 6 compares key characteristics of the 40 respondents with the 114 non-respondent, to ensure that our sample is representative: geographic location, number of staff, type of unit managing IP commercialisation and type of institution. With respect to type of institution, we distinguish between universities and colleges of higher education, and further sub-divide universities into 5 groups according to their historical origin (see Table 6, including table notes)

The distribution of respondents is not significantly different from the overall sample in most characteristics. However, the respondents are significantly less likely not to possess a unit dedicated to IP commercialisation (either internally or externally). As the survey was addressed to TTOs, staff at those universities without a unit may have felt that they weren't able to answer questions relating to IP management or that the survey was not relevant to their situation.

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7 These include: presence of in-house capability and/or of an external agency to seek out licensing opportunities for IP; presence of a commercialisation company and/or internal department to manage consultancy links and other external interactions; year of foundation of technology transfer office or similar unit; number of staff dedicated to technology transfer.

8 These include: HEI files patents in house/HEI outsources filing of patents/HEI takes other IP protection action.

9 These relate to: number of new patent applications filed during the year, number of patents granted during the year, cumulative portfolio of active patents, non-software licences granted, software only licences granted, total income from IP.

Table 6. Distribution of respondents and non-respondents

|                                  |                                       | sample<br>(154) | respondents<br>(40) | non-<br>respondents<br>(114) |
|----------------------------------|---------------------------------------|-----------------|---------------------|------------------------------|
|                                  |                                       | %               | %                   | %                            |
| Region                           | England                               | 81.2            | 87.5                | 78.9                         |
|                                  | Wales                                 | 5.8             | 5.0                 | 6.1                          |
|                                  | Scotland                              | 11.7            | 7.5                 | 13.2                         |
|                                  | Northern Ireland                      | 1.3             | 0.0                 | 1.7                          |
|                                  | <i>Total</i>                          | <i>100.0</i>    | <i>100.0</i>        | <i>100.0</i>                 |
| Total staff                      | <500                                  | 10.4            | 2.5                 | 13.2                         |
|                                  | 500-1000                              | 13.6            | 10.0                | 14.9                         |
|                                  | 1000-5000                             | 50.0            | 57.5                | 47.4                         |
|                                  | >5000                                 | 26.0            | 30.0                | 24.6                         |
|                                  | <i>Total</i>                          | <i>100.00</i>   | <i>100.00</i>       | <i>100.00</i>                |
|                                  | "old"                                 | 6.5             | 10.0                | 5.3                          |
|                                  | "red brick"                           | 19.5            | 30.0                | 15.8                         |
|                                  | "plate-glass"                         | 14.9            | 17.5                | 14.0                         |
|                                  | former Polytechnics                   | 22.7            | 22.5                | 22.8                         |
|                                  | "modern"                              | 18.2            | 10.0                | 21.1                         |
|                                  | Colleges                              | 18.2            | 10.0                | 21.1                         |
| <i>Total</i>                     | <i>100.0</i>                          | <i>100.0</i>    | <i>100.0</i>        |                              |
| Unit for IP<br>commercialisation | external commercialisation<br>company | 13.6            | 17.5                | 12.3                         |
|                                  | internal unit                         | 71.4            | 77.5                | 69.3                         |
|                                  | Neither                               | 14.9            | 5.0*                | 18.4                         |
|                                  | <i>Total</i>                          | <i>100.0</i>    | <i>100.0</i>        | <i>100.0</i>                 |

Signif. codes: '\*\*\*\*' 0.01 '\*\*\*' 0.05 '\*\*' 0.1

#Type of institution is defined via a typology (based upon the age characteristics of the university) which is widely used by practitioners and in the higher education literature:

- "old" universities (founded before the mid-XIX century);
- "red brick" universities (founded between the mid-XIX century and the mid-XX century);
- "plate glass" universities (founded between the 1960s and the end of the 1980s);
- "former polytechnics" (institutions formerly designated "polytechnics" which changed their status to universities in 1992);
- "modern" universities (founded after 1992, not formerly designated "polytechnics").

As shown in Table 7, there are no significant differences between respondents and non-respondents in terms of age of the technology transfer units or in the share of academic staff in the fields of engineering and technology, medicine, and natural sciences. Respondents have significantly more income from all sources. So, better endowed and larger institutions were more likely to answer the survey. By contrast, non-respondents have lower income from all sources, and significantly lower income from services, consultancies, IPRs, endowments and investments.

Table 7. Average values for sample, respondents and non-respondents

| Variables   | sample (154) | respondents (40) | non-respondents (114) |
|---|--------------|------------------|-----------------------|
| Date in which TTO was established                     | 1998         | 1993             | 2000                  |
| Funding body grants                                   | 54849        | 69692*           | 49595                 |
| Tuition fees & education contracts                    | 40191        | 52351**          | 35886                 |
| Research grants & contracts                           | 24233        | 40220*           | 18574                 |
| Other income - other services rendered <sup>10</sup>  | 9219         | 6209             | 10285                 |
| Other income - other <sup>11</sup>                    | 18900        | 24881            | 16783**               |
| Endowment & investment income                         | 3221         | 4238             | 2860***               |
| Total income  | 150612       | 197591           | 133982                |
| Share of academic staff in engineering and technology | 0.16         | 0.17             | 0.16                  |
| Share of academic staff in medicine                   | 0.20         | 0.22             | 0.19                  |
| Share of academic staff in natural science            | 0.11         | 0.13             | 0.10                  |

Signif. codes: '\*\*\*\*' 0.01 '\*\*\*' 0.05 '\*\*' 0.1

Our survey showed that 77.5% of respondents have an internal unit for IP commercialisation, with 17.5% relying upon an external company, and only 5% having no such support. In the overall sample, 14.9% of institutions had no commercialisation unit. However, only 14 of our 40 institutions (35%) file patents in-house, while 23 (57%) outsource this activity to external organisations. The majority of universities always require staff to disclose inventions, computer software or databases, industrial designs, trademarks and new plant or animal varieties. Only 20% of our sample universities always require staff to disclose literary or artistic works, 32.5% apply such requirement to integrated circuit topographies and 42.5% to educational software and multimedia. Disclosure is generally rewarded economically (by 38 universities, or 95%).

The results of the analysis are discussed on the basis of the five research questions presented earlier (in section 2 and summarised in Table 1).

10 This includes all income in respect of services rendered to outside bodies, including the supply of goods and consultancies.

11 This includes income from residences & catering operations (including conferences), grants from local authorities, income from health & hospital authorities, release of deferred capital grants, income from intellectual property rights and other operating income (all other operating income not covered above such as TEMPUS and ERASMUS grants)

### 3.4. Universities' complementary use of different forms of IP

(RQ1): Do universities transfer different forms of IP (patents, copyright, open source, non-protected protection), and if so, do they use them as complementary or alternative? What specific IP governance forms do universities use more intensively when transferring IP?

As Table 8 shows, most universities transfer patents – selling them or licensing them to others - and other types of intellectual property. While 13 universities (32.5%) do not transfer any of these forms of IP (although they may hold such IP without transferring it) most transfer at least one type of IP. Most universities transfer both “hard” and “soft” IP (42.5% of respondents and 62% of those that transfer IP). This indicates that, for most universities, participation in “hard” and “soft” IP marketplaces represent complementary rather than alternative strategies of knowledge acquisition and transfer.

Table 8. Engagement in different types of IP transfer (intra IP measurements)

| Types of IP transferred            | Number of universities | %    |
|------------------------------------|------------------------|------|
| Patent                             | 23                     | 57.5 |
| Copyright                          | 13                     | 32.5 |
| Open source                        | 12                     | 30.0 |
| Non-patented innovations           | 13                     | 32.5 |
| Number of different forms of IP: 0 | 13                     | 32.5 |
| Number of different forms of IP: 1 | 9                      | 22.5 |
| Number of different forms of IP: 2 | 6                      | 15.0 |
| Number of different forms of IP: 3 | 8                      | 20.0 |
| Number of different forms of IP: 4 | 4                      | 10.0 |
| Only “hard IP”                     | 8                      | 20.0 |
| Only “soft IP”                     | 2                      | 5.0  |
| Both                               | 17                     | 42.5 |

As shown in Table 9, the universities that transfer patents are particularly active in selling and licensing them to others (“out-licensing”). Only universities that responded that they explicitly have a policy of making formal registrations of their copyright were asked about their engagement in each copyright governance form. Of these, most are active in selling and out-licensing copyright, and few in buying and licensing copyright from others (“in-licensing”). These results are in line with the conventional view of universities as performers of basic research, active in developing IP and transferring it to other organisations rather than in acquiring protected IP from the outside. Universities tend to file their own patents rather than licensing them from other organisations, since the total stock of in-licensed patents is a small fraction (about 6%) of the total stock of owned patents. On average, the number of patent transactions in the previous two years represented just over a quarter of the universities’ total portfolio of owned patents.

All universities that engage in open source development do so with software.

With non-protected innovations, universities are very active both in releasing and using such knowledge. This suggests that in order to foster their own knowledge acquisition processes, universities prefer to rely on freely disseminated knowledge rather than protected knowledge. We return to this point in the discussion of RQ2.

Table 9. Engagement in different governance forms for the transfer of IP

| Forms of IP and governance structures |                                 | Number of universities | %     |
|---------------------------------------|---------------------------------|------------------------|-------|
| Patents                               | Selling                         | 13                     | 56.5  |
|                                       | Buying                          | 1                      | 4.3   |
|                                       | Out-licensing                   | 22                     | 95.7  |
|                                       | In-licensing                    | 2                      | 8.7   |
|                                       | Cross-licensing                 | 3                      | 13.0  |
|                                       | Pooling                         | 2                      | 8.7   |
| Copyright                             | Selling                         | 7                      | 53.8  |
|                                       | Buying                          | 3                      | 23.1  |
|                                       | Out-licensing                   | 11                     | 84.6  |
|                                       | In-licensing                    | 6                      | 46.2  |
| Open source                           | Software                        | 12                     | 100.0 |
|                                       | Pharmaceutical                  | 3                      | 25.0  |
|                                       | Other                           | 12                     | 100.0 |
| Non-patented innovations              | Releasing to public             | 12                     | 92.3  |
|                                       | Releasing to private firms      | 12                     | 92.3  |
|                                       | Using                           | 12                     | 92.3  |
|                                       | Collaborating with universities | 12                     | 92.3  |

### 3.5. IP transfer and the strategic management of knowledge flows

(RQ2): How and to what extent is the transfer of different forms of IP related to the universities' strategic management of their knowledge flows from the research base into use (and vice versa)?

We analyse the motivations underpinning the universities' decision to transfer each type of IP by looking at the management of different flows of knowledge and financial resources: stimulating knowledge flows from the research base, either by transferring knowledge directly or by increasing public awareness of the research base, and receiving feedback and finance from users.

Table 10 shows how many universities transfer each type of IP categorised by knowledge and financial flows. Where more than half the universities recorded a particular benefit from their IP activities, this is shown in bold.

Table 10: IP strategies in relation to knowledge and resource flows (intra IP measurements)

|  | <i>Patent</i> | <i>Copyright</i> | <i>Open source</i> | <i>Non patented innovations</i> |
|--|---------------|------------------|--------------------|---------------------------------|
| Number of universities transferring each type of IP  | 23            | 13               | 12                 | 13                              |
|  | %             | %                | %                  | %                               |
| Knowledge transfer   | <b>57</b>     | <b>77</b>        | <b>83</b>          | <b>77</b>                       |
| <ul style="list-style-type: none"> <li>• building informal relationships with industry networks</li> </ul>                                   | 48            | <b>62</b>        | <b>58</b>          | <b>69</b>                       |
| <ul style="list-style-type: none"> <li>• increasing ability to enter collaborative agreements</li> </ul>                                     | 39            | 46               | <b>58</b>          | <b>62</b>                       |
| <ul style="list-style-type: none"> <li>• giving something to the community</li> </ul>  | 17            | 23               | <b>58</b>          | <b>62</b>                       |
| Awareness  | 17            | <b>62</b>        | 17                 | 43                              |
| <ul style="list-style-type: none"> <li>• increasing market share</li> </ul>  | 4             | 39               | 0                  | 8                               |
| <ul style="list-style-type: none"> <li>• professional recognition or brand recognition</li> </ul>  | 13            | 31               | 17                 | 23                              |
| <ul style="list-style-type: none"> <li>• competitive signalling</li> </ul>   | 8             | 8                | 0                  | 15                              |
| Knowledge feedback   | 17            | <b>54</b>        | <b>58</b>          | <b>54</b>                       |
| <ul style="list-style-type: none"> <li>• being able to use the best inventions, innovations, creative expressions</li> </ul>                 | 0             | 8                | 33                 | 31                              |
| <ul style="list-style-type: none"> <li>• setting common standards / making or using compatible technology or creative expressions</li> </ul> | 0             | 39               | 25                 | 15                              |
| <ul style="list-style-type: none"> <li>• innovation methodology: developing better technology or creative expressions</li> </ul>             | 9             | 8                | 42                 | 46                              |
| <ul style="list-style-type: none"> <li>• benefiting from user or supplier involvement</li> </ul>   | 13            | 15               | 33                 | 23                              |
| Financial flows  | <b>57</b>     | <b>69</b>        | n.a.               | 46                              |
| <ul style="list-style-type: none"> <li>• direct income from market transaction</li> </ul>  | <b>52</b>     | <b>62</b>        | n.a.               | 39                              |
| <ul style="list-style-type: none"> <li>• cost cutting</li> </ul>   | 9             | 8                | n.a.               | 8                               |
| <ul style="list-style-type: none"> <li>• increasing ability to raise venture capital</li> </ul>  | 30            | 15               | n.a.               | 0                               |

Transferring knowledge directly is the main motivation for universities to transfer IP; however, “soft IP” enhances this flow of knowledge to a greater extent than “hard IP”, promoting all types of benefit (building informal relationships with industry networks, increasing ability to enter collaborative agreements, giving something to the community). Creating awareness of the university and its knowledge base is particularly important with copyright and - to a lesser extent - non-patented innovations.

Universities also exchange “soft IP” and copyright to receive useful knowledge from external agents that can be fed back into their research base. In particular, “soft IP” enables better technological or creative expressions, and greater user or supplier involvement.

Finally, flows of financial resources from industry and other agents to the university systems (mainly direct income) largely reflect the sale or licensing of patents and copyright (although almost 40% of universities that transfer non-patented innovations seek direct income too).

What specific governance forms underpin these flows? The relative importance of the different flows when using different governance forms or IP marketplaces can be shown by computing a “revealed governance advantage - RGA” (or “revealed marketplace advantage - RMA”) index that measures the importance of a type of flow or strategic benefit in a particular governance form relative to the overall importance of the same flow across all governance forms.<sup>12</sup>

The RGA or RMA for a specific flow or benefit is constructed in a similar way to the Revealed Technological Advantages (RTA) index (first developed and used in patent statistics by Keith Pavitt and John Cantwell) and the Revealed Comparative Advantage (RCA) index, which is an index (first developed and used in international economics by Bela Balassa) for calculating the relative advantage or disadvantage of a certain country in a certain class of goods or services as evidenced by trade flows.

The RGA or RMA index only assumes positive values: a value that is smaller than 1 indicates that a governance form or marketplace is relatively under-specialised in a certain flow, while a value greater than 1 indicates that it is relatively over-specialised in that flow. Values of the index greater than 1 are highlighted in bold.

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12 In more rigorous terms, let  $x_{ij}$  be the number of times that flow  $i$  is chosen in governance form (or marketplace)  $j$ , and  $\sum_i x_{ij}$  the number of times that any flow is chosen in governance form (or marketplace)  $j$ ; let  $\sum_j x_{ij}$  be the number of times that flow  $i$  is chosen in all governance forms (or all marketplaces), and  $\sum_i \sum_j x_{ij}$  the total number of times any flow is chosen across all governance forms (or all marketplaces). Then, for a certain governance form (or marketplace), the revealed governance advantage RGA (or revealed marketplace advantage RMA) index is:  $RGA = (x_{ij}/\sum_i x_{ij})/(\sum_j x_{ij}/\sum_i \sum_j x_{ij})$  (or  $RMA = (x_{ij}/\sum_i x_{ij})/(\sum_j x_{ij}/\sum_i \sum_j x_{ij})$ )  
That is, the index is the ratio between the share of flow  $i$  in governance form (or marketplace)  $j$  and the share of flow  $i$  in all governance forms (or all marketplaces).

Table 11. IP and knowledge and resource flows: revealed advantage of marketplaces and governance forms

| RMA or RGA                        | Knowledge transfer | Awareness of research base | Knowledge feedback | Financial flows |
|-----------------------------------|--------------------|----------------------------|--------------------|-----------------|
| Patents                           | <b>1.03</b>        | 0.68                       | 0.55               | <b>1.58</b>     |
| • Selling                         | 0.99               | 0.95                       | 0.00               | <b>1.24</b>     |
| • Buying                          | 0.00               | <b>6.67</b>                | 0.00               | 0.00            |
| • Out-licensing                   | <b>1.09</b>        | 0.65                       | <b>1.16</b>        | <b>1.01</b>     |
| • In-licensing                    | 0.87               | <b>2.22</b>                | <b>4.00</b>        | 0.00            |
| • Cross-licensing                 | 0.65               | <b>1.67</b>                | <b>3.00</b>        | 0.65            |
| Copyright                         | 0.79               | <b>1.36</b>                | 0.96               | <b>1.10</b>     |
| • Selling                         | <b>1.13</b>        | 0.76                       | 0.68               | <b>1.25</b>     |
| • Buying                          | 0.54               | <b>1.26</b>                | <b>2.27</b>        | 0.60            |
| • Out-licensing                   | 0.97               | <b>1.01</b>                | <b>1.13</b>        | 0.95            |
| • In-licensing                    | <b>1.08</b>        | <b>1.26</b>                | 0.57               | 0.89            |
| Open source                       | <b>1.42</b>        | 0.61                       | <b>1.71</b>        | 0.00            |
| • Software                        | <b>1.01</b>        | <b>1.21</b>                | 0.94               | n.a.            |
| • Pharmaceutical                  | 0.00               | 0.00                       | <b>2.56</b>        | n.a.            |
| • Other                           | <b>1.28</b>        | 0.00                       | 0.85               | n.a.            |
| Non-patented innovations          | 0.93               | <b>1.20</b>                | <b>1.12</b>        | 0.86            |
| • Releasing to public             | <b>1.04</b>        | <b>1.48</b>                | 0.84               | 0.65            |
| • Releasing to private firms      | 0.84               | 0.84                       | 0.99               | <b>1.53</b>     |
| • Using                           | 0.89               | <b>1.19</b>                | <b>1.25</b>        | 0.65            |
| • Collaborating with universities | <b>1.19</b>        | 0.59                       | <b>1.05</b>        | 0.97            |

#The specific strategic benefits underpinning the four broader groups (knowledge transfer, awareness of research base, knowledge feedback and financial flows) are in Table 10.

We find that universities are relatively more likely to transfer “hard IP” for financial reward (mainly by selling and licensing patents), and to a lesser extent to enhance knowledge transfer flows (mainly by licensing patents). These are the conventional benefits that universities are expected to derive from the sale or licensing of patents. Copyright is sold or used to create awareness of the research base (mainly by buying, out-licensing, in-licensing). This may relate to the university’s willingness to rely upon widely used technologies and creative expressions (such as copyrighted software and databases) to reach a wider public.

Open source enhances flows of knowledge to and from the research base. Both software and other open source communities seek to transfer knowledge from universities, while universities that engage in open source pharmaceuticals do not seem motivated by knowledge transfer objectives.

At the same time, non-patented innovations is used to enhance flows in both directions, by creating awareness of the knowledge base (mainly through releasing the innovations to the public) and by enhancing knowledge feedback (mainly through collaborating with other universities). The use of non-patented knowledge allows universities to acquire valuable knowledge that enables them to produce better innovations, while its use and release enables universities to interact with numerous organisations that learn about the universities’ research base as a result.

The result is that universities are more likely to try to enhance direct knowledge transfer and knowledge feedback through the transfer of copyright, open source and non-patented innovations than through patents (as shown in Table 10). The strategic importance of knowledge feedback flows is relatively higher for open source and non-patented innovations (as shown in Table 11).

These findings of what universities think to work, regarding their IP strategies, counter the assumptions behind recent patenting legislation that the implementation of “hard IP” enhances the circulation of knowledge between university and the commercial sector, particularly through feedback from industry to academia.

Another pattern that emerges is that the flows of knowledge and the flows of IP do not necessarily travel in the same direction. We find, for example (from Table 11), that using non-patented innovations is perceived by universities to enhance awareness of the university’s knowledge base as well as improving knowledge feedback. In general, any IP transfer can be accompanied by flows of knowledge in both directions, since these transactions are rarely similar to the spot transactions described by mainstream economic theory: they are embedded in social relationships, which allow mutual learning to take place.

### **3.6. *Role of organisational characteristics in IP management***

(RQ3): Do universities with different organisational characteristics transfer different forms of IP and use different IP governance structures?

Using data from HEFCE’s Higher Education and Business Interaction Survey (HE-BCI) for 2005-2006 we have categorised our respondents according to the organisation of their IP management activities. 34 universities (85%) have internal resources dedicated to filing or commercialising IPR, or both; four universities (10%) fully outsource these activities; while two (5%) do no filing or commercialising of IPR. As can be seen from Table 12, those universities that outsource their IPR activities typically have a higher number of disclosures, patent applications, patents granted, active patents - and a larger income from IP (although they do not differ significantly in the number of licenses granted). The small number of observations in some of these groups however suggests caution in interpreting these figures.<sup>13</sup>

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13 Moreover, the short period of observation of these variables may imply an underestimation of a university’s patenting effort, if it had filed numerous patents in previous years which have not yet been granted due to delays in the patenting process, especially at international level.

Table 12. Management of technology transfer activities

|  | <i>internal<br/>filing and/or<br/>commercialisation<br/>of IPR</i> | <i>outsources<br/>filing and/or<br/>commercialisation<br/>of IPR</i> | <i>no filing or<br/>commercialisation<br/>of IPR</i> |
|--|--|--|--|
| Number of universities according to management of licensing and patenting activities | 34   | 4  | 2  |
| Average number of:   |  |  |  |
| • Disclosures  | 36   | 74   | 0  |
| • New patent applications filed in year  | 20   | 39   | 0  |
| • Patents granted in year  | 7  | 17   | 0  |
| • Cumulative portfolio of active patents   | 150  | 371  | 0  |
| • Non-software licences granted  | 29   | 28   | 0  |
| • Software only licences granted   | 7  | 6  | 0  |
| • Total income from IP (£000s)   | 536  | 682  | 0  |
| • Technology transfer staff  | 58   | 42   | 7  |
| % that always require disclosure on:   |  |  |  |
| • Inventions   | 67   | 75   | 0  |
| • Computer software or databases   | 56   | 50   | 0  |
| • Literary or artistic works   | 21   | 25   | 0  |
| • Educational software and multimedia  | 44   | 50   | 0  |
| • Industrial designs   | 56   | 25   | 0  |
| • Trademarks   | 68   | 75   | 0  |
| • Integrated circuit topographies  | 32   | 50   | 0  |
| • New plant or animal varieties  | 53   | 50   | 0  |
| • Other  | 3  | 25   | 0  |
| Management of consultancy links and other external interactions (%)                  |  |  |  |
| • Internal department  | 91   | 100  | 100  |
| • Commercialisation company  | 47   | 50   | 0  |

Our qualitative interviews with our social sciences university (University 1) and former polytechnic (University 3) suggest that scale is an important factor in determining the universities' decision to organize their IPR activities. Only universities that generate sufficient patentable research outcomes can justify the cost of creating an external commercialization company for this purpose.

A review by Rogers et al (2009) of survey data provided by HEFCE and UNICO for 2006 and 2007 shows that the share of universities using the services of external agents is increasing, implying that some universities have switched from an in-house to an external model.

Unsurprisingly, the universities that manage their IPR licensing and filing internally tend to employ more technology transfer staff. Even those universities that fully outsource their IPR activities and those that do not engage in IPR at all still maintain an internal department for the management of other types of technology transfer activities (such as consultancies, Knowledge Transfer Partnerships, employer-based training or joint university-industry collaborations). According to Rogers et al, TTO staff numbers have grown considerably over time, confirming the overall trend of

intensified efforts by universities to market their inventions. The number of inventions disclosed has also increased considerably.

Our next step is to correlate different IP strategies (related to patent, copyright, open source, non-patented innovations, only “hard IP”, only “soft IP”, “both hard and soft” IP) with different features of the university institution: (i) total staff size (ii) historical origin (iii) disciplinary specialisation (share of academic staff in scientific disciplines) and (iv) research quality (share of research-active staff that perform research rated 3\* and 4\* according to RAE 2008).

Table 13 looks at universities of different sizes and historical origins. Shares greater than 50% are highlighted in bold. We can see that larger institutions tend more often to transfer patents, copyright and non-patented innovations, while open source is relatively more prevalent in smaller institutions. At the same time, larger institutions are more likely to transfer both “hard” and “soft” IP, indicating that they may be better able to sustain the transaction costs involved in engaging in different IP marketplaces. Our qualitative interviews, particularly with university 1 (social sciences) and university 2 (scientific research) confirmed that a large scale operation is important for certain types of IP transfer activity and to take advantage of government programmes. Greater size and volume of activities allows a TTO to specialise and hence to pay greater attention to different types of IP transfer model.

Old universities founded before the 19th century and former polytechnics that have become universities in 1992, are most likely to transfer patents, but red brick and new universities are also very active in this sense. Both old universities and former polytechnics (to a lesser extent) are also most active in the transfer of all other forms of IP. For most of these universities, “hard” and “soft” IP are complementary rather than alternative. This echoes our interviews which suggest that the most research-intensive universities produce a wide variety of research outputs and hence generate a large variety of IP, while the more teaching-oriented universities produce less output from basic research but strive to have a greater variety of commercial interactions with industry.

*Table 13. Engagement in different forms of IP exchanges according to organisational characteristics: size and historical origin*

|                              |    | <i>Patents</i> | <i>Copyright</i> | <i>Open Source</i> | <i>Non-patented innovations</i> | <i>Only hard IP</i> | <i>Only soft IP</i> | <i>Both hard and soft</i> |
|------------------------------|----|----------------|------------------|--------------------|---------------------------------|---------------------|---------------------|---------------------------|
| (i) Size                     | N  | %              | %                | %                  | %                               | %                   | %                   | %                         |
| • <500                       | 1  | 0              | 0                | <b>100</b>         | 0                               | 0                   | <b>100</b>          | 0                         |
| • 500-1000                   | 4  | <b>50</b>      | 25               | 0                  | 0                               | <b>50</b>           | 0                   | 0                         |
| • 1000-5000                  | 23 | <b>61</b>      | 30               | 26                 | 35                              | 26                  | 4                   | 44                        |
| • >5000                      | 12 | <b>58</b>      | 42               | 42                 | 42                              | 0                   | 0                   | <b>58</b>                 |
| (ii) Type/historical origin# | N  | %              | %                | %                  | %                               | %                   | %                   | %                         |
| • “old”                      | 4  | <b>75</b>      | <b>50</b>        | <b>50</b>          | <b>75</b>                       | 0                   | 0                   | <b>75</b>                 |
| • “red brick”                | 12 | <b>50</b>      | 33               | 25                 | 17                              | 25                  | 0                   | 33                        |
| • “plate glass”              | 7  | <b>57</b>      | 29               | 14                 | 43                              | 14                  | 0                   | 43                        |
| • former Polytechnics        | 9  | <b>89</b>      | 44               | 33                 | 44                              | 22                  | 0                   | <b>67</b>                 |
| • “modern”                   | 4  | 25             | 25               | 25                 | 0                               | <b>50</b>           | 25                  | 0                         |
| • Colleges                   | 4  | 25             | 0                | <b>50</b>          | 25                              | 0                   | 25                  | 25                        |

# See table 6 (table notes), for the definitions of the different types of institutions.

Table 14 reports the engagement in IP transfer activities on the part of universities according to the size of their scientific research staff, research excellence and how they organise their IP commercialisation activities. The results confirm that having a larger share of staff in Science and Technology (at least 25%) is associated with a greater propensity to transfer patents. This is not the true, however, for other forms of IP, where there is no such correlation. This finding does explain - at least in part - the greater engagement in patent exchange by older universities, which tend to be more oriented to these disciplines. However, it does not account for the patenting activities of former polytechnics, with less scientific staff: their greater involvement in patents may simply reflect their stronger focus on commercial IP transactions.

Universities with higher RAE rankings tend to transfer more copyright and more non-patented innovations. However, there is no clear relationship between research quality and transfer of patents.

*Table 14. Engagement in different forms of IP transfer according to organisational characteristics: scientific focus, research quality and organisation of commercialisation activities*

|   |    | <i>Patents</i> | <i>Copyright</i> | <i>Open Source</i> | <i>Non-patented innovations</i> | <i>Only hard IP</i> | <i>Only soft IP</i> | <i>Both</i> |
|---|----|----------------|------------------|--------------------|---------------------------------|---------------------|---------------------|-------------|
| (iii) Share of staff in S&T                   | N  | %              | %                | %                  | %                               | %                   | %                   | %           |
| • < 25%                                       | 5  | 20             | 40               | 20                 | 40                              | 40                  | 20.0                | 20          |
| • 25-50%                                      | 13 | <b>69</b>      | 39               | 39                 | 39                              | 15                  | 7.7                 | <b>54</b>   |
| • 50-75%                                      | 17 | <b>59</b>      | 29               | 29                 | 18                              | 18                  | 0.0                 | 41          |
| • > 75%                                       | 5  | <b>60</b>      | 0                | 40                 | <b>60</b>                       | 20                  | 0.0                 | 40          |
| (iv) Research quality (3* and 4* in 2008 RAE) | N  | %              | %                | %                  | %                               | %                   | %                   | %           |
| • < 10%                                       | 12 | <b>58</b>      | 42               | 25                 | 33                              | 25                  | 8.3                 | 42          |
| • 10 - 20%                                    | 18 | <b>67</b>      | 28               | 39                 | 33                              | 22                  | 0.0                 | <b>50</b>   |
| • 20 - 30%                                    | 4  | <b>50</b>      | <b>50</b>        | 00                 | <b>50</b>                       | 0                   | 0.0                 | <b>50</b>   |

### 3.7. Role of organisational characteristics in the strategic use of IP

(RQ4): Do universities with different organisational characteristics seek different strategic benefits from the management of their IP?

As a final investigation into how different forms of IP enhance different flows of knowledge and resources, we examine the link between organisational characteristics and the decision to enhance each type of flow through the transfer of different types of IP.

Table 15 reports the results of four Probit regressions on the importance of each flow (across all forms of IP) as a function of the use of different types of IP and of various organisational characteristics (the dependent variable in each regression is a binary variable which takes value 1 if the university has chosen that type of flow, 0 if not).

Table 15. Choice of benefits as a function of organisational characteristics

|   | 1.                        | 2.               | 3.                        | 4.                       |
|---|---------------------------|------------------|---------------------------|--------------------------|
|   | <i>Knowledge transfer</i> | <i>Awareness</i> | <i>Knowledge feedback</i> | <i>Financial rewards</i> |
| • Intercept   | -0.19                     | 0.35 **          | 0.59 *                    | 0.10                     |
| • Patent transfer                                   | 0.15                      | 0.16             | 0.31                      | 0.42 **                  |
| • Open source engagement                            | 0.24 **                   | -0.01            | -0.05                     | -0.13                    |
| • Copyright transfer                                | 0.33 **                   | 0.08             | -0.10                     | 0.41                     |
| • Transfer of non-patented innovations              | -0.18                     | 0.76 ***         | 0.32                      | 0.04                     |
| • Transfer of both hard and soft IP                 | 0.73 ***                  | -0.17            | 0.09                      | 0.17                     |
| • Number of academic staff                          | 0.00                      | 0.00             | 0.00 *                    | 0.00                     |
| • Age of university                                 | 0.00                      | 0.00             | 0.00                      | 0.00                     |
| • Share of academic staff in science and technology | 0.41 **                   | 0.00             | -0.66 *                   | -0.23                    |
| • Number of technology transfer staff               | 0.00                      |                  | 0.00                      | 0.00                     |
| • IP filed and/or commercialised in-house           | -0.02                     | -0.34 *          | -0.09                     | 0.03                     |
| • Share of members of governing body from business  | -0.56 **                  |                  | -0.60                     |                          |
| • Income from IP                                    | 0.00                      |                  | -0.00 *                   |                          |
| • “Modern” university                               | 0.07                      |                  |                           |                          |
| • University college                                | 0.49 **                   |                  |                           |                          |
| • “Red brick” university                            | 0.09                      |                  |                           |                          |
| • “Plate glass” university                          | 0.19                      |                  |                           |                          |
| • Former polytechnic                                | 0.14                      |                  |                           |                          |

Signif. codes: ‘\*\*\*’ 0.01 ‘\*\*’ 0.05 ‘\*’ 0.1

The importance of knowledge transfer benefits (column 1) is positively related to the use of open source and copyright, and to the simultaneous use of both “hard” and “soft” IP. Universities with more business people on their governing body are less interested in achieving knowledge transfer through IP exchange. This may indicate that these universities have greater commercial orientation. By contrast, having a high a larger scientific staff and being a college of higher education or university increases the perceived importance of knowledge transfer benefits from IP.

The importance of creating awareness from IP (column 2) is positively related to the exchange of non-patented innovations and negatively related to the presence of an in-house commercialisation unit. The importance of knowledge feedback from IP (column 3) is positively related to the number of academic staff, and negatively related to the proportion of scientific staff and to the university’s ability to derive income from IP. The qualitative interviews (especially University 1 and University 3) have confirmed that universities derive numerous benefits from their knowledge transfer activities not only financially but also through feedback for their teaching and research activities. The benefits include reputation-enhancement, employment opportunities for students, student internships and work on hands-on projects at partner firms, the possibility to set up courses for companies, and enhancement of research activities. From the interviews, these feedback benefits seem particularly important to the teaching-oriented university, with its social science, arts and humanities knowledge base. This may explain why science-oriented universities are significantly less likely to seek to enhance knowledge feedback flows.

Finally, the importance of financial benefits (column 4) is positively related to the use of patents and copyright.

These results support the findings that different types of knowledge and financial resource flows are associated with different forms of IP. When universities seek to raise money, they primarily turn to “hard IP”, but when the objective is to transfer knowledge and raise awareness of the research base, they prefer “soft IP” (or a combination of “hard” and “soft” IP). There are no strong correlations between organisational characteristics and the decision to enhance particular knowledge flows, indicating that all types of flow are of importance to all types of university.

### **3.8. Obstacles to IP flows**

(RQ5): What obstacles do universities encounter when transferring IP, which prevent them from effectively and efficiently managing their flows of knowledge between research base and commercial use?

Table 16 shows the obstacles to knowledge flows experienced by UK universities (results are highlighted in bold when a particular obstacle is experienced by more than 39%). With patents, copyright and non-patented innovations, the main obstacles have to do with lack of transparency in the marketplace, due to the difficulty of assessing the degree of novelty/originality of the IP, unclear IP documentation and – most importantly - difficulty in assessing the economic value of the IP. Universities also find it difficult to locate patent users.

Contract negotiation is also a problem, particularly with copyright. When dealing with open source, universities have problems locating the owners and users of IP (search), and in finding the best IP. They also have difficulties with transparency and enforcement (especially lack of trust and presence of opportunistic behaviour).

Since many universities encounter such problems, their TTOs may need to dedicate more resources to the search for potential users or to strengthen their internal capabilities in IP management. They may benefit from improving their knowledge and understanding of IP content, the commercial capabilities to correctly value IP and IP contract negotiation.

It is interesting that these problems are found to a similar extent with both “hard” and “soft” IP, suggesting that the institutions of the patent and copyright marketplace (formal registration, searchable databases, codified documents describing the innovation) do not necessarily solve the complex issues involved in the transaction of information goods: information asymmetries and market failures (such as the difficulty in finding a buyer and identifying an equilibrium price) remain. Relatively few respondents suggest that the problems lie with too little or too much regulation.

These results suggest that improving the capabilities of TTOs may help reduce some problems but it is unlikely to solve all of them. For example, the uncertainty surrounding the value of university IP is likely to remain (since uncertainty in terms of potential applications, and hence commercial value, is a key feature of the outcomes of academic research, see e.g. Nelson, 1959) so it may make more sense for universities to try to maximise the knowledge transferred through their IP rather than the price that they can derive from it.

*Table 16. Obstacles to knowledge flows within IP marketplaces*

|   | <i>Patents</i> | <i>Copyright</i> | <i>Open source</i> | <i>Non-patented innovation</i> |
|---|----------------|------------------|--------------------|--------------------------------|
| Number of universities transferring each type of IP                         | 23             | 13               | 12                 | 13                             |
|   | %              | %                | %                  | %                              |
| <b>Search</b>   | <b>30</b>      | <b>15</b>        | <b>33</b>          | <b>39</b>                      |
| • Difficulty in locating the owners of IP                                   | 4              | 15               | 8                  | 15                             |
| • Difficulty in locating the users of IP                                    | <b>30</b>      | 8                | 17                 | <b>31</b>                      |
| • Difficulty in finding the best IP   | 4              | 0                | 25                 | 8                              |
| <b>Transparency</b>   | <b>44</b>      | <b>62</b>        | <b>33</b>          | <b>46</b>                      |
| • Difficulty in assessing the degree of novelty of IP                       | 26             | 15               | 0                  | 15                             |
| • The description or drawing in the IP document is not clear                | 0              | 0                | 8                  | 23                             |
| • Difficulty in assessing the economic value of IP                          | <b>44</b>      | <b>54</b>        | 25                 | <b>39</b>                      |
| <b>Contract negotiation</b>   | <b>35</b>      | <b>46</b>        | 8                  | <b>39</b>                      |
| • Difficulty in negotiating a price for the IP                              | 22             | <b>46</b>        | 0                  | <b>39</b>                      |
| • Difficulty in negotiating the terms (not related to price) of the IP      | 26             | 15               | 8                  | 15                             |
| <b>Enforcement</b>  | 22             | 23               | <b>33</b>          | <b>39</b>                      |
| • Excessive cost of enforcing the IP contract                               | 9              | 23               | 0                  | 23                             |
| • Problems (not related to cost) with enforcing the contract                | 9              | 0                | 8                  | 8                              |
| • Trust issues (e.g. opportunistic behaviour, free-riding, or similar)      | 0              | 8                | 25                 | 15                             |
| <b>Regulation and practices</b>   | 17             | 8                | 25                 | 8                              |
| • Regulations allow too exclusive rights                                    | 4              | 0                | 8                  | 8                              |
| • International regulations do not fit the needs of different local markets | 13             | 8                | 8                  | 8                              |
| • Differences in practices of firms   | 0              | 8                | 17                 | 0                              |

Universities face a variety of obstacles in all IP marketplaces. Therefore, it is helpful to compute which obstacles are relatively more frequent in which IP marketplaces and IP governance forms.

We can do so by computing a “revealed disadvantage” index which is constructed in the same way as the RGA and RMA indexes introduced earlier (see text to Table 11), this time focusing on obstacles rather than benefits. The “revealed governance disadvantage” (RGD) (or “revealed marketplace disadvantage”, RMD) index measures the extent to which universities that take part in a certain IP governance form or marketplace experience a certain obstacle, relative to the overall experience of this obstacle in all IP governance forms or marketplaces. Values of the index greater than 1 are highlighted.

*Table 17. Obstacles to knowledge flows: revealed disadvantage of marketplaces and governance forms<sup>#</sup>*

| <i>RMD or RGD</i>                 | <i>Search</i> | <i>Transparency</i> | <i>Contract negotiation</i> | <i>Enforcement</i> | <i>Regulation and practices</i> |
|-----------------------------------|---------------|---------------------|-----------------------------|--------------------|---------------------------------|
| Patents                           | <b>1.09</b>   | 1.00                | <b>1.13</b>                 | 0.89               | 0.56                            |
| • Selling                         | 0.96          | <b>1.07</b>         | 0.83                        | <b>1.45</b>        | 0.00                            |
| • Out-licensing                   | 1.00          | 1.00                | 1.00                        | <b>1.25</b>        | 0.00                            |
| • In-licensing                    | 0.00          | <b>1.50</b>         | <b>1.93</b>                 | 0.00               | 0.00                            |
| • Cross-licensing                 | <b>1.29</b>   | 0.86                | <b>1.10</b>                 | 0.00               | <b>3.86</b>                     |
| • Pooling                         | <b>1.13</b>   | 0.75                | 0.96                        | 0.00               | <b>6.75</b>                     |
| Copyright                         | 0.45          | <b>1.17</b>         | <b>1.23</b>                 | 0.86               | <b>1.64</b>                     |
| • Selling                         | 0.88          | 0.93                | 0.97                        | <b>1.18</b>        | <b>1.18</b>                     |
| • Buying                          | <b>2.30</b>   | 0.97                | 0.84                        | <b>1.02</b>        | 0.00                            |
| • Out-licensing                   | <b>1.15</b>   | 0.97                | <b>1.25</b>                 | 0.77               | 0.77                            |
| • In-licensing                    | 0.00          | <b>1.21</b>         | 0.52                        | <b>1.28</b>        | <b>1.92</b>                     |
| Open source                       | <b>1.43</b>   | 0.92                | 0.32                        | <b>1.35</b>        | <b>1.29</b>                     |
| • Software                        | <b>1.07</b>   | 0.86                | <b>1.07</b>                 | <b>1.07</b>        | <b>1.07</b>                     |
| • Other                           | 0.00          | <b>3.00</b>         | 0.00                        | 0.00               | 0.00                            |
| Non-patented innovations          | <b>1.14</b>   | 0.88                | <b>1.02</b>                 | <b>1.08</b>        | 0.82                            |
| • Releasing to public             | <b>1.26</b>   | 0.81                | 0.87                        | <b>1.01</b>        | <b>1.89</b>                     |
| • Releasing to private firms      | <b>1.07</b>   | <b>1.03</b>         | <b>1.48</b>                 | 0.64               | 0.00                            |
| • Using                           | 0.91          | 0.87                | 0.94                        | <b>1.36</b>        | 0.00                            |
| • Collaborating with universities | 0.79          | <b>1.26</b>         | 0.82                        | 0.94               | <b>1.77</b>                     |

<sup>#</sup>The specific market obstacles underpinning the give broader groups (search, transparency, contract negotiation, enforcement, and regulation & practices) are in Table 16.

Table 17 shows that different obstacles are relatively more important in different IP marketplaces and in different governance forms. Search and contract negotiation problems are relatively more important with patents compared to other IP marketplaces: search is particularly important when cross-licensing and pooling patents, contract negotiation when in-licensing and cross-licensing patents.

Lack of transparency (particularly when in-licensing copyright), difficulties in contract negotiation (particularly when out-licensing copyright) and regulation problems (particularly when selling and in-licensing copyright) matter most with copyright.

Problems of search (particularly when releasing non-patented innovations to the public and to private firms), contract negotiation (particularly when releasing non-patented innovations to private firms) and contract enforcement (particularly when using non-patented innovations) are most important with non-patented innovations.

### **Summary of Section 3:**

#### Concerning RQ1: Universities' IP activities:

- All universities use several forms of IP (both “hard” and “soft”) in their knowledge acquisition and transfer.
- For most universities, participation in “hard” and “soft” IP marketplaces represents complementary strategies of knowledge acquisition and transfer.
- Universities tend to sell and out-license patents and copyright, rather than buy or in-license them. However, universities are very active both in releasing and using non-protected knowledge.

#### Concerning RQ3: Role of organisational characteristics (with respect to RQ1):

- Larger institutions tend to transfer patents, copyright and non-patented innovations, while open source is relatively more prevalent in smaller institutions. Larger institutions are also more likely to transfer both “hard” and “soft” IP. Greater size and volume of activities allows TTOs to specialise and hence more effectively to exploit different types of IP, afford the transaction costs involved in engaging in different IP marketplaces and take advantage of government incentives.
- Certain types of university are particularly active in transferring a wide range of IP. This is in line with our interviews, which suggested that the most research-intensive universities (such as the “old” universities) produce a wide variety of research outputs and hence generate a large variety of IP, while the more teaching-oriented universities (such as the former polytechnics) produce less output from basic research but strive to have a greater variety of commercial interactions with industry.

#### Concerning RQ2: Strategic management of IP by universities and the role of different forms of IP and IP governance:

- Different types of strategic benefit from flow of knowledge between research base and commercial use are associated with different forms of IP. When universities seek to raise more money, they primarily turn to “hard IP” (although the effectiveness of the patent instrument for this purpose is debated, - see section 2), but when the objective is to transfer knowledge and raise awareness of the research base, universities rely upon “soft IP” (or on a combination of “hard” and “soft” IP).
- Universities seek different types of strategic benefit from different IP governance forms for the exchange of IP. This is particularly so in the case of “hard IP”, where financial resources and knowledge transfer are particularly sought from selling or licensing patents or copyright to others. In the case of “soft IP”, all governance forms confer benefits relating to knowledge feedback, awareness of research base and knowledge transfer, to a similar extent.

Concerning RQ4: Role of organisational characteristics (with respect to RQ2):

- There is no strong correlation between organisational characteristics and the decision to enhance particular knowledge flows, indicating that all flows are of importance for all types of university.

Concerning RQ5: The effectiveness of IP markets to facilitate flow of IP and the role of different forms of IP and IP governance forms:

- Universities face a variety of obstacles to their flow of knowledge in all IP marketplaces. However, it is possible to identify certain obstacles as relatively more important in certain IP marketplaces and for certain IP governance forms. These obstacles particularly concern transparency and contract negotiation with respect to the nature of academic knowledge, the economic value of which is difficult to assess. This in turn generates difficulties in the negotiation of contracts, including price. It is also hard to locate IP users. Improving the internal capabilities of TTOs may help mitigate problems of search, lack of transparency and difficulties in contract negotiations.

## 4. Conclusions

Over time, policy approaches to university-industry knowledge transfer have evolved from an almost exclusive focus on the funding of basic research with no attention paid to the problem of knowledge dissemination, to a much greater appreciation for the need to involve universities in knowledge transfer processes. The university has changed from an “ivory tower” to a key participant in its national and local innovation system, expected actively to engage in the bilateral exchange of knowledge and resources with business and government agencies.

Although the important role that universities play in the production and dissemination of new knowledge is now widely shared and acknowledged, there is still a debate about the most effective forms of knowledge transfer. Since the 1980s, many policymakers have believed (or been advised) that intellectual property rights protection is required for university-produced knowledge to be transferred effectively. This has stimulated legislation aimed at encouraging universities to appropriate the IP of the discoveries emerging from academic research and to set up organisational structures supporting the exploitation of such IP. However, this model has recently been challenged and numerous scholars have encouraged universities and policymakers to look at alternative models. In particular, it is now increasingly appreciated that direct collaborations between university and industry, rather than simple patent or copyright transactions, are a key vehicle for knowledge transfer. These collaborations can include research contracts, joint ventures, consultancies, joint supervision of students, graduate employment, and other channels.

It has been shown (Bruneel et al, 2009; Cohen et al, 2002; Mowery and Sampat, 2005) that industry considers “open science” channels such as publications and conferences as the most important way to access academic knowledge, followed by several types of collaboration; the exchange of patents always ranks much lower. Although the patent model of knowledge transfer has been enthusiastically adopted for universities, empirical evidence shows it to be effective only for a few industries (biotechnology and pharmaceuticals) while firms in most other industries rely on different business models to protect their knowledge and develop innovations. Since universities produce a variety of research outputs of interest to a variety of industries, focusing too strictly on the patent model is likely to hamper rather than stimulate knowledge transfer efforts.

This is supported by our original empirical evidence which shows that: (i) universities generate and exchange a wide variety of IP, not limited to patents; (ii) most universities exchange more than one type of IP (different forms of IP are used in a complementary way); and (iii) bi-directional knowledge flows are enhanced by the transfer of non-protected IP.

It is also increasingly appreciated that the diversity in the nature of the universities’ knowledge bases, research outcomes and organisational features needs to be reflected in a variety of knowledge transfer models. Policies therefore need to be flexible enough to allow universities to develop different approaches to knowledge transfer. As the metrics used to measure university performance are an important driver of the universities’ choice of knowledge transfer activities, it is important that those metrics are not primarily focused on indicators measuring patenting and licensing activities, but that they take account of a wider variety of knowledge transfer possibilities.

The diverse organisational features of universities are important in influencing their choice of knowledge transfer model. Qualitative interviews with universities have confirmed that the importance of these different models varies according to numerous interdependent factors, including the extent to which the university is research-intensive or more oriented to teaching, the university’s knowledge base, its entrepreneurial culture and the competencies of its technology transfer office (TTO).

The empirical analysis also shows that, while all universities are generally interested in enhancing all types of knowledge and resource flow, the intensity with which they do so and the forms of IP that they transfer differ according to their characteristics. The most research-intensive universities produce a wide variety of research outputs and hence generate a large variety of IP, while the more teaching-oriented universities (often the former polytechnics) produce less output from basic research but have a greater variety of commercial interactions with industry, so they also transfer a wide variety of IP. Other types of university such as art and music colleges are more specialised in certain types of IP. This also supports the argument that policies need to be flexible enough to allow different types of university to identify the best knowledge transfer model.

Our empirical analysis relies upon a small set of organisational variables (history, age, size, region, research orientation), which are combined with the universities' IP transfer behaviour. Understanding the relationship between a university's organisational characteristics and broader IP transfer activities can enable more tailored policy advice with respect to the most appropriate models for knowledge transfer for different types of university.

Several authors have suggested that universities' objectives are too focused on maximising revenue over the volume of knowledge transferred. If the objective of universities' third mission activities is knowledge transfer, in line with their mission as "public service" organisations, then we should consider which mechanisms allow universities to maximise the flows of knowledge between university and society in both directions. Doing so should broaden the pool of knowledge available to society. Our empirical survey casts doubt on the suitability of a model of IP transfer predominantly based on the exchange of intellectual property rights in achieving this objective. In fact, when universities transfer "hard IP", they primarily seek to raise money, but when they rely upon "soft IP" their main objective is to enhance bi-directional knowledge flows. It may well be that for certain types of university, the release of non-protected knowledge is the best way to maximise IP transfer. For others, a combination of IPRs and open access knowledge may be more appropriate. More research into the extent to which "hard" and "soft" IP complement each other would be welcome, as this is a very important but so far under-explored area of research. The empirical investigation presented in this report is very original in its approach.

Circulating knowledge through IP exchange has many obstacles. Certain obstacles seem more prevalent for certain types of IP and for certain governance forms. Overall, we found that the most significant obstacles experienced by UK universities concern transparency and contract negotiation with respect to the nature of academic knowledge, the economic value of which is difficult to assess; this in turn generates difficulties in the negotiation of contracts. Universities also find it difficult to locate the users of their IP. More research in this area could investigate ways to reduce these obstacles. One problem may be that some academic knowledge is characterised by uncertainty in terms of potential applications, and hence commercial value (see e.g. Nelson, 1959), generating difficulties in the negotiation of contracts. Another problem is that patent litigation and enforcement is a very complex area, which can involve high costs in time and effort, and costly patenting disputes can also damage relationships with industry instead of promoting knowledge transfer. For these reasons, some critics have argued that universities' resources would be better spent fulfilling their mission of providing education and developing new knowledge - and making it openly available.

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