BACKGROUND PAPER - An evaluation of incentives and policies that affect research institutions' knowledge transfer activities

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Outline and research approach

In the past decades, more and more attention has been focussed on the way universities and other public research organizations contribute to economic growth. At European, national, and institutional level, various policies have been introduced to improve knowledge transfer between research and industry. These policies address, directly or indirectly, a wide variety of channels for knowledge transfer, ranging from publications to intellectual property rights. There is an ongoing debate on the relative effectiveness of these different policies. This paper aims to evaluate those incentives and policies that affect the knowledge transfer activities of individual researchers as well as research institutes such as universities and Public Research Organisations (PROs).

In order to do so, we firstly focus on the relationship between policies and incentives for different channels of knowledge transfer. We distinguish between incentives for individual researchers (created by either research institutes or at national/European level), and incentives for research institutes (which are, in turn, created by national governments or the EU). Some of these incentives are created by intentional policies, while others are built in.

Secondly, we discuss the effectiveness of selected policies and incentives. This selection will include those policies highlighted by policy makers and technology transfer managers in recent years, as well as some novel ones. Our focus is on IPR policies, spin-offs policies, funds for collaborative research, and innovation voucher systems. The discussion is based on academic papers and research evidence as well as impact and policy evaluation reports. We will also pay specific attention to ways of measuring and monitoring all these policies.

Thirdly, we reflect on the role of the discussed policies in the wider realm of knowledge transfer. What is their relative role, compared to that of the more traditional means of dissemination of academic knowledge? Can we safely rely on the metrics we apply to evaluate our policies? How can we measure the additionality of policies? - in other words, to what extent would knowledge transfer also have taken place in the absence of specific policies?

This position paper is predominantly based on a review of existing literature, focussing on studies that provide factual evidence. The selection of papers was done as follows: Initially, papers were identified and chosen by querying a set of keywords using Scopus. Preference was given to papers in journals with relatively high impact factors. Additionally, one journal was selected on the basis of its direct relevance to this topic, the Journal of Technology Transfer. Recent volumes of this journal were scanned entirely. From here on, the snowball method was used to identify other relevant literature and seminal contributions to this field of research. As much as possible, findings were collated on the basis of evidence and measurements (preferably quantitative), not on unproven expectations. As a consequence of the availability of material, a rather large part of the input relates to the United States, where many more studies have been performed. This does have consequences for the generalizability of the findings. On the other hand, evidence – even if from another region – is more valuable than guesses. And, fortunately, there have also been good European studies, notably in Italy, Spain, the Netherlands, and Scandinavia.

1. Introduction to knowledge transfer

Two related issues on knowledge transfer have dominated the agenda of researchers. One refers to the tacit and codified nature of knowledge and the implications for its transfer. The other refers to the nature of the transfer process. Studying the differences in tacit and codified knowledge and the channels for its diffusion has revealed that codified knowledge involves skills and knowledge development for its codification as well as for its interpretation and application (Cohendet and Steinmueller, 2000; Cowan et al., 2000). Indeed, research has shown that some tacit competencies are not specific to one organisation, while certain codified knowledge is strongly specific and non-transferable (Dosi et al., 2000; Coriat and Dosi, 2002). The study of the nature of the transfer process has shown that the process of knowledge transfer is not dissociated from the process of knowledge development, thus adoption and application of external knowledge involve learning and knowledge development (Geroski, 2000; Metcalfe 2005). Consequently, social context and institutional/organisational characteristics affect the rate and form of knowledge transfer (Rogers, 1995). In other words, to engage in sharing knowledge and processes of learning, two actors need to have incentives and to feel somehow rewarded (Cohendet and Steinmueller, 2000 Cohendet and Meyer-Krahmer, 2001). Thus, depending on the characteristics of knowledge, the skills of the actors involved, and the incentive and reward systems ruling the activities of both
actors, knowledge may be exchanged through a great variety of channels (David and Foray, 1996; Coriat and Weinstein, 2002).

In the past decades, increasing attention has been paid to the process of knowledge transfer between universities and other public research organizations and industry, focusing on the way public research contributes to economic growth. The existing evidence suggests that academic research has a positive impact on the development of industrial innovation (Salter and Martin, 2001). In particular, some authors have shown that around 10% of the new products and processes introduced by firms would not have been developed (or only with great delay) without the contribution of academic research (Mansfield, 1991, 1998; Beise and Stahl, 1999).

Knowledge is found to flow between university and industry through several channels, from publications to informal contacts, from collaborative research projects to flows of personnel, and from consultancy or contract research to patents and spin-offs (Meyer-Krahmer and Schmoch, 1998; Cohen et al., 2002). This variety in the use of different channels of knowledge transfer seems mainly related to the disciplinary origin, the characteristics of the underlying knowledge, as well as the individual characteristics of researchers involved in producing and using this knowledge, and the environment in which knowledge is produced and used (institutional characteristics) (Bekkers and Bodas Freitas, 2008; D’Este and Patel, 2007).

Thus, also in the specific case of university-industry interaction, knowledge transfer does not occur in a void. Instead, the personal motivation of participating actors, the reward and incentive systems of the organisations in which they are working as well as national institutions and policies affect the pattern of university-industry interaction (Foray and Steinmueller, 2003). Both motivation related to personal preferences for curiosity, problem-solving and applicability, as well as professional motivation (access research resources and open up research possibilities) may lead university researchers to engage in excellent research as well as in interaction with industry (Lee, 2000; Geuna and Nesta, 2006; Bodas Freitas and Verspagen, 2008). In particular, Bodas Freitas and Verspagen (2008) show how national and institutional incentives affect the alignment of industrial and university researchers’ motivation to collaborate, as well as the organisation for knowledge development and transfer.

Assuming that national competitiveness depended on the improvement of knowledge flow between university and industry, and that this could be achieved by creating incentives for more intense interaction between university and industry and making universities more entrepreneurial, various industrial innovation and science policies have been introduced to improve knowledge transfer between research and industry at European, national, regional, and institutional/organisational level. In particular, the European Commission through the Framework Programme has been fostering collaboration among businesses as well as between business and public research organisations. Moreover, national innovation policies have been supporting collaborative and contract research projects with industry, while national science policies have been encouraging entrepreneurial universities, such as ruling on university intellectual property rights (IPR) and encouraging Technological Transfer Offices (TTO), as well as fostering greater involvement of academic and industrial researchers by framing research funds in the context of university-industry collaboration. Additionally, European universities have established supportive infrastructures such as TTO, to promote university patenting, licensing and spin-offs. They have also been revising their reward systems, in an attempt to make their researchers more entrepreneurial and business oriented while encouraging their participation in contracted research.

All these policies address in some way a wide variety of channels for knowledge transfer, ranging from publications to IPR. As the responsibility of universities for economic development is increasingly acknowledged and required, and the financing of research activities is becoming less based on structural public funding but increasingly reliant on the allocation of competitive private and public funds and commercialisation of university activities, there is ongoing debate on the relative effectiveness of these different policies. This paper attempts to evaluate those incentives and policies that affect knowledge transfer activities both at the level of individual researchers and that of research institutes.

We start by examining the incentives for interaction with industry through different channels of knowledge transfer in order to map the relationship between required individual and organisational incentives, the main channels of knowledge transfer used, and the governmental and institutional policies for knowledge transfer. In particular, we will analyse the motivation and incentives for using the six main channels of knowledge transfer between university and industry: publications, labour mobility, informal contacts, collaborative and contract research, spin-offs, patents and licensing. We distinguish between incentives for individual researchers and incentives for research institutes. Some of these incentives are created by the established academic career design and by intentional policies, while others are fundamental to individual researchers and the research activity. Moreover, we examine the incentives that governmental and institutional policies can create and have been creating to encourage academic researchers to make greater use of each of these channels. In addition, we will focus on the measurement and assessment of scientists’ involvement in technology transfer activities. In
particular, we explore measures for individual and organisational involvement and sources of information for those measures.

Once we have mapped existing individual and institutional incentives for using the main channels of knowledge transfer, we will then examine the effectiveness of selected policies designed to increase the involvement of academic researchers in technology transfer activities. This selection will include those policies highlighted by policy makers and technology transfer managers in recent years, as well as some novel policies. We focus on (1) IPR policies, (2) spin-offs policies, (3) funds for collaborative research, and (4) innovation voucher systems. Thus specific policies address three of the main types of channels of knowledge transfer, as specific policies for publications and informal contacts are almost non-existent or do not stand alone. Our discussion will be based on academic papers and research evidence as well as impact and policy evaluation reports. We will also pay specific attention to ways of measuring and monitoring these policies. Additionally, building on the exercise of mapping the relationship between required incentives and channels of knowledge transfer, we will address the issue of additionality and proper use of certain policies to foster university-industry interaction.

Finally, we reflect on three broader issues related to the effectiveness of technology transfer activities and policies. The first issue is whether policies can effectively address all forms of technology transfer, as well as the consequences of the invisibility of some of these channels for policy makers and institutional managers. We also analyse the measurement of individual and organisational involvement in technology transfer activities, along with the performance of these activities. Related to this point, we will address the second issue that refers to the underlying performance factors of technology transfer activities, such as the absorptive capability of industry, and the organisation and quality of academic research. In particular, we will discuss the rationale and evidence behind European Paradox, and how it impacts on policy. Finally, we will focus on the implications for Science and Innovation industrial policy of the observed interdependencies of channels of knowledge transfer, as well as of incentives for interaction with industry.

This paper is set out as follows: Section 2 discusses the general nature and dimensions of incentives and rewards, looking in more depth at the individual and organisational incentives to interact with industry through diverse types of channels. Moreover, it maps the relationship between incentives, the use of different channels of knowledge transfer, policies, and measures for such involvement and its performance. Section 3 reviews the effectiveness of policies focusing on (1) IPR policies, (2) spin-offs policies, (3) funds for collaborative research, and (4) innovation voucher systems. Section 4 concludes this paper by reflecting on broader issues related to the effectiveness of technology transfer activities and policies.

2. Incentives for knowledge transfer and how they relate to policies

Incentives are inherent to the economic activity of actors, to the form of organization and governance and consequently to the existing evaluation and reward mechanisms. Exogenous incentives are often put in place by managers and governments to encourage behaviour, a course of action or a relative choice. Therefore, the analysis of the differences in performance, behaviour and preferences across economies, organisations and individuals needs to include the examination of incentives and reward structures across economies and organisations within an economy.

In an analysis of the nature and scope of incentives and rewards, we examine how incentives match personal and institutional motivation to undertake activities, achieve objectives, as well as whether and how incentives and rewards affect the outcomes and performance of individuals and organisations. Building on this analysis, we examine and map the relationship between incentives for interacting with university through a variety of channels. Some of these incentives are created by intentional policies, while others are intrinsic characteristics of individuals, organisations and research activity. In particular, we distinguish between incentives for individual researchers and incentives for research institutes. Finally, we address the issue of measurement of the individual and institutional involvement and performance in technology transfer activities.

2.1. Main channels of knowledge transfer between university and industry

The existing literature is quite consensual that knowledge transfer between university and industry occurs through a diversity of channels. Some studies have analysed the importance of a very extensive list of channels; an example is shown in Table 1, where both university research staff (the “senders” of knowledge if we adopt a linear view) and industrial R&D researchers (the “receivers” of knowledge) were asked to rate the various knowledge exchange channels they utilised themselves (Bekkers and Bодas Freitas, 2008). Other studies have
found similar ratings (Cohen et al., 2002; D’Este and Patel, 2007). Most often, the wide range of channels can however be reduced to a handful groups: publications, labour mobility, informal contacts, collaborative and contract research, spin-offs, patents and licensing.

### Table 1: Importance rating for various knowledge transfer channels by industrial R&D staff and by university research staff

<table>
<thead>
<tr>
<th>Form of knowledge transfer from universities to firms</th>
<th>Industrial R&amp;D staff (n=575)</th>
<th>University research staff (n=454)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average importance</td>
<td>Share of high importance</td>
</tr>
<tr>
<td>Scientific publications in (refereed) journals or books</td>
<td>3.1</td>
<td>76%</td>
</tr>
<tr>
<td>Other publications, including professional publications and reports</td>
<td>3.0</td>
<td>82%</td>
</tr>
<tr>
<td>Patent texts, as found in the patent office or in patent databases</td>
<td>3.0</td>
<td>71%</td>
</tr>
<tr>
<td>Personal (informal) contacts</td>
<td>3.0</td>
<td>73%</td>
</tr>
<tr>
<td>University graduates as employees (B.Sc. or M.Sc. level)</td>
<td>3.0</td>
<td>69%</td>
</tr>
<tr>
<td>University graduates as employees (Ph.D. level)</td>
<td>3.0</td>
<td>62%</td>
</tr>
<tr>
<td>Participation in conferences and workshops</td>
<td>2.9</td>
<td>67%</td>
</tr>
<tr>
<td>Joint R&amp;D projects (except those in the context of EU Framework Programmes)</td>
<td>2.8</td>
<td>60%</td>
</tr>
<tr>
<td>Students working as trainees</td>
<td>2.8</td>
<td>63%</td>
</tr>
<tr>
<td>Joint R&amp;D projects in the context of EU Framework Programmes</td>
<td>2.7</td>
<td>49%</td>
</tr>
<tr>
<td>Contract research (excl. Ph.D. projects)</td>
<td>2.5</td>
<td>44%</td>
</tr>
<tr>
<td>Financing of Ph.D. projects</td>
<td>2.4</td>
<td>37%</td>
</tr>
<tr>
<td>Sharing facilities (e.g. laboratories, equipment, housing) with universities</td>
<td>2.4</td>
<td>33%</td>
</tr>
<tr>
<td>Staff holding positions in both a university and a business</td>
<td>2.4</td>
<td>36%</td>
</tr>
<tr>
<td>Flow of university staff members to industry positions (excl. Ph.D. graduates)</td>
<td>2.4</td>
<td>35%</td>
</tr>
<tr>
<td>Licenses of university-held patents and ‘know-how’ licenses</td>
<td>2.4</td>
<td>32%</td>
</tr>
<tr>
<td>Temporary staff exchange (e.g. staff mobility programmes)</td>
<td>2.3</td>
<td>27%</td>
</tr>
<tr>
<td>Personal contacts via membership of professional organisations (e.g. KIVI NIRIA)</td>
<td>2.3</td>
<td>32%</td>
</tr>
<tr>
<td>University spin-offs (as a source of knowledge)</td>
<td>2.3</td>
<td>32%</td>
</tr>
<tr>
<td>Consultancy by university staff members</td>
<td>2.3</td>
<td>35%</td>
</tr>
<tr>
<td>Specific knowledge transfer activities organised by the university’s TTO</td>
<td>2.0</td>
<td>15%</td>
</tr>
<tr>
<td>Contract-based in-business education and training delivered by universities</td>
<td>2.0</td>
<td>14%</td>
</tr>
<tr>
<td>Personal contacts via alumni organisations</td>
<td>1.9</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Total Average</strong></td>
<td><strong>2.55</strong></td>
<td><strong>46%</strong></td>
</tr>
</tbody>
</table>

Publications and informal contacts are found to be the most important form through which university knowledge serves as an input to industrial innovation. It is through scientific publications that industry identifies the streams of university research they need and the people they need to contact (Narin et al., 1997; McMillan et al., 2000; Cohen et al., 2002, Bekkers and Bodas Freitas, 2008). In particular, knowledge accessed through publications was found to be concerned either with the properties, characteristics or composition of materials and components, or with laws, theories, and general principles (Gibbons and Johnston, 1974). Informal contacts are both a crucial driver and an outcome of academics’ interaction with industry. The more informal the contacts, whether of a personal or professional nature (previous work experience, student supervision), the more an academic is expected to engage in collaborative research projects with industry (D’ Este and Patel, 2007; Ponomariov and Craig, 2008).

Labour mobility (i.e. flows of university staff members to industry positions, staff holding positions in both a university and a business; temporary staff exchange) seems to be an important form of transferring knowledge between university and industry, especially if breakthroughs are expected and knowledge is not likely to be written, published or fully embodied (Bekkers and Bodas Freitas, 2008). The employment of university researchers is described as an effective way to transfer knowledge from universities to firms, especially for the successful application of university patents and spin-offs in commercializing products and surviving (Zucker, et al., 2002; Gübeli and Doloreux, 2005; Bercovitz and Feldman, 2006). In this paper, we also consider staff mobility as postgraduate students doing projects with industry because in many European countries, doctoral students are also considered as university staff. These students are a particularly important channel of knowledge transfer because they are already connected to inventions through academic activities (Lam, 2005; Balconi and Laboranti, 2006; Lockett et al., 2008).

Collaborative and contracted/consulting research seems particularly important for transferring written and published as well as systemic and interdependent knowledge because university and industry join and overlap

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4 Answers are on the basis of a 4-point Likert-like scale, with values ranging from 1 (‘of very little importance’) to 4 (‘very important’). Respondents that indicated that they did not use a channel were excluded for calculating these averages.
research efforts to develop innovations, experiment with products and concepts, and solve complex problems (Kline and Rosenberg, 1986; Pavitt, 1998; Bekkers and Bodas Freitas, 2008). Indeed, collaboration with universities allows firms to have person-to-person interaction with scientists, who play the important role of “translating” information from scientific journals into a form meaningful to the industrial ‘problem-solver’ (Gibbons and Johnston, 1974, p. 236). Collaborative research is a main form of interaction with large knowledgeable firms (Tether, 2002; Bodas Freitas et al., 2008).

Patents and licensing are important channels for the transfer of more applied or experimental research rather than of basic research findings, particularly in biology, chemical engineering, and material sciences (Agrawal and Henderson, 2002; Bekkers and Bodas Freitas, 2008). National science policies have been increasingly focusing on the commercialisation of university knowledge through the promotion of university patenting, licensing and spin-offs. However, the evidence is compelling; these channels are among the least used and the ones found less important to transfer knowledge. In particular, Agrawal and Henderson (2002) show that patents account for only around 10% of all knowledge transfer activities in mechanical and electrical engineering at the Massachusetts Institute of Technology (MIT). This is the perspective of both scientists and industrial researchers (Bekkers and Bodas Freitas, 2008; D’Este and Patel, 2007; Cohen et al., 2002).

### 2.2. Relationship between individual incentives and national and institutional policies

For the purpose of this study, we will analyse individual and institutional incentives to interact with industry, making use of the six (groups of) channels mentioned before. Table 1 summarises individual incentives to transfer knowledge using these six main channels, as well as governmental and institutional policies that can influence scientists’ individual incentives to use these channels.

#### Table 2: Incentives and policies targeting individuals

<table>
<thead>
<tr>
<th>Incentives</th>
<th>University/PRO Policies</th>
<th>National/EU policies</th>
<th>Measurement and evaluation</th>
</tr>
</thead>
</table>
| Academic and professional publications | * Recognition by peers  
* Personal motivation  
Fulfill job tasks  
Job promotion  
Conference participation | Output requirements  
Budget/resource planning (incl. teaching load)  
Job requirements (institute level)  
Career planning rules  
Making conference budgets available | Job requirements (public calls),  
career planning rules (NL: UFO)  
Travelling funds  
Funds for individual or group research projects (NL: NWO/STB, IT: FIRB) | Bibliometrics |
| Informal contacts | Social recognition  
Networking  
Access to resources  
Identifying promising research areas  
Stepping stone for other TT channels | Travelling budgets  
Guest lecturers from industry  
Allowing part-time positions | Funds for conference participation | Network analysis (e.g. bibliometric) |
| Labour mobility | * Change in jobs/activities  
* Desire for applicability  
* Diversity in work  
* Complementarily of work  
Financial/salary  
Resources/facilities at firms  
Identifying promising research areas | Career planning rules  
Allowing part-time positions  
Allowing/encouraging traineeships at firms  
Staff mobility programmes  
Budget/resource planning (incl. teaching load)  
Prevent outflow of staff (negative incentive) | Reducing bureaucratic barriers  
Individual funds (Marie Curie)  
Funds for labour mobility work (Marie Curie)  
UK funds for mixed uni/firm Ph.D.  
Allowing part-time positions | CV |
| Collaborative and contract research | Funds for own research or for group (also: Ph.D. / postdoc funds)  
Resources/facilities at firms  
Recognition by peers or industry  
Maintaining contacts  
Fulfill job tasks  
Job promotion | TTO activities and supports  
Budget/resource planning (incl. teaching load)  
Encouraging/requirements to attract funds | Funds for contract research (e.g. innovation voucher)  
National funds for collaborate research  
EU funds for collaborate research (e.g. FP7) | CV, institute data |
| Spin-offs | Job opportunities / hopping  
Funds for own research or for group (also: Ph.D. / postdoc funds)  
Desire for applicability  
Entrepreneurship | TTO activities  
Encouraging spin-offs  
Financing/equity in spin-offs  
Allowing temporary leave or part-time position | Allowing temporary leave or part-time position  
Funds for entrepreneurship | CV, institute data |
| Patents and licensing | * Pleasure of being an inventor  
* Recognition by peers or industry  
Income (private) | Revenue sharing rules  
Career planning rules  
Disclosure rules | Revenue sharing rules  
Rules of funding agencies on IPR (NL: STW)  
University patent legislation | CV, institute data |
network might also be linked to the inherent social characteristics of individual researchers. Also on the research network of contacts, which is a very rough measurement of ability to develop and on research opportunities, according to Lam, 2005; Balconi Laboranti, 2006; D’Este and Patel, 2007, this network of contacts can be used by scientists to leverage their possibilities of co-authorship, setting up interesting and multidisciplinary research projects, accessing private and public research grants, accessing important resources and infrastructures owned by other organisations including firms to proceed with their own (or their group) research activities.

Consequently, expanding the network of contacts may be as vital as expanding the publication record for academic researchers. A large contact network allows academics to have updated information on knowledge developments and on research opportunities, as well as to leverage access to complementary research resources. Therefore, recognition among peers is increasingly dependent not only on the publication record but also on the research network of contacts, which is a very rough measurement of ability to access complementary resources to research. Additionally, incentives to build and continue to expand their professional and relational network might also be linked to the inherent social characteristics of individual researchers.
Participation in conferences, supervision of master and doctoral students, participation in collaborative projects are means through which academics can maintain and exploit their informal contacts (Ponomariov, 2008, D’Este and Patel, 2007). Most of the European and national competitive research funds preview a budget for travelling and networking, and participation in conferences and workshops. Additionally, some national and European networking programmes might provide not only a directory of research activities, but may also foster interaction between research and with industry (Smid, 2007).

University policies previewing basic travelling budgets for the participation of researchers in conferences, and for setting up internal research seminars and allowing the invitation of other academic as well as industrial researchers as guest lecturers can leverage individual efforts to network. University management should be aware that, to a certain extent, participation in conferences is not only a form of extending the network of research partners, of being exposed to the new knowledge developments, but also often works as a real incentive to publication, as well as a reward to scientists who enjoy diffusing their research results and being immediately reward by their research performance.

In addition, university and national efforts to encourage collaborative master and PhD theses, as well as rules for part-time professorship status create positive incentives for individual researchers to invest in extending their network of relationships.

2.2.3. Labour mobility

Specific personal characteristics of researchers such as desire for changing of job activities regularly, for having diverse job and work experiences, or desire for applicability or achieving a higher complementarity between research and application, are certainly leading to mobility. Consequently, younger and non-tenured researchers are more likely to be mobile and perceive labour mobility as an important channel of knowledge transfer between university and industry (Cespri et al., 2006; Bekkers and Bodas Freitas, 2008).

Wage differentials and desirability of applicability also affect the decision of individual academics to move in or out of academia. Indeed, part-time professorships tend to be involved in research projects that result in the development of industrial solutions, with higher level of usage and commercialisation (Bodas Freitas and Verspagen, 2008). Moreover, academic inventors with more valuable patents, building on their previous work and on specific technological applications, are more likely to go to industry because firms seek valuable know-how with precise economic potential (Cespri et al., 2006). The aim to identify promising research areas, as well as to use certain resources and facilities, which in some specific research areas are mainly owned by industry, are other incentives that might lead to mobility (Lam, 2005; Balconi and Laboranti, 2006). Still, the scientific productivity of patent inventors does not seem to have an impact on their likelihood of moving (Cespri et al., 2006).

Institutional and governmental policies may encourage or at least not prevent mobility through the redesign of academic careers. In particular, policies reducing existing barriers to mobility (possibility to move in and out of academia without major penalisation), allowing or facilitating rules for part-time professorships, and creating programmes for staff mobility could encourage academic researchers to be mobile. In many European countries, academic career designs do not reward labour mobility to industry, and in some cases not even mobility across national research institutions. Except in some very specific research areas, academic career designs tend to go against mobility. Strong cross-country differences in the level of mobility of European academic inventors are found to reflect different academic careers regulation and institutional set-ups (Gittelman, 2006). In particular, in the UK, the Netherlands and Germany, the levels of mobility were found to be higher (Arundel and Geuna, 2004; Crespi et al., 2006).

Moreover, institutional and governmental policies revising educational and doctoral programmes, as well as research grants regulations for collaborative projects in order to make them more supportive of postgraduate theses under research projects with industry, would definitely be a form of fostering technology transfer, labour mobility and expansion of university informal contacts. Master and doctoral students are the visiting card of a university, and a direct means of communication with their professors. Moreover, in the future these postgraduate students could be working in the same industries.

Marie Curie grants are for some of the most well known labour mobility programmes, which focus on international mobility, as well as on mobility between academic organisations and industry. In most European countries, national programmes which encourage collaborative research programmes with industry also finance, albeit indirectly, the mobility of researchers.
2.2.4. Collaborative and contract research

Scientists participate in collaborative and contract research in order to access research resources and funds for graduate students and lab equipment, as well as to gain insight into their research and to test their theory and research, which enables them to improve their publication portfolio, and maintain or expand their relational network (Lee, 1996, 2000; Balconi and Laboranti, 2006). Moreover, participation in collaborative research has increasingly become a way of gaining peer recognition and achieving promotion. On the one hand, allocation of competitive research funds is usually based on assessment of the academic curriculum (productivity and quality) of proponents and on the quality of the research proposal (Manjarrés et al., 2008). On the other hand, in the context of the reduction in structural governmental allocation of funds to university research, there is increasing pressure on academics to bring in money/business to their department (Geuna, 2001). In some research institutions, involvement in collaborative contract research is already a requirement for a contract extension or for promotion. Given the increasing mix of grants for basic research and for university-industry research projects, accessing additional funds to research often implies collaboration with industry, independently of finance from public or private organisations (Dosi et al., 2006). Thus, participation in public and private research sponsored projects is associated with high publication productivity (Bozeman and Gaughan, 2007).

National funds for collaborative research projects as well as the European Framework programme create incentives for academics to engage in research collaboration with industry. By allowing researchers to develop collaboration competencies, these competitive research funds improve both the possibilities of future participation and performance in collaborative and contract research projects (Lee, 1996, 2000; Laredo, 1998; Bodas Freitas and Verspagen, 2008). Collaborative research is almost restricted to large firms and spinoffs; consequently, some nations such as the Netherlands have introduced a “voucher” system, which is basically a cheque that firms receive to go to universities and get some work done.

Institutional policies establishing contract research frameworks that allow reduced time in contract setting, and policies supporting the management of collaborative and contract research may encourage the engagement of university researchers in these projects. Moreover, institutional formal and informal policies, requiring scientists’ involvement in collaborative and contract research projects as an expected accomplishment, and referring to their compliance for performance evaluation and job promotion purposes, are ways of encouraging researchers to participate in collaborative projects. However, these policies need to go hand in hand with a revision of how much time scientists are allocated for teaching, administration, and research.

In addition, despite enhances contact with other scientists, collaboration with industry also restrict communication among scientists because of the secrecy rules set by firms, and because of their increased effort to commercialise their research results and patenting (Welsh et al 2008). Competition among researchers, which is based on the ability to choose relevant research purposes, and to determine their research agendas (Ziman, 1987; Dasgupta and David, 1994), is expected to increase in the context of competitive allocation of public funds for research, and it is likely to lead to a decrease communication among scientists. Therefore, several studies and programmes evaluations have stressed that too much industry influence on academic research could undermine future pay-offs from academic research not only because of its incentives to distract researchers from basic curiosity-driven research but also to invert the values of traditional academic freedom (Berman, 1990, Dosi et al. 2006, Goldfarb, 2008).

2.2.5. Spin-offs

A scientist’s involvement in a spin-off reflects his/her inherent entrepreneurial characteristics and his/her personal desire for applicability, but also his/her perspectives of job opportunities, and additional income (Zucker et al., 2002; O’Shea et al, 2005). Despite being mainly associated with entrepreneurship and business-driven incentives, the creation of spin-offs often reveals a strategy to access additional and independent research funds to proceed with specific lines of investigation, as national and regional policies provide financial support for the creation of university spin-offs (van Ewijk, 2007). Often spin off creation underlies a research management effort to separate curiosity-driven, long-term public funded research and more applied, short term and contracted research, both with public and private organisations (van Ewijk, 2007).

Spin-offs reflect the entrepreneurial activity of academics and of universities. Given the great success of some spin-offs, which has been exacerbated by university managers, media, and policy-makers, the large failure rate of university spin offs is often neglected (O’Shea et al, 2005; Lowe, 2006).

National policies providing financial and managerial support to academic entrepreneurship exist in almost all European countries. These policies may encourage the decision of entrepreneurial researchers to create a spin-off activity. They also influence the performance and survival of the spin off because such policies tend to include support for training and advice for spin off management, as well as the running activity.
Institutional and governmental policies allowing and facilitating temporary leave and part-time positions may also create incentives for the more entrepreneurial researchers to be engaged in spin-off activities. In many institutions, rules for combinations of spin off and professorships exist or are defined a la carte during the process of spin-off creation. If clear and objective rules existed, eventually more scientists could be interested in being involved in such a process.

Additionally, institutional support, usually through the university technology transfer offices, plays an important role in supporting academics with the bureaucracies as well as the managerial skills required to set up and run a business (Lowe, 2006; van Ewijk, 2007). The institutional decision of universities to participate in the equity of the spin-off might also give more security to the more risk adverse individuals.

2.2.6. Patents and licensing

Patenting and licensing represent a source of additional income for inventors and/or their research group. In particular, academic researchers have both the financial and intrinsic research motivation to patent, as they answer to both royalties in the form of cash and research lab support. Therefore, some studies show that universities, allocating a higher percentage of royalty payments to faculty members, tend to be the ones with the greater number of licensing agreements and greater licensing revenue (Link and Siegel, 2005; Lach and Schankerman, 2008). Moreover, a researcher’s inherent pleasure in being an inventor and being recognised as such by peers and industry, determines whether a scientist decides to become involved in patenting activities.

Academic involvement in patenting also reveals specific research disciplinary interests. In some disciplinary areas, patent is an important and quite common academic output recognised by peers. Indeed, university patenting is increasingly believed to be a means of signalling industrial partners as well as sponsors rather than a means of appropriating and supporting innovation (Bodas Freitas and Nuvolari, 2008). Given the increasing mix between public sponsoring for basic research and for university-industry collaborative research projects, the patent portfolio of academics is increasingly being positively evaluated by project proposals reviewers. Thus, academics with a high patent portfolio tend also to have a high publication portfolio (Dietz and Bozeman, 2002; Geuna and Nesta, 2006; Stephan et al., 2007).

Institutional policies for setting or revising disclosure rules and revenue sharing may affect academics’ incentives to patent. Institutional technology transfer offices play a crucial role in supporting patenting of university results, as well as licensing agreements. At national and regional level, policies relating to the establishment of university IPR rules and the proportion of licensing royalty payments allocated to faculty members might lead to an increase in scientists’ patenting activities. Similarly, policies establishing the rules of IPR for research results of sponsored research projects may create positive incentives to university patenting, as it is already done in several countries, such as the Netherlands. Moreover, the positive evaluation of the patent portfolio of academics applying for research and collaborative funds might also encourage researchers to allocate more time to patenting (Bodas Freitas and Nuvolari, 2008). However this may not be as desirable a policy outcome as often thought, and we will discuss this further in section 3.2.

2.2.7. Scientists face trade-offs

University researchers are motivated by several different and possibly contradictory incentives to allocate their time to teaching, personal long-term curiosity-driven research, participation in collaborative research projects, and technology transfer activities. In particular, they are motivated by curiosity, reputation, career (in particular secure a tenure position), access to research resources and personal financial gain (Lee, 1996, 2000; Geuna and Nesta, 2006; Crespi et al, 2006). University researchers’ performance criteria increasingly include good scientific productivity of peer-reviewed publications, participation in high-quality, multi-disciplinary and multi-team collaborative research projects, and good student evaluation. Moreover, political and institutional discourse always puts more and more pressure on scientists to become involved in technology transfer, to foster research applicability and be entrepreneurial.

Given the personal and professional incentives on the one hand, and the policy-making incentives on the other, scientists face a trade-off between producing traditional university outcomes (good research, skilled students) and being entrepreneurial and producing applied research outputs (patents, spin offs, and industrial contract research). According to some authors, the relative productivity of researchers in fundamental and applied research will affect their time allocation decision, and consequently their response to policies encouraging patenting (Beath et al., 2003; Jensen and Thursby, 2004). However, the rise in applied research might not lead to less basic research, as there is no evidence for substitution, or crowding-out between patenting and publishing.
activities (Agrawal and Henderson, 2002; Jensen and Thursby, 2004). Indeed the most productive researchers in terms of publishing are also those with the most patents, although this is likely to differ significantly across scientific fields (Geuna and Nesta, 2006; Stephan et al., 2007). Moreover, researchers who combine research and industry interaction obtain higher funding from competitive public sources than those who only engage in research (Bozeman and Gaughan, 2007; Manjarres et al., 2007).

Nevertheless, increased pressure for applicability and university patenting raises issues concerning the disproportionate incentives for short-term research and the quality of education provided to students (Aldo, 2001; Beath et al., 2003). Especially the quality of teaching might be compromised due to less time allocated by scientists to it as well as over-emphasis on short-term specific skill needs at the expense of a broader education (Dosi et al., 2006). Scientists end up only being involved in short-term research, and not being able to maintain a personal line of research, in case they are not able to frame their basic long-term line of research to the sequence of the collaborative and contract research projects they are involved in (Bozeman, 1994; Geuna and Nesta, 2006). Indeed, Manjarres et al (2007) show that university-industry relations have a positive effect on university scientific productivity only if they are based on the development of R&D contacts and if the funds obtained through these activities do not exceed 15% of the researcher’s budget. When interaction with industry is based on low scientific technological content — technology support and consultancy as well as specific training contracts — the activity may reduce productivity. In particular, the productivity of most-performing scientists decreases when involved in long-term relationships with one specific industry-related sponsor (Goldfarb, 2008).

2.2.8. Measuring individual scientists’ involvement in TT activities

Despite consensual evidence that publications are among the most used channels of knowledge transfer between university and industry, the publication record of a scientist is not per se a proxy for his/her involvement in technology transfer activities. Co-authorship with industrial researcher might be a better proxy for involvement in technology transfer activities. However, it should be noted that if the number of publications co-authored with industry is taken as an official indicator of involvement in technology transfer activities with relevance for a scientist’s career, a trend towards increased co-authorship of university publications is expected (i.e. scientists would be encouraged to include the names of friends and relatives working in industry activities, even if not in research-related activities). Not only the indicators for publication productivity but also the level of co-authorships with industry need to be based on time and labour-intensive bibliometric data and methods.

Measuring the level and growth of researchers’ informal contact network is a difficult task. Network analysis based on bibliometric data on co-authorship is a possible proxy. Other possible measures are the number of various research projects (collaborative, contract and consultancy) involving different research organisations in which the scientist is involved, number of visiting periods in other universities and firms, invitations and participation in seminars and conferences.

Data on the involvement of academic researchers in labour mobility and in collaborative and contract research, need to be collected from the curriculum of the scientist. To a certain extend, financial and administrative departments of faculties may have good information on the number of collaborative and contract projects, but may not be prepared to spend time providing this information. Information on the number of spin offs, patents and license agreements can be collected from the researchers’ CVs or at the university level, close to the TTO. However, these new infrastructures will probably not have information for the period before their creation nor they will have full information on the number and size of contract and collaborative research projects at the university. Moreover, the information collected by the TTO will only reflect the number of patents owned rather than the number of patents invented by the universities. Better proxy for the applicability and patenting efforts of researchers, such as identification of the number of patents in which researchers appear as inventors, would require a tremendous bibliometric effort using patent databases.

2.3. Relationship between institutional/organisational incentives and policies

We will now focus on the institutional/organisational incentives prevalent at the university to improve the level of interaction with industry, and potential and existing policies that address institutional motivation directly.

Table 2 summarises organisational/institutional incentives to get scientists involved in transferring knowledge using the six main channels of knowledge transfer, as well as governmental policies that can affect institutional motivation.
Table 3: Incentives and policies targeting institutions (uni/PRO)

<table>
<thead>
<tr>
<th>Institutional Incentives</th>
<th>National/EU policies</th>
<th>Measurement and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic and professional publications</td>
<td>* Attracting high-quality staff and students</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Ranking and scoreboards</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Level of government funding (UK: RAE)</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Attract contract/collaborative research</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td>Informal contacts</td>
<td>* Improve performance level of staff (creativity, new horizons)</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Access to resources</td>
<td>Access to resources</td>
</tr>
<tr>
<td>Labour mobility</td>
<td>* Improve performance level of staff (creativity, new horizons)</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Industrial applicability of research</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Prevent outflow of staff</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td></td>
<td>Attract contract/collaborative research</td>
<td>* Improve performance level of staff</td>
</tr>
<tr>
<td>Collaborative and contract research</td>
<td>Ranking and scoreboards</td>
<td>Benchmarking exercises</td>
</tr>
<tr>
<td></td>
<td>Attract research funds</td>
<td>Funding policies</td>
</tr>
<tr>
<td></td>
<td>Resources/facilities at firms</td>
<td>Funding system</td>
</tr>
<tr>
<td></td>
<td>Networking</td>
<td>Funding system</td>
</tr>
<tr>
<td></td>
<td>Identifying promising research areas</td>
<td>Funding system</td>
</tr>
<tr>
<td>Spin-offs</td>
<td>Ranking and scoreboards</td>
<td>Benchmarking exercises</td>
</tr>
<tr>
<td></td>
<td>Financial benefits (e.g. equity)</td>
<td>Funding policies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Benchmarking exercises</td>
</tr>
<tr>
<td>Patents and licensing</td>
<td>Ranking and scoreboards</td>
<td>University patent legislation</td>
</tr>
<tr>
<td></td>
<td>Financial benefits (license fees)</td>
<td>University patent legislation</td>
</tr>
</tbody>
</table>

2.3.1. Publications

Universities have incentives to maintain a high production of quality publications in order to attract good students, and good new staff. In the context of national governments making increasingly more use of competitive mechanisms for allocation of research funds, granted on the basis of the academic curriculum of the proponents and on the excellence of proposals, a high institutional publication performance leverages the institutional access to research funds and staff (Aldo, 2001; Bozeman and Gaughan, 2007; Manjarrés et al., 2008). This is even more important in countries such as the UK, where the structural funding for research is also allocated on the basis of the publication performance of institutions (RAE).

In addition, industry looks for collaboration with good quality universities, which are the ones with recognised research productivity and well-trained students. The individual scientist in higher academic quality universities may, however be less likely to interact with industry, because he/she perceives higher incentives to engage in basic, peer-reviewed research (Ponomariov, 2008, D’Este and Patel, 2007). Nevertheless, compared with low-quality research universities, in high quality universities, the supervision of PhD students with grants enhances much more scientifc involvement in technology transfer activities (Ponomariov, 2008). Thus, high institutional publication productivity, which is not per se a good proxy for involvement in knowledge transfer with industry, is a necessary condition to access other channels of interaction with industry, such as collaborative, contract and consultancy research projects as well as master and doctoral students with grants.

National policies related to the allocation of structural and competitive funds for research will influence greatly both the institutional incentives to reward publications and the level of attraction of contracted and collaborative research. Additionally, benchmarking exercises leading to the elaboration of university rankings in productivity of peer-reviewed publications, and numbers of undergraduate and postgraduate students might also provide incentives for university to increase the reward for academics’ productivity.

2.3.2. Informal contacts

Universities have great incentives to employ staff with wide informal contact networks, as the quality and extension of these networks reflect the potential level of access to research resources (funds and quality research opportunities), as well as to updated information on scientific and business governance environments (Lam, 2005; Balconi and Laboranti, 2006; Ponomariov and Boardman, 2007). Consequently, universities are interested in encouraging academics to expand their contact network in order to become more creative and productive, to access additional funds sources, and to increase their involvement in collaborative research and technology transfer activities.
National policies supporting networking of industrial and university research are important sources of incentives for increasing informal contacts. Still, it has been argued that policies for developing informal contact networks and labour mobility are easier to implement and manage, and are more likely to be efficient if they address individuals rather than organisations (Crespi et al., 2006; Ponomariov and Boardman, 2007).

2.3.3. Labour mobility
Universities might have incentives to gain a certain share of labour mobility in and out of academia, since mobility seems to improve creativity, and eventually productivity, as it allows identifying and being inspired by new promising research areas (Balconi and Laboranti, 2006). In particular, encouraging certain staff mobility and a proportion of master and doctoral students working in projects with industry might enable improvement in the level of applicability of university research, expanding the university informal contact network, and consequently the possibility to attract more collaborative and contract research (Lam, 2005; D’Este and Patel, 2007; Lockett et al., 2009).

On the other hand, some studies have found that academic inventors with more valuable patents, based on previous research work, were more likely to be mobile towards industry (Crespi et al, 2006). This result seems to suggest that a brain drain of the most competent and commercial scientists, which is especially bad news at this time when universities are encouraged and expected to commercialise their research results, and national fund allocation for research is increasingly more competitive and less structural (Aldo, 2001; Crespi et al. 2006). Moreover, postgraduate students’ projects with industry can be in some situations particularly difficult to manage, requiring more supervision time from university professors (Versteeg, 2007). Despite all this, the university might also have incentives to prevent the departure of good scientists, to avoid the increase in numbers of scientists with a great industrial background but with poor or average academic curriculum, or the growth of postgraduate theses in collaboration with industry.

National policies on academic career design, allowing part-time professorships, reducing bureaucracy and penalisation for temporary leave from university to industry might be a more efficient way to improve labour mobility than programmes providing specific incentives for organisations to cope with staff mobility. Similarly, encouraging the development of some postgraduate theses with industry would be an effective policy to improve technology transfer through labour mobility.

2.3.4. Collaborative and Contract research
Nowadays, collaborative and contract research are widespread forms of organisation of work and research, reflecting specific labour division and specialisation (Hagedoorn, 1996; Dosi et al., 2000; Lam, 2005). For universities, scientists’ participation in collaborative and contract research is also a form of financing new research projects and new temporary research positions, as well as expanding the existing network of contacts (Lee and Gaertner, 1994; Lee, 1996, 2000; Caloghirou et al., 2003). Thus, the dynamism, performance and financial balance of universities are increasingly associated with the ability of scientists to access public and private research grants, and to contract research with industry, especially as public structural allocation of funds for research tends to fall. On the other hand, the involvement of staff in low-scientific activities and the excess involvement in applied R&D activities might be contra-productive in the mid and long term (Manjarres et al., 2007). Moreover, the productivity of most-performing scientists decreases when involved in long-term relationships with one specific industry-related sponsor (Goldfarb, 2008).

National policies on the allocation of research funds create institutional incentives for universities to encourage scientists’ involvement in private/public sponsored or contracted research.

2.3.5. Spin-offs, patents and licensing
Given the increasing attention paid by policy-makers to university knowledge commercialisation, in particular through spin-offs and patents, quality institutional performance in terms of spin-offs and patents guarantees a good place on the national universities’ ranking. Indeed, many universities (in some countries all universities) have created a technology transfer office to support bureaucracy and specific management competencies to set up a business, to patent or to negotiate licensing with industry. Often this was done in response to governmental incentives.
Universities may also have financial incentives for successful spin-offs, especially if they participate in the equity of firms. Moreover, successful spin-offs tend to attract the attention of the media and policy-makers, which serves to promote the quality of the university, thus attracting students and staff.

The financial incentives and benefits of university patenting are not evident, as licensing is found to be not profitable for most European universities (Geuna and Nesta, 2006). This finding seems related to the fact that often university researchers’ motivation to patent is signalling rather than protection, and consequently patenting and publication are not found to be substitutes, but tend to overlap (Stephan et al, 2007; Bodas Freitas and Nuvolari, 2008). Thus, the increase in university patenting and the reinforcement of national policies for commercialisation of university knowledge may result instead in increased differences across universities in terms of financial resources and research output (Geuna and Nesta, 2006). Additionally, IPR is an area of confusion and conflict within academia and industry (Lockett et al., 2009).

National policies setting rules for university IPR, as well as introducing rules for the IPR for research results of public sponsored research projects (individual or in collaboration with industry) would encourage universities to patent, to support spin offs, and to interact with industry. The university would not need to negotiate the property of developed knowledge with industry. On the other hand, university patents are mainly a signalling rather than a protection device, and the financial incentives for the university are low (Penin, 2005). Consequently, patenting is more likely to represent a cost than a potential benefit for public research (Geuna and Nesta, 2006; Bodas Freitas and Nuvolari, 2008).

2.3.6. University face trade-offs

University institutions are confronted with a trade-off between short-term and long-term objectives in research and teaching. On the one hand, the quality of the university relates to the quality of the research done by its staff, and consequently by the publication productivity of scientists as well as by the level of students it is able to attract and the jobs their students are able to get after graduation. On the other hand, increasing short-term financial constraints and national policies create incentives in universities to raise the level of collaborative and contract research, and commercialisation of research results, applicability and spin-offs.

The literature is not consensual on the importance of institutional differences in the level and intensity of scientist interaction with industry. Some authors, especially those focusing on the US context, find that institutional differences in the level of industrial financing and quality of university are good predictors of the involvement of scientists with industry rather than the level of intensity of that interaction (Ponomariov, 2008). Other authors argue that the institutional characteristics of the UK universities are not important when individual characteristics of scientists are considered (D’Este and Patel, 2007). Moreover, Bozeman (1994) argues that there is no relationship between effectiveness of technology transfer activities and organisation of departments.

The established design of academic career is an important structural incentive system for scientists; consequently it may enhance or prevent efficacy of national policies. In particular, Gittelman (2006), analysing the biotechnology industry, shows that academic career design affects scientists’ decision on whether and through which channels to work with industry. “In the US, the central hub of knowledge in biotechnology occurs between research scientists and start-ups. In France, it occurs between public labs and large pharmaceutical firms.” This has a consequence that “there are fewer embodied knowledge transfers in France than in the US, because of the lower labour mobility; instead much transfer occurs through licensing or funded research contracts” (Gittelman, 2006, p. 1059). Bozeman (1994) shows that the channel used does not affect the performance of the transfer.

Thus, the design of academic careers, independently or together with national authorities, is the form through which institutions can transfer to scientists their expectations and priorities in terms of performance. In particular, the prevailing academic culture and structure may exert resistance against changes in reward and incentives structures, and consequently, formal policies and structures are not generated, but rather ad hoc solutions to punctuated problems are designed in a top-down fashion without a clear vision of where the institution is heading (Horowitz Gassol, 2007). In each country, the responsibility for academic career design is shared differently between national governments and university departments. Therefore, in some countries, possibility for some career design changes rests more with governments in others with universities.

Furthermore, national and institutional incentives — introduced by specific policies, by the established academic career rules, and by the established institutional organisation of teaching, research and postgraduate training — play a role in the alignment of industrial and university researchers’ motivation to collaborate, as well as the organisation for knowledge development and transfer (Bodas Freitas and Verspagen, 2008).
With changes in the funding structures of university research, and the new industrial revolution in the 1980s based on the development of science-based (biology and electronics) technologies, there has been a transformation in the attitude of faculty members towards recognition of industry interaction as valid university activity (Hagedoorn, 1996; Lee, 1996, 2000; Azagra et al, 2006, Manjarres et al, 2007). Some authors even claim that science and industrial research worlds have been developing flexible organisational structures to facilitate knowledge development; consequently, they are always less dissimilar (Lee and Gaertner, 1994; Lam, 2005). Indeed, several authors show that interaction with industry is widespread (D’Este and Patel, 2007; Bekkers and Badas Freitas, 2008). Moreover, universities, industry and policy-makers are changing their view of postgraduate students as recipients of knowledge to considering students part of the knowledge transfer process (Horowitz Gassol, 2007; Lockett et al. 2009).

However, universities benefit very little from technology transfer activities (Bozeman, 1994; Geuna and Nesta, 2006). Moreover, not all collaborative and contract research is equal in terms of scientific content and impact on researchers’ productivity. In particular, high-scientific interaction with industry, when maintained as a minor activity of scientists, increases the productivity of scientists (Manjarres et al, 2007). Moreover, the productivity of most-performing scientists decreases when involved in long-term relationships with one specific industry-related sponsor (Goldfarb, 2008). Therefore, collaborative research contracts, licensing and business start-ups are perhaps of greater importance to the university than performing specific intermittent services, not only because of their high income-generation potential, but because of their high innovation-generation potential (Horowitz Gassol, 2007).

In summary, individual and organisational capabilities and incentives are not similar and interchangeable (Gittelman, 2006, p. 1067). Therefore, policies that promote higher involvement of universities in industry research by focusing on a reduced number of channels, and at same time making the financial support of universities increasingly less structural, are most likely not to be successful. In order to succeed, policies need to address a wide variety of channels to support research, teaching quality and high scientific content interaction with industry (Crespi et al., 2007; D’Este and Patel, 2007; Manjarres et al, 2007).

2.3.7. Measuring institutional involvement in TT activities

Measurements of institutional publication productivity and level of industrial co-authorship might be derived from bibliometric data through very labour-intensive and time-consuming methods. It is also difficult to obtain measurements at institutional level for informal contacts and involvement of staff in labour mobility. Besides co-authorship analysis through bibliometric methods, the number of master and doctoral theses with industry, the number of part-time professorships, the number of labour mobility grants obtained (to receive and allow staff to leave temporarily) are some of the possible rough proxies for institutional involvement in TT activities. Rough measurements for public-sponsored collaborative research projects might be obtained from national public research sponsors. Instead measures for projects sponsored by non-governmental, private and foreign organisations are almost impossible to obtain from other sources than the university or the academic researcher.

Measurements of spin offs and patents might be obtained by the universities themselves. Still, these numbers will only reflect the number of patents owned rather than the number of patents invented by universities. Better indicators for patents would require a tremendous bibliometric effort, using patents databases to identify the number of patents in which university researchers were cited as inventors.

3. Assessment of selected policies for UI knowledge transfer

In this chapter, we discuss the effectiveness of selected policies and incentives. This selection will include those policies highlighted by policy makers and technology transfer managers in recent years, as well as some novel ones. Our focus is on IPR policies, spin-offs policies, funds for collaborative research, and innovation voucher systems. The discussion is based on academic papers and research evidence as well as impact and policy evaluation reports. We will also pay specific attention to ways of measuring and monitoring all these policies.

3.1. IPR policies

Without doubt, university patenting has attracted the hottest topic of discussions on the commercialisation/valorisation of public research, and in the more general discussion on knowledge transfer between universities and industry. Growth in university patents has been a very visible phenomenon, particularly in the USA and to a lesser degree in Europe and other parts of the world. Over the years, various university patenting policies have been introduced. Some aim to achieve their objectives by imposing obligations and
right, others try to change behaviour by providing or strengthening incentives, or raising awareness. Firstly, there are national or regional policies that target universities and PROs or individual researchers. The US Bayh–Dole Act is the best known example here. In Europe there are currently no comparable policies, but there have been policies / legislative changes relating to the ownership of university patents (see below). Secondly, there are institute policies that address individual researchers. In the USA, Bayh–Dole obliged universities to implement strict policies, whereas also in Europe and elsewhere, institutes introduced various policies relating to invention disclosure and royalty sharing.

This section looks at whether university patenting policies work. To address this question, one needs to know about the objectives of these policies. Table 4 provides an overview of the main policies and their objectives, as expressed by their implementers or as interpreted by commenters or those who performed evaluation / impact studies. For easy reference, the objectives are numbered and will be discussed below.

Table 4: Overview of selected IPR-related policies, and their main objectives

<table>
<thead>
<tr>
<th>Category</th>
<th>Example (region)</th>
<th>Typical objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>National policy, targeting institutes</td>
<td>US Bayh–Dole Act (US)</td>
<td>Solve ownership issues (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Growth university patents (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generate income (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Promote spin-offs and start-ups for local economy (5)</td>
</tr>
<tr>
<td>National policy, targeting individual researchers</td>
<td>Changes in Austria, Denmark, Germany, Norway, and Italy</td>
<td>Solve ownership issues (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facilitate knowledge transfer and licensing (3)</td>
</tr>
<tr>
<td>Regional policy, targeting institutes</td>
<td>IP Charter (EU)</td>
<td>Growth university patents (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facilitate knowledge transfer and licensing (3)</td>
</tr>
<tr>
<td>Regional policy, targeting individual researchers</td>
<td>Legislation on benefits of patenting for the researcher (EU)</td>
<td>Increase disclosure (6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Growth university patents (2)</td>
</tr>
<tr>
<td>Institute policy, targeting individual researchers</td>
<td>Legislation on patent ownership (US - all universities, relatively similar policies); Various countries (selected institutes, diversity of policies)</td>
<td>Increase disclosure (6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Growth university patents (2)</td>
</tr>
</tbody>
</table>

### 3.1.1. Solving ownership issues

The first objective mentioned in Table 4 is that of solving ownership issues. Though now often overlooked, this was the main driver for introducing the Bayh–Dole Act of 1980 (Verspagen, 2006). In the USA, significant numbers of university patents first appeared in the 1930s (as a result of discussions on the role of universities in the local economy, and top universities stimulating their faculties to apply for patents on their discoveries), and their numbers started to grow considerably by 1960/70. By that time, much of the research in US universities was federally funded. In particular, the National Institute of Health (NIH) funded much research in those areas where patenting was abundant. As a result, an intensive debate arose in the US over who should be the owner of university patents: the funding agency or the university. Time-consuming negotiations were done on a case-by-case basis, as US law did not provide immediate or clear answers to who held such rights. Later, various arrangements were developed by funding agencies. The Bayh–Dole Act of 1980 was introduced to streamline those multiple arrangements. Without a doubt, it achieved its aim. But it is important to note that this was a problem particular to the US context, and its objective is of no relevance in other parts of the world.

Of a different nature, but not less relevant, are ownership issues in Europe. A decade ago, national regulations on the ownership of IPR invented by university employees varied considerably from country to country. Whereas firms usually have title for any IPR invented by their employees (in as much as the IPR is related to the work of that person), some countries had exceptions for universities, thus giving title to the university employee (known as 'professor privilege'). Around the turn of the century, the view became widespread that such individual ownership hindered successful knowledge transfer because it reduced legal certainty of prospective licensees and introduced transaction costs. In Austria, Denmark, Germany and Norway, the law was changed and the professor’s privilege was abandoned. Remarkably, in Italy the opposite took place in 2001, and Sweden still has the professor’s privilege.. Although the abolishment of this privilege in most countries took some (mainly financial) incentives away from academic staff, this was usually replaced by a revenue sharing scheme. If the institutes turn out to be more successful at commercialising their IPR than individual researchers, the latter could benefit from this change, even if he or she only gets a part of the total revenue.

### 3.1.2. Growth of university patents

Another objective is that of the growth of university patents. Although it is hard to see this as an objective in its own right, it is best interpreted as an intermediate step towards more licensing and eventually a better transfer of knowledge, helping universities to fulfil their ‘third mission’, being economic and social development. Nevertheless, the number of university patents as such has been so central in both policy discussions and studies that it will be discussed here separately. There has been a clear surge in US university patents since the 1980s, as
demonstrated by the data collected on a regular basis by the Association of University Technology Managers (AUTM). Although the Bayh–Dole Act has undoubtedly contributed to this growth, more and more studies have provided evidence that this patent surge has been largely independent of policies like Bayh–Dole (see Nelson (2001); Mowery et al., 2001; Mowery et al., 2004; Sampat et al., 2003, but criticised by Shane, 2004). It has been attributed in particular to the growing technical opportunities in the biomedical sector (and possible also in ICT), and the feasibility to pursue these opportunities in laboratories. This also explains why patent growth started to take off before Bayh–Dole was passed, as well as the growth in other countries that do not have this type of legislation. For the European situation, also other causes have been suggested, one of them being that growing industrial funding of universities is being positively correlated to university patenting (Gulbrandsen and Smeyby (2005), Ranga (2003) in Guena and Nesta, 2006).

It is true to say that Bayh-Dole and the IPR policies universities adopted to comply with that law, are important incentives for staff to disclose what might be valuable inventions (as they are now required to) and let the university patent them. This is similar to the policies that have already existed for a much longer time in industry’s R&D laboratories. Interestingly, this still does not ensure that all potentially interesting cases correctly follow this procedure. Recent studies show two phenomena that represent a significant departure from the ‘official’ rules. Firstly, a significant amount of ‘good’ inventions never actually gets disclosed. Jensen et al (2003) report on talks they had with TTO managers of US universities: ‘Many directors believe that substantially less than half of the inventions with commercial potential are disclosed to their office [...] [T]he directors we talked with believe that some of the best inventions may not be disclosed because the most productive faculty is less likely to want to take the time to disclose inventions, much less work on further development. Paradoxically, the directors we talked with also believe that many of the inventions disclosed to them are of questionable value.’ In their discussion, they reveal what can be considered as a considerably negative incentive: getting involved as a researcher in patenting means that very often (71% of cases), the researcher needs to spend time on further research that is necessary to achieve commercial success. Secondly, a significant part of the inventions does get patented, but is assigned solely to firms and not to the university (which is, as explained before, not in line with rules on this in US universities). Thursby et al (2009) report that in a sample of 5811 US patents with faculty as an inventor, 26% were solely assigned to firms. They also find that the latter patents are less basic (and might have been the outcome of faculty consulting). Some end up being assigned to inventor-related start-ups, but that happens less often when faculty gets a high share of the licensing revenues. In another, earlier paper Thursby and Kemp (2002) offer an additional explanation for such failures to report inventions: they might be due to the unwillingness to delay publication resulting from the patent and licensing process.

For a long time, there was considerably more data available on university patenting in the US than in other countries. This was one of reasons for the OECD to initiate a substantial project on this topic, including a large, harmonised survey to be sent out in all participating OECD countries. The results, published in the report ‘Turning Science into Business’ (OECD 2003), provide interesting insights into the phenomenon in a number of European countries. However, one should be careful in interpreting the results, as the response was restricted (though in some countries better than in others), and substantial differences in the organisation of the academic and research sector, as well as cultural differences, make it hard to draw far-reaching conclusions. The OECD itself also refers to the dataset as ‘an experiment’, though one that is worth repeating. Where there is a tendency to shift focus from assessing university patenting towards university licensing, being considered as a better proxy for successful knowledge transfer, structural licensing data for Europe is virtually non-existent.

In recent years, it has also become clearer that we might have seriously underestimated the involvement of universities in patenting, as the traditional measurement methods mask significant types of involvement. Section 4.2 discusses this in detail.

3.1.3. Facilitating knowledge transfer and licensing

As indicated above, growth in university patenting often serves an underlying objective, facilitating knowledge transfer and licensing. Some policies have this as a stand-alone objective (see Table 4). To understand how patents do help effective knowledge transfer, it is necessary to understand the underlying economic rationale of university patents. Like the economics of patents themselves, this is a relatively complex area. Patents are in fact instruments designed to address the market failure when actors are unwilling to invest in research and when competitors would be able to benefit from their efforts without paying, by copying the innovation. As such, patents provide an incentive to perform research. Patents are one of the three “Ps” - Property Rights, Patronage, and Procurement, all alternative policies that aim to address the same market failure (see David, 1993). The difficulty with university patenting is that the incentive to conducting research at universities has already been addressed by an alternative mechanism: patronage. In this mechanism, governments take financial responsibility for the development of new knowledge, by means of instituting a publicly financed system of research aimed at generating and diffusing new knowledge (Verspagen, 2006). This makes it hard to consider university patents in a regular way, as providing incentives to research.
Some have addressed this by claiming other, specific arguments why universities should patent. The most important one is that university patents may help effective knowledge transfer to industry. The argument here is as follows: basic inventions may require substantial further investment to develop them into commercial products. Even (and especially) when the basic invention is brought into the public domain, firms will not be willing to invest in necessary further research if they do not have the exclusive right to do so, facing the prospect of deterring possible imitations by competitors. This downstream investment argument, however, implies at least two assumptions. Firstly, the additional investments needed for these ‘embryonic’ inventions should be non-trivial (in contrast to ‘off the shelf’ inventions, that may be implemented with little cost). Secondly, there should be no prospects of further (patent) protection during this further investment period. Thirdly, for obvious reasons, the university patent should only be licensed on an exclusive basis. One can certainly think of situations in which all three conditions are likely to be satisfied (for instance some pharmaceutical inventions, where substantial clinical trials are needed). It is unlikely, however, that these necessary criteria will be met on a large scale. In fact, recent evidence from the US shows that only about half of all university licences are non-exclusive (Thursby and Thursby, 2007). This poses serious questions about the policy objective of having university patents facilitating knowledge transfer. Mazzoleni (2006) also follows this line of reasoning and argues that in the area of biomedical technologies, university patenting and licensing restrictions are a hindrance to downstream R&D, rather than a stimulus.

One might legitimate university patents in other ways. Below, four of these are briefly discussed:

(1) Patents might help to create feasible spin-offs or start-ups. Again, an exclusive license is indispensable.

(2) They might raise awareness of commercially useful research, preventing valuable knowledge from remaining in the ‘ivory tower’. Studies on how industrial researchers rate patent as a transfer mechanism makes this argument rather weak. Both in the US and in Europe, industrial researchers find open publications, informal contacts and collaborative research much more important mechanisms to identify useful knowledge (see Cohen et al., 1998 and 2002 for the US, and Bekkers and Bodas, 2008 for Europe). Related to this argument, patents would allow other organisations to commercialize or market university inventions effectively. A fascinating example is the British National Research Development Corporation (NRDC), later renamed the British Technology Group (BTG) which was established in 1948 to exploit the many products that had been developed during World War II by Defence Research Establishments. Later, it served as the obligatory outlet of British university patents. Nowadays, BTG’s role has changed considerably.

(3) University patents may prevent ‘pirating’, applications of inferior quality, or unethical use. These arguments were raised in university patenting discussions in the 1930s, but do not have seem to played a serious role recently (Verspagen, 2006). Also, the ‘piracy’ argument (preventing commercial firms from taking out patents and limiting free applicability) implies non-exclusive licensing, making it incompatible with other arguments.

(4) Universities may patent in order to own ‘exchange’ chips ensuring access to IPR owned by others. By doing so, however, they are at serious risk of effectively losing their current ‘research exemption’ and may be caught up in a much trickier situation. (See Heller and Eisenberg (1998) on the risk of the Tragedy of the Anti-commons for research tools, where an abundance of patents effectively blocks effective access and use.). All in all, we may conclude that none of these argument provides a very strong argument for university patenting being beneficial for knowledge transfer (or, at least, better than alternative means such as open publications).

3.1.4. Additional university funding

The fourth objective listed in Table 4, is the generation of additional income or funds for universities. It is certainly true that some universities attract substantial funds with their patents. Typically, universities licence their technologies to private and public firms, usually in exchange for the reimbursement of patent costs, an up-front licensing fee, and a percentage of product sales. However, the revenue generated by universities has a very disproportionate distribution. It is disproportionate at institute level: a very small number of universities receive a very large share of the total revenue from university patents. In 1995, the University of California (UC), Stanford and Columbia University earned 60, 36, and 31 million US dollars from licensing respectively (Mowery et al., 2001). Stanford’s recombinant DNA gene-splicing patent earned US$ 143 million (Baldini, 2008). In comparison, roughly half of all US universities had a licensing income below 1million in that year. The distribution is also skewed at the level of the individual patents: within those successful universities a very small number of patents receive the largest share of the total revenue of that institute. In the three universities mentioned above, the revenue share of the top five patents was 66%, 85% and 94%. Within the area of biomedical innovations (the most significant area in this field, accounting for more than 60% of all disclosures at UC), this percentage went up to 100% for two of these universities. For most universities, licensing is a loss-making activity if the costs incurred are also taken into account. The 2003 OECD survey on university patenting showed that the majority of surveyed universities and PROs gained little or no income from their IPR. Most universities’ budgets for their TTOs outweigh the income generated by commercialising their IPR, and Nelson (2001) states that it is a myth that
universities may expect a lot of money from licensing activities. Implicitly this is also acknowledged by the EU report (@TBA) that suggests that member states should be willing to fund TTO activities because these are often, particularly in the starting phase, loss-making. Licensing is not profitable for most universities, though some do succeed in attracting significant revenue. (Geuna and Nesta, 2006). Similarly, Thursby et al. (2007) conclude ‘licensing for many if not most universities is a net drain on university resources’. Altogether, this source of finance has characteristics that are quite similar to a lottery and it is hard to be imagined that licensing income can turn into a stable source of finance for universities (Verspagen, 2006). One cannot expect to hit the jackpot too often.

Certainly, much of the imbalance is related to demand. After all, many patents owned by firms are not worked or licensed, and their value is also very skewed, so why should one expect this to be different for university patents? Nevertheless, there might also be intrinsic factors at work, endogenous to the university or the PRO. When Swamidass (2009) conducted a survey at 99 randomly selected US universities, seventy-five percent of his respondents mentioned shortage of staff for non-legal and legal processing of inventions. More than a third of his respondents claimed that, in 2006, they failed to process more than 26% of the inventions due to insufficient processing capacity in the TTO. Particularly, the difficult marketing of hi-tech innovation falls behind. As many European universities are smaller than their American counterparts, it is likely that they are even more affected by the disproportionate value of patents, and the challenge to staff their TTOs with highly-qualified people.

3.1.5. Promoting spin-offs and start-ups

University patenting may also be implemented in order to support spin-off and start-up companies. These phenomena are the subject of Section 3.2, so we will discuss them there.

3.1.6. Increase disclosure of innovations

The last objective discussed here is that of an increase in disclosure of innovations. Just like patents, this is never a separate objective, but nevertheless believed to be desirable in the context of effective knowledge transfer. The US experience demonstrates that in those universities which adopted strict disclosure rules in order to comply with Bayh-Dole, the number of disclosures went up significantly (other universities already had such rules before the act was passed) (Mowery et al., 2001). We recall the findings of Jensen et al. (2003), reported above, that there are indications that less than half of the innovations with commercial potential have still not been disclosed, and that TTO managers believe that they have been left with inventions of questionable value. A higher disclosure rate is also the aim of policies at various European universities, and of more general awareness campaigns by European Commissions. However, as far as known by the authors, there have been no studies on their effectiveness. The ‘Intellectual property guidance document for researchers’ by the EC suggests that the typical use for patents is ‘for new knowledge (inventions) likely to be able to be actually exploited in industry’, whereas publications should be typically used ‘for knowledge for which there are no patenting intentions, or a patent application has already been filed’. This would in fact make patenting the default mode of operating.

There is, however, insight into the effect of revenue sharing schemes. Studies from the US show that such incentive schemes work. Lach and Schankerman (2008) demonstrate that US universities which provide stronger royalty incentives to faculty scientists generate greater licence income, controlling university characteristics. They observe that faculty responds to royalties both in the form of cash and research lab support, indicating both pecuniary and intrinsic research motivation. Link and Siegel (2005) conclude that universities that allocate a higher percentage of royalty payments to faculty members, tend to be more efficient in technology transfer activities. Within the European context, however, Baldini (2007), studying a large sample of Italian faculty members who are inventors of university-held patents, concludes that personal earnings do not represent a main incentive for these people. Instead, his findings show that respondents get involved in patenting activities to enhance their prestige and reputation, and look for new stimuli for their research. In a later paper, the same author concludes that the effect of incentives on the commercialisation of university research depends on individual characteristics, which makes it hard to derive clear policy implications (Baldini, 2008).

3.1.7. Summary and discussion

Table 3 summarises the insights found on university patenting policies. After this evaluation of policies, some attention will be paid to the possible negative consequences of university patenting. Concerns have been expressed that university patenting: (a) may negatively affect publication, (b) may affect the open science paradigm, (c) could result in a reduction in basic research in favour of more applied research, (d) might affect teaching efforts, (e) threaten the current research exemption - current patent law in most countries allows for the use of patent technology, and (f) cause increased liability of faculty members and departments. There are also additional concerns and possible threats. In a review of 82 studies, Baldini (2008) distinguishes 17 issues and divides them into four categories: threats to scientific progress, changes in research, threats to teaching
activities, and threats to industry. He reports both evidence of threats as well as evidence that some concerns are not grounded, but the overall conclusion is that the current insights are still mixed and indecisive.

The main concern, patenting vs. publishing, has without doubt attracted the most attention in the academic literature on university patenting. Nowadays, there is robust evidence that both activities are complementary (see Stephan et al., 2007). In other words, researchers patent to publish more, not less. This seems to hold for top scientists in particular, but might be less the case for younger scholars. Carayol (2007) observes that older researchers are more likely to patent. He suggests that this might be linked to the relative window of opportunities for publishing on the one hand and patenting on the other. Young researchers tend to focus more exclusively on publishing as that is the more valuable for their career at that point. Older researchers switch to focussing more on patenting as the expected pay-offs are more immediate that those from publishing, and may provide a source of income beyond retirement. Although Carayol confirms earlier findings on a correlation between patenting and publishing, he argues that it might not be at laboratory level: the probability of patenting is found to be greater in large labs.

The other concerns are still subject of debate, and we will not discuss them here extensively. However, we do emphasize that much of the research in this area has been retrospective. For instance Mowery et al. (2001) did not find evidence of changes from basic to applied research. Not yet, anyway. Where there is a short-run approach, where the phenomenon of university patenting may be considered exogenous, no evidence is found. Yet substantial impact is still possible in the longer term (as an analogy, one could compare static efficiency with dynamic efficiency). In the longer term, in a dynamic system, patenting could become an endogenous part of the system, departments could prefer candidates with a patenting record over those without one, thus changing the composition of their groups, etc. (see Geuna and Nesta, p. 796). This will certainly be an area of future debate.

### 3.2. Spin-offs, start-ups and entrepreneurship policies

Formerly, universities sought to sell licences for their patents to existing, larger firms. Now, universities increasingly transfer appropriate technology (patented or not) to a start-up company. Why create companies from research? There are several answers to this question, but perhaps the most important ones are (1) to contribute to national competitiveness and thus fulfill the university’s third mission, (2) to create jobs locally, and (3) to ensure financial return for the university. An underlying rationale is that a great deal of knowledge developed at universities is tacit (and uncodifiable) and the transfer of that knowledge requires the direct

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1 This finding neatly aligns with the data of the PatVal survey, showing that the average age of inventors in European Patents is 45 years and thus no longer young researchers.
involvement of researchers (Zhang, 2009). In fact, as has been shown in the previous section, in almost three quarters of the cases in which universities sell licences to larger firms, the involvement of the original scientist(s) is still needed in order to transfer tacit knowledge.

There are several types of start-up companies. If a new company is founded by faculty members, it is also called a spin-off or, more specifically, an IPR-based spin-off (as there is a patent involved). The patent, which is transferred or exclusively licensed, is one of the most important assets of this new company. Spin-offs that are not based on a patent may well include new companies that provide consulting services or other similar business models. There is a large variety in type and definition of spin-offs. The new company might be founded by university employees, bringing their (tacit) knowledge and experience to the firm. In that case they are called spin-offs or spin-outs (in Britain), while some use the term ‘academic entrepreneurship’. In other cases, faculty members may serve on the scientific advisory board of a new company, without actually moving there (note that in some countries it is not allowed or usual that a faculty member works part-time in a commercial company as well).

<table>
<thead>
<tr>
<th>Table 6: Grouping of spin-off model (based on O’Shea et al. 2008, who adapted it from Nicolau and Birley, 2003)</th>
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<tbody>
<tr>
<td>Orthodox</td>
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<tr>
<td>Hybrid</td>
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<tr>
<td>Technology—only</td>
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Typically, new firms that are not created by faculty members but nevertheless rely particularly on a university invention, are called start-ups, although some scholars also refer to these as ‘spin-offs’.

This section aims to seek more understanding of the phenomenon of start-ups and spin-offs from the perspective of policies. To that end, we focus on five relevant areas:

1. Individual attributes as determinants of spin-off activity
2. Organizational determinants of university spin-off activity (including TTO policies)
3. The economic impact of spin-offs (both local/regional and national)
4. Success chances of spin-offs
5. Generating university funds

3.2.1. Individual attributes as determinants of spin-off activity

Initially, personality, motivation and disposition may play a role in determining which faculty members will actually found a spin-off company, and which will not. On the basis of a literature review, O’Shea et al (2008) summarize that:

- academic entrepreneurs with outgoing, extrovert personalities were more likely to engage in spin-off activity;
- academic entrepreneurs found that university entrepreneurs tend to be older and more scientifically experienced than “typical” high-technology entrepreneurs;
- scientific “stars” collaborating with firms had substantially higher citation rates than purely academic “stars”; and
- scientists are more likely to become entrepreneurs when they work in departments where colleagues had previously made the transition, particularly when the individuals who had become commercialists were prestigious scientists.

Fini et al. (2007) interviewed 88 Italian academics involved in the creation of 47 spin-offs between 1999 and 2005 and found that the academics’ involvement in creating new ventures is not driven by an entrepreneurial attitude, but rather by the expectation of generating results which will enhance their academic position, the creation of stimuli for further research activities, and gains in prestige and reputation as leading academics. Interestingly, these results are similar to those discussed above by Baldini (2007) concerning incentives for university patenting, who concluded that patenting behaviour by Italian academics was also not driven by personal income motives. More in general, studies like those of O’Gorman (2008) in Ireland and Franzoni and Lissoni (2006) stress that academics predominantly take account of traditional academic rewards when considering the pay-offs of commercialisation activity. Some argue that top scientists (in contrast to average-performing scientists) may be more inclined to extract economic interest rates (e.g. extra budget for their group) from their achievements. If they work at top universities, they might find it easier to assemble resources to create start-ups for reasons of credibility (DiGregorio and Shane, 2003, in O’Shea, 2008).

In fact, some studies point out that licencing revenue sharing schemes might not only be relatively unimportant for academics to get involved in entrepreneurial activities, they might even impede it. DiGregorio and Shane

⁴ AUTM seems to use the term ‘start-up’ for this category (see Niosi, 2006).
Some studies have taken a more critical stance towards the role of TTOs for creating spin-offs. Siegel et al. (2003 in O’Shea, 2008) found evidence that university technology transfer policies that allocate a higher share of inventors’ royalties reduce spin-off activity due to the increased opportunity cost in engaging in firm formation (quoted in O’Shea, 2008). On the basis of a study of 128 US universities, Markman et al (2004), come to a similar finding. He concludes that a higher revenue share given to scientists is significantly but negatively related to the amount of equity licensing and the number of start-ups. There are studies that provide other results, however, Link and Siegel 2005 show that universities which give higher percentages of royalty payments to their faculty members impact positively on the efficiency of university technology transfer activities (may include spin-offs and start-ups, but also other transfer activities). It has been found that, in general, there is a lack of entrepreneurial spirit among academics (see for instance Franzoni and Lissoni (2006) on Italy). This might very well be the result of self-selection: maybe many academics chose academia precisely because they do not feel such a drive. This lack of entrepreneurial spirit among (prospective and actual) spin-off founders has consequences, though. Established companies that are not market oriented, stay on the university campus, and do not strive for growth but merely for survival. This limits their economic impact. Similar results are reported by Johansson et al (2005), studying Swedish spin-offs. They report that these have a small number of strong ties to their former university only, and are limited in terms of network presence and also weak ties, whose importance has been evident since the seminal work of Granovetter (1973).

3.2.2. Organizational determinants of university spin-off activity

Another key area of research is the degree to which organizational features – especially of universities’ TTOs – affect spin-off creation and development. Some success stories contribute this achievement to the policies and procedures at the TTO. For instance, a study on the 34 companies that spun out of the Katholieke Universiteit Leuven, by Debakere (2000) concluded that this success was based on the right mix of governance structures (i.e. matrix structures facilitating interdisciplinary research), processes (i.e. seed capital fund, patent protection, business plan and new venture development services) and context (embedded in history).

In a paper on a typology of spin-outs, Clarysse et al. (2005) elaborated on three broad models. These are:
- ‘low selective’, aiming at the creation of self-employment oriented spin-outs, which will be predominantly service-oriented (consulting etc.);
- ‘supportive’, aiming at growth-oriented spin-outs, that use a service-oriented business model to service during the period they ramp up something bigger and more promising;
- ‘incubator’, where financial gain from an eventual exit is paramount for the mother institute.

They found quite a few universities were trying to emulate one of these ‘pure models’ without having the proper resources to do so successfully, whereas the adoption of hybrids (two or all three models at the same time) is even more challenging, especially adhering to clear objectives.

Important questions raised above are how selective universities are when licencing start-ups. Are all potentially available patents licenced out (exclusively) to start-ups, or is there a selective screening procedure, and are cases selected on strict criteria relating to the predicted chances of success among other things of the new start-up? Davenport et al. (2002 in O’Shea, 2008) distinguish three ‘selectivity strategies’:
(1) spin-offs by exception — unintentionally initiated by the entrepreneur where support from the parent organization may be on a contingent basis;
(2) spin-offs by occasion — may be intentionally initiated by the entrepreneur where support and management for the spin-off is on a case-by-case basis;
(3) spin-offs as strategy — formed intentionally with a formal strategy and procedures in place.

After investigating 134 US research universities, Powers and McDougall (2005) conclude that universities which are more selective in deciding which technologies to patent and licence start-ups and small companies have a larger portfolio of start-ups that have gone public (IPO). They also conclude that the same is true for universities located in an entrepreneurial dense area (e.g. California, Massachusetts). However, they also observe complex effects of interaction; universities located in an entrepreneurial dense area benefit less from being selective than universities in sparse areas. In the dense areas, universities can afford to be less selective and let the venture capitalists decide what to take up. Summarizing, Powers and McDougall advice policy makers to study the specific local/regional context, the need and the appropriability of programmes for spin-off support, and carefully assess choices related to spin-offs.

Some studies have taken a more critical stance towards the role of TTOs for creating spin-offs. Siegel et al. (2003 in O’Shea, 2008) found the marketing and negotiation skills of TTO personnel to be seen as dissatisfactory by 55% of the entrepreneurs, scientists and administrators they interviewed. According to the study, the TTO was shown to be inflexible and conservative in some respects. Fini (2007) finds that the presence of TTOs in Italy is irrelevant in the view of the spin-off founders. These offices are too slow and costly, and academics find it more convenient.
to patent with industry. Again, the results are in line with Swedish findings where entrepreneurs confirm that university policy and support were of no importance in their decision to found a spin-off (Johansson et al, 2005).

However, in cases where the spin-off came into being, this appears to have a positive effect on the monetary incentives of the TTO. In the earlier mentioned study by Markman et al (2004), that reported a negative correlation between faculty member revenue sharing, amount of equity licensing and the number of start-ups, this relationship was found to be positive for the average annual salary of TTO staff. Higher staff likely translates into a more skilful TTO.

In a study labelled ‘University spin-off firms: Lessons from ten years of experience in Europe’, Mustar, Wright and Clarysse (2008) examined the effects of various TTO and national policies relating to spin-offs. They stress that the large heterogeneity of this phenomenon, both at the level of the objectives, types of companies, teams, parent institutions and TTOs, poses major challenges for the development and implementation of specific effective political tools and schemes. On the various European schemes and policies that have been introduced, they conclude: ‘Despite the provision of substantial sums of support funding, the results across Europe seem disappointing. This failed expectation is, as we have shown in this paper, mainly linked to the fact that the difficulties which are expected in the commercialisation of research through the creation of spin-offs were certainly underestimated, and also to the fact that the multiple actors involved with this issue at national, regional, institutional and spin-off firm levels have experienced some difficulties in defining their strategies.’ It takes a number of deliberate choices, like the degree of selectiveness (see above), and focus on creation or development. These choices have to be thought over, and a TTO must be equipped with the capacity and skills to match the chosen line (which is often not the case). Expectations are often much too high (most spin-offs remain small) and to deal with the heterogeneity, a less mechanical view should be adopted.

It has also been argued that long-standing features and culture at universities largely determine the level of entrepreneurship. Etzkowitz’s essay of 1983 (one of the founding fathers of the ‘Triple Helix’) portrays the entrepreneurial university as the outcome of a revolutionary process started in the US with the Big Science programmes launched in the aftermath of World War II. Franzoni and Lissoni (2006) further build on this and argue that the unprecedented degree of freedom US universities have (not only private colleges but also more recent state universities) is the main background for the transformation into entrepreneurial organizations. In the US environment, entrepreneurial academic behaviour is largely explained by to what extent commercial activities may or may not help scientific entrepreneurs to progress in their careers. Ad-hoc legislation and policies matter much less than long-lasting characteristics of the culture in the institute.

Also, it is concluded by Franzoni and Lissoni (2006) that academic entrepreneurs who are active in patenting and firm founding come disproportionately from the ranks of scientific entrepreneurs with a brilliant scientific record, possibly oriented to fundamental research. These scientists’ economic agenda is centred upon entrepreneurial efforts within the university, aimed at gaining a reputation through discipline building, creation and management of laboratories and research teams, and an appetite for the economic resources necessary to pursue those goals. The combined policy of reducing academic budgets in the hope that they will be replaced by income from spin-offs, may therefore be ill-fated.

3.2.3. External determinants of spin-off activity

Other factors beyond the control of the university/TTO or individual entrepreneur may influence the creation and further development of spin-offs.

Perhaps the characteristics of the local economy are the most influential external factors for the success of spin-outs. Of course, everybody knows about success areas such as Southern California (Silicon Valley), Route 128/greater Boston, Cambridge (UK), etc. Clarysse et al (2005) stress that these areas are very atypical and can be viewed as ‘local incubators’ themselves. Also O’Shea et al. (2007) note the unusual circumstances in such areas, related to the unusual knowledge infrastructure present there, a subject extensively addressed in literature on regional innovation and technopoles. Related to this, venture capital, one of the key inputs of spin-offs, is usually present in these success areas but less present (or hardly present at all) in underdeveloped areas.

Also, disciplinary and sectoral focus at the supply and demand side seems to play a role. In particular, specific technical opportunities appear to have prompted a relatively large share of spin-offs in the areas of biotech and ICT. Life sciences, mostly represented by biotechnology, account for nearly 50% of all spin-offs in US and Canadian universities and almost 50% of all patents and licences, for that matter (Niosi 2006). After biotechnology, information technology industries take the largest share (Zhang, 2009). Universities that might ‘happen’ to be strong in specific areas might benefit from this. O’Shea et al. (2005) studied the spin-off rate at 141 US universities from 1995 to 2001 and found evidence that funding with a particular orientation in biological
3.2.4. The economic impact of spin-offs on the economy

Universities and governments share one motivation for promoting spin-offs: their contribution to the local, regional or national economy. This aspect has been emphasized by some very visible and successful spin-offs. These include leading biotech firms as Genentech, Amgen, Biogen and Chiron, as well as information technology firms Cisco, Cirrus Logic, Akamai, Silicon Graphics, and Netscape (the last two founded by serial entrepreneur Jim Clark). Examples of the economic impact of spin-offs are:

- A study from Band Boston reveals that MIT graduates had founded 4,000 companies by 1997, creating 1.1 million jobs worldwide and generating annual sales of $232 billion (O’Shea, 2008).
- According to the Association of University Technology Managers, spin-offs from American academic institutions between 1980 and 1999 have contributed 280,000 jobs to the US economy and $33.5 billion in economic value-added activity (O’Shea, 2008).
- In Canada, the approximately 1200 university spin-offs that have appeared in the past 20 years together employ some 21,000 people, and have a revenue of 3.6 billion Canadian dollars (Niosi, 2006).

Spin-offs are closely linked to the local economy. Despite anecdotal evidence that these companies might move away from the area where the parent university is based in order to find a more attractive environment (e.g., more venture capital), more than two-thirds of US spin-offs stay in the same state (Zhang, 2009).

Certainly, spin-offs are only a small part of all new companies being established in a given period. However, of the sub-category of companies that attract venture capital (which arguably are the more promising ones from an economic perspective), they represent a significant share. Out of all US start-up companies founded between 1992 and 2001 that are backed by venture capital, 11% were founded by university entrepreneurs. In the biopharmaceutical industry this is even as much as 50% (Zhang, 2009).

Given the very specific distribution of university spin-offs over economic sectors (many in biotech and ICT, few in other sectors), it is clear that their local, regional and nationwide contribution to economic growth is also restricted to some industries. Although many spin-offs are in the area of biotechnology, their growth seems to stagnate. In spite of frequent support from venture capital companies and a higher likelihood of becoming public companies, Niosi (2006) finds that biotechnology spin-offs are not growing, compared to spin-offs in other areas.

But, putting the role of spin-offs in a small European economy such as Finland into context, Meyer (2006) points out that most academic patents are still utilized in established and predominately large firms: ‘The findings suggest that start-ups and spin-offs are important in transferring technology invented by academics but do not play a dominant role in capitalizing science.’

3.2.5. Which spin-offs succeed

Do university spin-offs have a better chance than otherwise similar companies? It could be argued that university spin-offs have a higher chance of success, because: a) they benefit from the tacit knowledge of the original creators of the invention, b) the value of the inventions is significantly higher than those not developed at universities, and c) a good academic reputation might help to attract venture capital (VC). Zhang (2009) indeed finds that venture-backed university spin-offs have a higher survival rate than other venture-backed start-ups. However, he finds no significant differences in other venture-backed firms in terms of the amount of VC money raised per round, total amount of VC raised, the possibility of completing an IPO, the probability of making a profit, or employment size. He offers several possible explanations why university spin-offs tend to survive longer: “It may be that the higher opportunity cost of academic entrepreneurs motivates them to engage in more self-screening before they create a company. It is also possible that university spin-offs are built around a truly advanced technology that enhances the company’s chance of survival. And finally, incubatory and other support from parent universities or local governments may have also helped keep university spin-offs in business.”

As argued above, university spin-outs are a typical type of new firm and, for instance, much more likely to receive venture capital than a regular new firm. This may explain why also in other metrics, university spin-offs stand out from the crowd. This is illustrated in a literature overview by O’Shea: ‘According to Shane (2004a), spin-off companies are 108 times more likely than the average new firm to go public and also to create more jobs than the average new business in the US. Furthermore, the survival rate of university spin-off companies is extremely...’

Ironically, the ICT industry also provides famous examples of university drop-outs as successful founders, including Bill Gates, Steve Jobs, and Michael Dell.
high. According to AUTM (2001), of the 3,376 university spin-offs founded between 1980 and 2000, 68% remained operational in 2001, which again is a higher number than the average survival rate of new firms in the US. Similar results have been found in other countries. For example, Mustar (1997) found that only 16% of the French spin-offs he studied failed over the 6-year period he tracked them. Dahlstrand (1997) found that only 13% of the spin-offs from Chalmers Institute of Technology in Sweden founded between 1960 and 1993 had failed by 1993. Furthermore, Nerkar and Shane (2003) analyzed the entrepreneurial dimension of university technology transfer, based on an empirical analysis of 128 firms that were founded between 1980 and 1996 to commercialize inventions owned by MIT. Their findings suggest that new technology firms are more likely to survive if they exploit radical technologies and if they possess patents with a broad scope. The same author also quotes some more critical findings: ‘In a study of start-up teams, Ensley and Hmieleski (2005) compared the performance of university-based start-ups with independently started ventures and found lower performance with regard to net cash flow and revenue growth in the university-based ventures. They attributed this to the teams not being as well developed as their independent venture counterparts due to difficulty in finding the level of expertise required on the university campus, thus highlighting the importance of networks.’

Spin-outs are one way of transferring technology, but this transfer mechanism is far from universally successful (Niosi, 2006). In particular, they can suffer from the relatively narrow range of competencies university staff possess, often excluding finance, marketing, manufacturing, and general management. This might actually reduce the chances of technology being transferred successfully, compared to other means such as licensing to a large existing firm.

3.2.6. Generating university funds

Given the usually limited cash position of such a new company, universities typically do not require a spin-off or start-up to reimburse patent costs, an up-front licensing fee, and a percentage of product sales. Instead, they often assume ownership of a part of the firm (equity) and/or a product royalty. If the new company is eventually bought by a large firm, or it offers shares to the public (Initial Public Offering – IPO), this could prove to be an interesting source of income for the university. For instance, Carnegie Mellon University earned $25 million when the company that developed the Lycos Internet search engine went public (Baldini, 2008). Such instances of university spin-offs going public are usually very visible, but there are certainly many cases in which the new companies never get to that point, because they cease to exist after a while, or muddle on.

Such success stories mask the real income prospects of such ventures for an average university. Similar to patents, income from spin-offs are very skewed (Geuna and Nesta, 2006). This is confirmed by other data: O’Shea reports that each US research university generates an average of 1.91 spin-offs per annum, though masking a highly skewed distribution in the data in which the most productive university, MIT, spawned 31 spin-offs in one year alone (O’Shea et al. 2005). A study by Lockett and Wright in 2005 provides similar findings for the UK. This imbalance makes spin-offs unpredictable sources of income, if any. Obviously, the prospects of income are also related to the policy of the university and its TTO; for instance, the ‘low selective’ model (see above) does not offer any income opportunities at all.

3.2.7. Summary

To conclude this section, Table 7 summarizes the main finding of the literature analysis.

Table 7: Summary of main findings on spin-offs and start-ups in the five defined areas

| a. Individual attributes as determinants of spin-off activity | - Academic entrepreneurship is determined by a number of individual characteristics, such as outgoing, extroverted personalities, higher age (than average firms founders), and previous work for industry  
- Academic entrepreneurs are mainly driven by prospects that will enhance their academic position and further research money for the group. Financial incentives are less and often even have an inverse effect on founding decisions  
- The relative lack of entrepreneurship results in spin-offs that are not very market-oriented, rather stay located at the campus, and limited growth opportunities |
| --- | --- |
| b. Organizational determinants of university spin-off activity | - Success stories show that TTO’s must find the right mix of governance structures, processes, and context.  
- However, that mix is hard to find and few TTOs manage to make clear choices concerning their goals and objectives, and are able to equip an office that is capable of fulfilling the necessary tasks.  
- Being selective is one way to spin out firms that are more valuable (providing the chance of going public), but at the obvious price of having a lower number of spin-offs.  
- In the eyes of academic entrepreneurs, the role and quality of many TTOs are disappointing.  
- TTO offices with highly paid staff (and thus likely to attract higher qualified staff) produce more equity licence deals and more start-ups.  
- Historical reasons and long-standing features and cultures at universities seem to determine entrepreneurship to a large degree, making it unlikely that new policies of TTOs and governments will quickly result in strong growth of academic entrepreneurship.  
- The typical successful academic entrepreneur is someone who built up a brilliant scientific record |
c. External determinants of spin-off activity
- The local/regional economy is a strong determinant of spin-off rates and success rates. Southern California (Silicon Valley??), Route 128/greater Boston, and Cambridge (UK) are very atypical and can hardly be imitated.
- Start-up decisions seem to be largely based on specific technical opportunities that happen to arise in a limited number of fields, namely biotech and information technology.

3.3. Funds for collaborative research

Since the 1980s, public funds for university-industry collaborative projects have multiplied in Europe and US, aimed at improving the competitiveness of national industries by supporting the development of national innovative competencies and the growth of a number of high-tech industries (Hextner et al, 1989; Laredo, 1998; Lam, 2005). In particular, the first ‘Framework Programme’, supporting collaborative R&D projects, was launched in 1983 (Grande and Peschke, 1999). Despite the relatively small size of the European science and technology budget compared to national budgets, the EU ‘Framework Programme’ has developed a collaborative culture in Europe and a comprehensive network of partnerships involving universities, research organizations and firms (Laredo, 1995, 1998; Grande and Peschke, 1999).

Nowadays, in Europe almost all the countries have in place policy programmes providing several specific types of incentives to university-industry collaboration. According to the Innovation Policy Trendchart, programmes for ‘R&D cooperation’ represent the most widespread type of incentive to innovation in Europe (European Innovation Progress report, 2008, p. 26). In particular, the innovation programme portfolio of the group of innovation-leaders countries (defined by the same report to include Sweden, Finland, Germany, Denmark and the UK) is characterised by being biased towards support to R&D cooperation, strategic long-term research policies, excellence, relevance and management of research in management, and public research organisations when compared to other groups of European countries (European Innovation Progress report, 2008, p. 27). The table below, which was built using data available at the Innovation Policy Trendchart website, shows that Germany, Denmark, Austria have more than 20 programmes aimed at encouraging cooperation and partnerships with research institutes. Belgium and the UK have 14 programmes, and Sweden 12 programmes. All the other countries are above the average which is 12 programmes.

To a certain extent, differences in the number of programmes relate more to organisational and institutional differences across countries (regional innovation policy making) rather than only emphasis on collaboration between industry and science. Still for instance Spain, only national projects are listed under this typology of innovative policy programs. To try to understand the intensity of efforts supporting R&D collaboration, wecalculated the share of R&D cooperation programmes as a share of total innovation programmes identified in the Trendchart. Results (Table, column 4) show that Germany and Denmark lead in the intensity of support for R&D cooperation with about one in each 5 programmes supporting collaboration, followed by Sweden, Austria, and Greece with one to 7 programmes, and then Norway, Italy and Spain with one in each 10 programmes supporting collaboration.
In this section, we will review existing evidence on the rationale for public grants to university-industry collaborative research projects, in particular the effects of these public supports on the private investment in R&D. We will also review evidence on the implicit and explicit criteria used by these supports, in particular we will analyse whether these supports are biased towards certain type of business and academics beneficiaries, as well as whether they tend to benefit already existing or new collaborations in terms of partners and technical areas.

a) Rationale

The growth on the number of policy incentives to university-industry collaboration has been based on the ground that university-industry collaboration facilitates the transfer of sticky and complex knowledge and consequently the utilization and transfer of academic knowledge, the development of technological innovation and economic competitiveness of national firms (Berman, 1990). Despite evidence suggesting the downstream nature of many sponsored projects (Laredo, 1995, 1998; Bodas Freitas and Verspagen, 2009), participants in public sponsored collaborative projects have much modest expectations than policy-makers on the economic benefits of the collaboration (Hetzner et al., 1989).

Collaboration with university is found to allow firms accessing new knowledge, ideas and technologies and making progress toward the development of new products and processes (Lee, 2000; Feller et al., 2002; Caloghirou et al., 2003; Lam, 2005). Also important it provides firms with informal access to students and direct personal links with top professors (Berman, 1990; Lam, 2005; Balcony and Laboranti, 2006). In particular, one way in which collaborative research work supports technological problems during innovation development includes person-to-person interaction. Consequently, the scientist plays the important role of “translating” information from scientific journals into a form meaningful to the industrial ‘problem-solver’ (Gibbons and Johnston, 1974, p.236). In addition, direct collaboration seems to allow building future possibilities of interaction and knowledge transfer. Because academic and industrial researchers develop direct personal links through participation on the same collaborative project, in the future they might be more willing to interact to get information, to solve problems or to come together in other research projects. In particular, these funds seem to support the development of long-term university-industry relationships (Hetzner et al. 1989, Berman, 1990; Balcony and Laboranti, 2006; ).

Moreover, Berman (1990) finds a complementary rather than a substitute relationship between R&D done with universities and internal R&D. In particular, he finds that direct industry funding of university research is associated with subsequent increases in industry R&D expenditures lagged of five years. Therefore, he argues that collaboration shortens the time lag between the development of university research and industrial application, as other studies analysing the importance of scientific publications have shown that larger time lag. In particular, Mansfield (1991, 1992 and 1998) have shown that about one-tenth of the new products and processes commercialized during 1975-85 could not have been developed (without substantial delay) without recent academic research, and that the average time lag between the conclusion of the relevant academic research and the first commercial introduction of the innovations based on this research was about 7 years. Gibbons and Johnston (1974) had also shown that the time lag between the date of the publication used by firms to solve problems and support innovation development was 12 years old (still, the industrial problem-solver relied on information resulting from scientific research which has been carried out since he/she took his/her degree or diploma).

Table 8: Relative importance of policy programmes for R&D cooperation (joint projects, PPP with research institutes) in some European Countries

<table>
<thead>
<tr>
<th>R&amp;D cooperation programmes</th>
<th>Total number of innovation programmes in Trendchart</th>
<th>Share of R&amp;D cooperation programmes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>29</td>
<td>150</td>
</tr>
<tr>
<td>Denmark</td>
<td>22</td>
<td>107</td>
</tr>
<tr>
<td>Austria</td>
<td>21</td>
<td>168</td>
</tr>
<tr>
<td>Belgium</td>
<td>14</td>
<td>149</td>
</tr>
<tr>
<td>UK</td>
<td>14</td>
<td>174</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>86</td>
</tr>
<tr>
<td>Norway</td>
<td>11</td>
<td>97</td>
</tr>
<tr>
<td>France</td>
<td>10</td>
<td>122</td>
</tr>
<tr>
<td>Hungary</td>
<td>9</td>
<td>98</td>
</tr>
<tr>
<td>Spain</td>
<td>8</td>
<td>83</td>
</tr>
<tr>
<td>Ireland</td>
<td>7</td>
<td>83</td>
</tr>
<tr>
<td>Greece</td>
<td>6</td>
<td>44</td>
</tr>
<tr>
<td>Italy</td>
<td>6</td>
<td>59</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6</td>
<td>74</td>
</tr>
<tr>
<td>Poland</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Portugal</td>
<td>5</td>
<td>67</td>
</tr>
<tr>
<td>Finland</td>
<td>5</td>
<td>120</td>
</tr>
</tbody>
</table>

Despite consensual evidence on the benefits of university-industry collaboration for the development of technical and organisational skills, these policy efforts seem to raise two main issues. The first refers to the fact that these policy efforts might lead to a reallocation or substitution of the R&D efforts within the firm rather than to an increase of the total R&D expenditures of firms. In other words, public subsidies to collaborative research projects may crowd-out private investment (i.e. firms may reduce their own R&D investment when they receive government funding) (Berman, 1990; David et al., 2000; Feldman and Kelley, 2006). In this case, policy support would not really create an incentive for increasing the R&D efforts; instead, the policy support would only attract firms and projects that would be implemented independently of the public support. Existing evidence seems to reject the hypothesis of the crowding-out effects of these policy supports on private investments in R&D as we will analyse next.

The second issue refers to the criteria of selection of projects to be sponsored. Which characteristics of firms, academics, and projects are rewarded? And are these chosen criteria the ones able to differentiate the quality of projects in terms of level of importance and level of diffusion of research results? Should these funds support only new collaborations or should they as well support the maintenance of existing university-industry collaborative relationships?

We will now review the existing evidence on the crowding-out effects of public grants for collaborative R&D projects, as well as on the potential bias, eventually related to the selection criteria, of the awarded projects, firms and researchers.

b) Crowding out / additionality

Most studies and evaluation studies find that the public sponsoring of collaborative R&D makes a difference in supporting promising R&D projects that would not otherwise go forward, or would only be pursued at a lower scale of effort (Davenport et al. 1999; Feldman and Kelley, 2006; Bodas Freitas and Verspagen, 2009). Some studies show that a great part of the non-awarded firms continued their research plans, but most of them conducted R&D at a smaller scale in the absence of government funding. Indeed, even when awards were given to established collaboration, participants on the projects state that they might not have started the project or certainly not at the same scale if the project had not been awarded (Davenport et al. 1999; Feldman and Kelley, 2006). These findings are compatible with those from studies based on innovation survey data, which show that firms, which collaborate, especially with universities, are the ones that invest more in internal R&D, and consequently the ones that have higher research capabilities (Tether, 2002; Fontana et al., 2006).

Additionally, evidence from evaluation of governmental subsidies to collaborative projects suggest that the grant may work as a label that a project has merit and increase subsequent private investment. Indeed, Feldman and Kelley (2006) find that firms receiving an R&D subsidy were less likely to seek additional funding, however when pursuing other funds, they were more likely to raise funds than non-awarded firms. As Feldman and Kelley (2006) argue, this might be related to the fact that the awarded project is better, but also to the fact that the award of public financing serve as an information signal to other investors, as differences in the level of funds between awarded and not awarded firm are not significantly different even when taking into consideration the technical quality differences of projects.

Furthermore, some evidence suggest that after being involved in a public sponsored collaborative project with university; firms carried out further R&D projects, increased their R&D funding, and many of them employed more technical people (Berman, 1990; Davenport et al., 1999).

Thus, evidence suggest a small degree of observed crowding out effects on the private investment in R&D. In most cases, public sponsorships for collaborative research will be able to increase the amount of research done in an economy and might as well encourage the future research involvement and investment of firms.

c) Sponsor criteria

c1) Firms

Several studies and evaluations reports have been unanimous on arguing that public grants for university-industry collaborative projects do not reach well small and medium firms (SMEs). Instead, the greater users of these funds are large firms and spin offs (Hetxner, 1989; Tether, 2002; Roberto et al. 2004), Laredo (1998) also finds that collaborations involving SMEs seem less quick in making progress and achieving results than collaborations involving large firms.

Moreover, Fontana et al. (2004) find that firms that collaborate with public research organisations are those that put more efforts in searching for external knowledge, screening the outside world using publications databases,
and also signalling their competencies by patenting. Indeed, the degree of openness to different sources of information and the breadth of collaborative links with other enterprises, connections to universities affect the success of the innovative strategies of firms (Belderbos et al., 2004; Laursen and Salter, 2004).

Therefore, firms, which received a public grant to undertake a collaborative research project with universities, seemed to have developed a more diverse set of linkages to other firms and exhibited openness in communicating research results, but did not differ significantly from the non-awarded firms with regard to their connections to universities. Feldman and Kelley (2006) argue that this result reflects that awarded firms had greater potential to disseminate R&D results more broadly, because still after controlling for technical merit and business potential, projects selected for the R&D subsidy were those in which participating firms are better positioned to deliver public benefits from their R&D activities. We can also argue that better-related firms were better informed about the most relevant/fashionable technological developments on recent promising academic research results. Thus, even that the quality of the proposal were not much different from the non-awarded projects of firms less well linked and open, the awarded projects of might have proposed a more attractive research line (Feldman and Kelley, 2006).

In sum, policy implementers of grants to university-industry collaborative research projects seem to award projects that have been mostly put forward by large firms and spin offs, with large technological capabilities and large networks of connections to universities and other firms. To a certain extent this is also the consequence of the fact that only the most capable firms look for collaboration with university and they are able to put together a collaborative project.

c2) Researchers

Among the most important outputs of collaborative projects for the industry are informal access to students and direct personal links with scientists (Berman, 1990; Lam, 2005; Balcony and Laboranti, 2006). Therefore, one of the objectives of public grants to collaborative projects is also to support the increase the network of contacts between university and industry, as well expand the culture of R&D collaboration. The selection criteria used by policy implementers of these subsidies should ensure that the proposed collaborations lead to the training of students and scientists in engaging in collaborative research projects and in being able to address the cultural and problem-solving gaps between scientific and industrial research (Bozeman and Corley, 2004; Lam, 2005).

For all these reasons, it is important that public grants are not only awarded to projects involving senior researchers. In particular, Bozeman and Corley (2004) analysed the different collaborative behaviours of scientist and they conclude that researchers with a Mentor strategy (i.e. researchers motivated to help junior colleagues and graduate students by collaborating with them) are the ones that demonstrate a more favourable attitude towards working with industry. Therefore, identification of promising young researchers with a ‘mentor strategy’ to collaboration and with a positive view towards collaboration with industry could be a way of enhancing scientific effectiveness and productivity of collaborative research projects, multiplying the training effects of the participation in the collaborative projects (training students, getting experience on collaboration, building contacts with industrial partners), and foster future university-industry interaction.

However, as Bozeman and Corley (2004, p. 614) argue “The inclusion of early career and underrepresented scientists in funded projects does not insure that they will have collaboration opportunities and it does not ensure that the collaboration opportunities afforded will help them significantly to enhance their S&T human capital.”. Moreover, tenured and old researchers are found to have more experience and to be more willing to participate in collaborative projects with industry (D’Este and Patel, 2007). Thus, the success of the university-industry collaborative research projects seem also to rely on the involvement of tenured and experienced researchers with a high scientific productivity, who have the skills to explore the linkages, and frame the search process of industrial applications into scientific quality research allowing excellence training of postdoctoral students.

Indeed, empirical evidence suggests that usually collaborative projects are implemented together with doctoral and master students. In particular, the framing of postdoctoral training of students into supporting university-industry interaction seem of particular importance to support the undertaking of exploration and exploitation projects aimed at pre-feasibility studies of industrial applicability, supporting product development or solving industrial technological problems. Moreover, national and European public granted projects seem more likely to produce a higher number of scientific publications than projects that were undertaken with alternative financing and organisational structures (Bodas Freitas and Verspagen, 2009).

As we have seen in section 2, researchers involved in high-technology content activities with industry, attracting higher level of public and private research grants, are those researchers that experience the greatest productivity in terms of publications and access to public and research grants.
c3) Basic/Applied research Project
Should the selection of the projects be based in terms of quality of the proposal and the potential scientific and technological contribution of the project interest or in terms of technical feasibility and the chances of commercial success? Risky research projects aimed at development of scientific and technological relevant knowledge may generate the highest social rates of return, when compared with more certain projects in terms of commercial success. When compared to product development investments, basic research might result in new knowledge that opens up much broader avenues of search and applications.

Analysing the implementation of the EU Framework programme, Laredo (1995, 1998) finds that awarded projects include those focusing on basic, applied and industrial development research. In particular, he points out that for a policy programme that aims at encouraging pre-competitive research collaboration, having one third of projects being able to provide direct economic benefits for its participants is not a coherent policy outcome (Laredo, 1995). Therefore Laredo (1998) argues that policy support for collaboration should be differentiated for collaborations aimed at basic and applied research and for development activities in order to allow the customisation of the specific research programmes and the thematic calls for proposals to launch.

Analysing collaborative projects in the Netherlands, Bodas Freitas and Verspagen (2009) find that sponsored university-industry projects often lead to higher level of scientific publication as well as to plans for the technological development and commercialisation of new products using complementary to existing technologies, when compared with projects that did not apply for grants.

This suggests that sponsored projects aimed at developing of somehow risky scientific-interesting technologies (Feldman and Kelley, 2006; Bodas Freitas and Verspagen, 2009). Consequently, the firm’s participation in collaboration with university and in granted projects is found to be likely to result to future increases in the firm’s investment in R&D (Berman, 1990; Feldman and Kelley, 2006).

Concerning the outputs of public sponsored collaborative research projects, the development of new processes and software, which after developed might be lead to the improvement or the launching of new products, is the most observed object of university-industry collaborations. In particular, some projects, dominated by large firms, also lead to the development of new market standards rather than only internal methods and software tools for the participants of the collaboration (Laredo, 1995; Freitas and Verspagen, 2009).

c4) New/Established collaborations
Most evidence suggests that public grants are a form of developing and maintaining an ongoing relationship with university (Davenport et al., 1999; Bodas Freitas and Verspagen, 2009). University researchers are motivated to join the project to maintain collaborative contacts and, to a lesser extent when part-time professors are the initiators of the project, to get insights on the applicability of their previous research results (Bodas Freitas and Verspagen, 2009). Therefore, most of the firms that had engaged in collaborative research prior to their awarded projects, these had been with the same partners (Davenport et al., 1999; Bodas Freitas and Verspagen, 2009).

Thus, application to public grants for undertaking collaborative research projects seems to be understood by university and industry researchers as a source of financing and legitimisation of the value of the research project plan in their organisation and thus facilitating development and transfer of skills and knowledge.

Feldman and Kelley (2006) argue instead that awarded projects were more likely to establish a new research partnership in terms of partners or in terms of focus on a new technical area. Indeed, the undertaking of research projects in new research and technical areas might need to involve new partnership involving both some old partners and some few new ones. Indeed, evidence suggest that in the mid 1990s the Framework programme seemed to have led to the stabilisation of the research partnerships (i.e. projects were found to increasingly be based on pre-existing collaborations), despite its incentives had allowed mobilizing the European Research systems and promoting large partnerships (Laredo, 1995, 1998; Grande and Peschke, 1999).

Additionally, evidence suggests that when compared with projects that were undertaken with alternative funds and organisational structures, in public sponsored projects, firms are less likely to participate actively in the design and performance of R&D, university-industry interaction tends to be less frequent, and knowledge transfer is usually done through reports and prototypes than in other collaborative projects (Bodas Freitas and Verspagen, 2009). To a certain extent, these evidences suggest that in sponsored projects, which tend to involved partners with previous common collaborative experience, the labour division may be easier and straightforward, and knowledge transfer more effective through informal contacts and not requiring working together.

For all these reasons, some authors argue that repeat support of the same partnership can be positive particularly if participants are still in a learning process about the scope, possibilities and managerial dimensions
of such collaborative arrangements, and if their previous collaborative projects have also been productive (Laredo, 1995; Davenport et al., 1999). These collaborations could build on the trust and research results built on the earlier collaborations. After several awarded projects, it will be the partner that will be less interested in applying to using the same partnership design (Davenport, et al., 1999)

c5) Other issues – management and IPR
Problems during the collaborative research projects are often caused by the different organisational incentives and objectives frameworks of university and industry, in particular their different attitude towards knowledge sharing, appropriability, and applicability, but also with unclear or unrealistic goals; unmet expectations; a lack of trust, honesty and openness; hidden agendas; lack of commitment, and lack of communication and misunderstandings between the partners (Davenport, et al. 1999; Bodas Freitas and Verspagen, 2009). These problems were found to be associated with the fact that there was no previous common collaborative experience, as well as with the involvement of large multinational following strict secrecy rules delaying university publications. Sometimes these barriers also derive from the relatively little experience of university researchers in managing industrial collaboration, and in realising the particular research needs and objectives of the firm, or from the little absorptive capabilities of the participating firm combined with operational rather than strategic priorities (Bodas Freitas and Verspagen, 2009).

Therefore, university-industry collaboration requires that a division of labour and respective organisation and co-ordination of the knowledge production and distribution process are agreed and set, as well as rules for accessing resources during development, and for appropriating and external diffusing knowledge generated (Foray and Steinmueller, 2003).

Indeed, public sponsored collaborative research projects, at least in the Netherlands, were found to be less likely to suffer from these problems caused by the different objectives and incentives frameworks of partners (Bodas Freitas and Verspagen, 2009). This might be related to the fact that Dutch as many other European research sponsors provide an organisational and interaction framework for the university-industry collaborative projects. In particular, this framework includes the requirement that each project sets up a user committee, used to report results and get technical feedback and direction for research projects. Other firms are likely to join the project, after the project beginning. Moreover, a minimum frequency for interaction and for reporting results within this committee tends to be defined. Additionally, specific procedures to analyse patentability of the research results, as well as to attribute and negotiate property rights of the knowledge generated within the project tend to exist.

Hence, the fact that Feldman and Kelley (2006) find that collaborative R&D subsidies are more likely to be attributed to projects and firms that have the greatest number of connections and consequently higher potential to achieve higher spillovers, might also reveal the fact that these projects need to follow certain diffusion and collaboration rules.

Thus, as in the 1990s, Laredo, (1995, 1998) argued that if the framework of implementation and development of sponsored collaborative projects introduces some rules with respect to the formulation of the work programme of the collaborative project, the division of labour and responsibilities, and the management of collaborative work, problems are expected to decrease.

In sum, public funds for research seem to have some social and economic rationale, as they are found to encourage significantly R&D efforts, not to crowd-out private investments and to have positive effects in terms of basic and applied outputs. Moreover, European and national funds for collaborative research projects have been found to both enlarge the collaborative network contacts as well as to support the development and learning of collaborative culture (Laredo, 1998).

3.4. Voucher systems
Innovation voucher schemes are policies that aim to build links between knowledge providers and small businesses (SMEs). They do so by setting up a program in which SMEs with a research question can apply for a cheque, which can be used to ‘buy’ knowledge at universities or PRO’s. Innovation vouchers are relatively new, though there are other (older) schemes with similar properties that do not always bear the same name. One of the first larger innovation voucher schemes, and arguably one of the best known, is that in the Netherlands. Given its pioneering role, we will go into some more detail on that scheme. The Dutch voucher scheme started with three pilots in 2004 and 2005, and from 2006 onwards, it has been available as a regular policy instrument. Its main objectives are to lower the thresholds for SMEs to seek contact with universities and research institutes, and to help them to become more demand-oriented. The current system includes so-called small vouchers, worth 2,500 Euros each (3000 available in total). Large vouchers are worth 7,500 Euros each and assume 33% matched funding from the application (3000 in total). Although the amounts are not very high, the large
vouchers of several SMEs may be bundled to a total of 75,000 Euro. Another interesting aspect is that vouchers may be used at universities and PROs, but are also allowed at larger firms that have R&D facilities.

Several policy evaluations of the voucher scheme have provided insights into its functioning. Interestingly enough, during the pilot schemes, vouchers were granted at random to approximately half of the applications, whereas the other applications received no vouchers. This allowed the evaluators to build a very solid data set and control sample to measure the use of this instrument. In particular, by comparing the number of actual studies commissioned by the successful applications with the number of studies commissioned by the unsuccessful ones, the exact additionality could be measured. The results, reported in Cornet et al (2006), are that ‘Out of every ten vouchers, eight are used for a project that would not have been assigned without such a voucher, one is used for a project that would have been assigned anyhow, and one voucher is not used.’ Thus, there is evidence for a very high additionality. A later evaluation of the regular scheme no longer enabled this methodology, as every application was granted a voucher. Via other means, the additionality measured was still very high and robust, though not as high as during the pilots (Bongers et al., 2008). An extensive survey, augmented by qualitative research, showed that the scheme was highly valued by SMEs, who believed that it contributed significantly to their innovativeness. In recent years, various countries have introduced similar schemes. An overview is given in Table 9. Given the relative newness, there have been no results of other evaluations yet.

Table 9: Overview of innovation voucher schemes in Europe

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>(Intended) Start Date</th>
<th>Name of the System</th>
<th>Organisation (Person Involved)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>2004</td>
<td>Innovatievoucher</td>
<td>Sentenroven; Ministerie Economische Zaken</td>
</tr>
<tr>
<td>Ireland</td>
<td>2nd half 2007</td>
<td>Innovation vouchers</td>
<td>Enterprise Ireland</td>
</tr>
<tr>
<td>Northern Ireland (UK)</td>
<td>2nd half 2008</td>
<td>Innovation vouchers</td>
<td>Invest Northern Ireland</td>
</tr>
<tr>
<td>West-Midlands (UK)</td>
<td>2007</td>
<td>Index Voucher System</td>
<td>Aston University</td>
</tr>
<tr>
<td>Austria</td>
<td>2nd half 2007</td>
<td>Innovationsscheck</td>
<td>FFG</td>
</tr>
<tr>
<td>France (run at regional level)</td>
<td>At least since 1995</td>
<td>Prestation Technologic Reseau (PTR)</td>
<td>OSEO et Reuze de developpement technologique regional</td>
</tr>
<tr>
<td>Denmark</td>
<td>2nd half 2008</td>
<td>Viden-kupon (knowledge vouchers)</td>
<td>The Danish Agency for Science, Technology and Innovation</td>
</tr>
<tr>
<td>Baden-Württemberg (DE)</td>
<td>2nd half 2008</td>
<td>Innovationsgutscheine</td>
<td>Wirtschaftsministerium B-W</td>
</tr>
<tr>
<td>Sachsen Anhalt (DE)</td>
<td>2008</td>
<td>Forschungsscheck</td>
<td>Investitionsbank Sachsen Anhalt</td>
</tr>
<tr>
<td>Piemonte (Italy)</td>
<td>2nd half 2007</td>
<td>Voucher</td>
<td>FINPIEMONTE S.p.A.</td>
</tr>
<tr>
<td>North Reink Westfalen (DE)</td>
<td>2nd half 2008</td>
<td>Pilot ‘Innovationsgutschein NRW’ (only textile sector)</td>
<td>Zitex zukunftsnititative Textil NRW</td>
</tr>
<tr>
<td>Catalunya (ES)</td>
<td>2nd half 2008</td>
<td>Bonos per Innovar</td>
<td>CIDEM</td>
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<tr>
<td>Valencia</td>
<td>2003</td>
<td>Cheque Innovacion</td>
<td>Impiva</td>
</tr>
<tr>
<td>Flemish Region (BE)</td>
<td>2003</td>
<td>Grondig Technologic Advies [GTA] ‘short technological service projects’</td>
<td>IWT</td>
</tr>
<tr>
<td>Walloon Region</td>
<td>2009</td>
<td>Cheque Innovation</td>
<td>Agence Stimulation Technologie</td>
</tr>
</tbody>
</table>

The conclusion is that voucher schemes are a successful way to promote technology transfer in a particular area, namely SMEs.

4. Reflection of knowledge transfer in Europe

In this section, we reflect on broader issues related to the effectiveness of technology transfer activities and policies. In particular, we address the issue of whether or not policies can effectively address all forms of technology transfer, as well as the consequences of the invisibility of some of these channels for policy makers and for institutional managers. We also analyse the subject of measuring individual and organisational involvement in technology transfer activities, as well as performance of these activities, such as university patents, spin-offs, and business funded research. On this subject, we will address the underlying performance factors of technology transfer activities, such as the absorptive capability of industry, and the organisation and quality of academic research. In particular, we will discuss the rationale and evidence behind European Paradox, and the implications for policy. Finally, we will focus on the implications for science and innovation industrial policies of the observed interdependencies between knowledge transfer channels, as well as incentives for interaction with industry.

9 Table is based on input from the Workshop “Benchmarkoefening van bestaande innovatievoucher- programma’s” on 17 June 2008 by IWT (Belgium).
4.1. Traditional university outputs versus commercialisation of university knowledge

In the 1990s, industrial policy was reduced to innovation policy, especially in the UK (Sharp, 2000); and now in the 2000s, we are observing the reduction of science policy into technology transfer policy. These observed phenomena in policy design and focus, especially the later one in science policy, might exacerbate the negative consequences of the observed with the changes in European industrial policy on European innovation performance (Dosi et al., 2006).

As we have seen in section 2, scientists interact and transfer knowledge with industry through a wide variety of channels. However, science policy has been increasingly focusing on the commercialisation of university knowledge through university patenting, licensing and spin-offs. Almost all the new science policies focus on these channels, which are among the least used and the ones found less important by scientists but also by industrial researchers (see Table 1 above, and also Cohen et al., 2002; D’Este and Patel, 2007; Bekkers and Bodas Freitas, 2008).

Publications, informal contacts and student flows, which are the traditional outputs of university to society and industry, are still among the most important channels, together with collaborative research projects. Moreover, evidence is consensual on the strong correlations between the importance of scores of publications, informal information exchange, and joint/cooperative R&D projects (Bekkers and Bodas Freitas, 2008; Bozeman and Gaughan, 2007). In particular, Cohen et al. (2002) show that industrial R&D personnel seek out academics, search the literature, or form cooperative ventures with public research institutions more commonly to address particular needs or problems than to generate new project ideas. Thus, research funds allocated on the basis of peer-review, efforts to redesign educational programmes encouraging interaction with industry, as well as the identification and diffusion of best-practices in management of collaborative master and doctoral theses with industry, would all have a significant impact on the quality of research and the potential level of interaction with industry.

National structural funds for purely university curiosity-driven research have definitely not been in fashion in Europe since the mid 1990s. European and national competitive research funds are increasingly framed on university-industry interaction (Dosi et al., 2006). Moreover, governments have been funneling support for technology transfer into the promotion of formal channels of knowledge transfer such as TTO, patents and spin-offs, and into revising university IPR rules. In many countries, universities have been encouraged to create their own TTO to support commercialisation of their research results, as well as entrepreneurship of scientists. However, most of the relevant mechanisms of knowledge transfer, such as personal consultancy, informal contacts, supervision of students with projects in industry, co-authored publication, and sponsored research contracts are invisible to TTO and to university management. Even most research contracts are done individually by researchers and their departments, often involving informal exchange of resources. Sometimes even consulting takes a decentralized form in the sense that it does not typically reflect formal, personal or institutional contracts. In addition, as seen in section 3.1, university research results usually end up in industry-owned patents; consequently TTOs do not have any information on them.

In addition, as seen before, an high correlation is observed between the scientific and applicability performance of scientists, revealing that those who engage in relevant applicable research tend to have a good scientific curriculum (Geuna and Nesta, 2005; Bozeman and Gaughan, 2007; Stephan et al., 2007;). Hence, what is the rationale for policies supporting commercialisation of university knowledge, compared to that of the more traditional means of dissemination of academic knowledge? The rationale for these policies seems much more based on basic accounting principles: continuous short-term evaluation of institutional and personal performance, rewarding short-term and financial university performance, and decreasing of fixed governmental budgets (Sharp, 2000). The effects of these policies on incentives for scientists and institutions were assumed to affect only the decision on the quantity of resources for different activities, while the impact on their quality and time-frame was not acknowledged. In other words, policy-makers did not take into account the specificity of different research activities (contracted services, training activities, patenting, teaching and basic research), their different levels of complementarity and substitution, and their different scientific content. Therefore, several authors argue that the promotion of universities-industry requires policies to address effectively a wide variety of channels and to keep incentives for long-term research lines (Lee and Gaertner, 1994; Bekkers and Bodas Freitas, 2008; D’Este and Patel, 2007).

Finally, both the assessment of policies supporting commercialisation of university knowledge and those supporting more traditional means of dissemination of academic knowledge are not without problems. If it is impossible to understand which papers have been read by industrial researchers (proxy number of citations in patents or in technical magazines and journals), it is also impossible to know exactly how many patents were thanks to university research (proxy the name of university researchers as inventors, citations of scientific publications).
4.2. **The supposed European lag in university-based patents**

In Europe, many policy makers have been eagerly looking at the share of US university patents in the total share of patents in that country. It is believed that Europe is strongly lagging behind. This perception is well illustrated by the talk that Michael Porter delivered for Dutch governmental and industry leaders (Porter, 2001). In this talk, he presents the supposedly low ratio of university patents as one of the key reasons why Europe, and the Netherlands in particular, are lagging behind in university-industry relations. He based his observations on a list ranking Dutch firms and organizations with regard to the number of US patents they obtained from 1996 to 2000. ‘The top U.S. university produced 1585 patents, while the top Dutch university produced just 13.’ (Porter, 2001, page 38).

The view expressed by Michael Porter aligns very well with the view of the European Paradox, which holds that Europe is good in basic research but the public research sector fails to commercialize its knowledge and get it across to the industry. However, when assessing the number of university patents, we also need to ask ourselves the question whether the data being used (in some regions more anecdotic than representative) is actually a reliable indication of university involvement in patenting. In recent years, significant new insights have been gathered on this, showing that the ‘official’ numbers on university patenting are seriously biased downwards. The key is that not all patents invented by university faculties are eventually assigned to (i.e. owned by) the university. There is a tendency for researchers/professors to let ownership of the patent be assigned to the company that financed the research project, but to be included in the list of inventors or to apply individually as patent assignees. Therefore it is useful to distinguish between university-owned and university-invented patents. Studies in Belgium, Finland, France, Germany and Italy - by Balconi et al. (2003), Meyer (2003) and Saragossi and van Potelsbergh de la Potterie (2003), all in Geuna and Nestel, 2006 - provided clear empirical evidence that the number of university-invented patents is much higher than the number of patents owned by universities. This was confirmed on a larger scale by PATVAL, a large scale survey among patent inventors conducted by the DIME Network of Excellence (see Giuri et al, 2007 for an extensive report on the study, and Verspagen (2006) on the findings related to university involvement). This survey provided a database of more than 9000 valid responses from France, Germany, Italy, the Netherlands, Spain, and the UK. When taking the university-invented into consideration, the total number of university-involved patents jumps up considerably. As reported by Verspagen (2006) on the basis of this data: ‘In Germany, France and Italy, university-owned patents are a very minor fraction of the total (<0.8%), but the fraction of non-owned, university-inventor-involved patents is larger than 2.5% in all three cases.’ From this, it can be concluded that university plays a considerably more important role for patenting than what is often assumed.

In summary, it can be argued that university involvement is substantially higher than most ‘official’ data suggests and arguably is not much below the US level. Many patents with academic inventors are assigned to companies, and this is arguably even a more successful way of technology transfer than university-owned patents.

4.3. **Revisiting the European Paradox: the actual research performance in European universities and the absorptive capacity of industry**

Fostering the level of industrial innovation, involves not only providing support for the demand side (industry), for the supply side (university), and for the process of technology transfer itself, but also to nurture and reinforce these market interactions. As some early studies advance, the importance of public research organisations to provide specific relevant innovative knowledge to firms depends on the quality and function of the interaction among different market actors in an economy (Bodas Freitas et al., 2008). We will try to discuss broadly the underlying factors of performance of university-industry interaction.

One of the first issues we wish to address is the capabilities of the firms (demand) for using university knowledge. Firms do not have necessarily the capacity to assimilate (absorb) and exploit the knowledge produced by universities or they may not be willing to make the required investment in upstream research activities; and they may well fail to actually benefit from this research (Cohen and Levinthal, 1989; Dosi et al., 2006). Instead, policy-
makers tend to look at technology transfer mainly as an issue of transferring intellectual property, assuming that once industry is provided with access to new scientific discoveries, it will invest the necessary resources to convert them into commercial technology and have the capabilities to develop an industrial innovation (Lee and Gaertner, 1994). In particular, Dosi et al. (2006) argue that one of the reasons for European lagging behind in innovation relates to the capabilities of the industry (demand). They argue that on average, Europe observes a “lower presence in sectors based on new technological paradigms (such as ICT and biotechnologies), a lower propensity to innovate, and a relatively weak participation in international oligopolies in many activities” when compared to the US. Industrial policies and technology development projects are claimed to be able to support the development of national innovative and competitive competences (Sharp, 2000; Dosi et al., 2006).

The second issue affecting the performance of university-industry interaction refers to the quality of European science (the supply). While the apologists of the ‘European Paradox’, argue that “EU countries play a leading global role in terms of top-level scientific output, but lag behind in the ability of converting this strength into wealth-generating innovations” (Dosi et al., 2006, 1450), bibliometric data shows, however, that Europe is lagging behind the US in top-level science, with the exception of a few institutions and disciplines. Moreover, this lag in scientific quality is expected to be accentuated by the current national and European science policies that have been put in place - the decrease in structural funds for public research, the increasing inclusion of industrial applicability in the competitive allocation of research funds, the pressure on universities and scientists to become entrepreneurial and patent (Sharp, 2000; Dosi et al., 2006; Geuna and Nesta, 2006). Indeed, Lee and Gaertner (1994) show that some experimental cutting-edge technology development projects at universities were successful and on time, because the university could build on its own comparative advantage in strong research.

Excessive pressure for applicability and short-term research affects the time allocation of researchers to teaching and curiosity-driven research (Geuna, 2001; Beath et al., 2003). This has not only short-term implications on the quality of teaching and on the maintenance of individual long-term research lines, but more importantly restrict the long-term quality of university output (including skilled labour force, basic knowledge developments and skills to manage very ambitious long-term research projects) (Sharp, 2000; Geuna and Nesta, 2006). In particular, researchers, who had part of their research agendas financed on a long-term basis by one specific industry-related fund, were found to be less able to maintain their high performance (Goldfarb, 2008). In addition, despite enhances contact with other scientists, collaboration with industry also restrict communication among scientists because of the secrecy rules set by firms, and because of their increased effort to commercialise their research results and patenting (Welsh et al 2008). Competition among researchers, which is based on the ability to choose relevant research purposes, and to determine their research agendas (Ziman, 1987; Dasgupta and David, 1994), is also expected to increase in the context of competitive allocation of public funds for research, and it is likely to lead to a decrease communication among scientists. Therefore, several studies and programmes evaluations have stressed that too much industry influence on academic research could undermine future pay-offs from academic research not only because of its incentives to distract researchers from basic curiosity-driven research but also to invert the values of traditional academic freedom (Berman, 1990, Dosi et al. 2006, Goldfarb, 2008).

Several policies have been suggested to address these points. Desirable European science policies include the distinction between research and graduate teaching universities, from undergraduate and technical colleges, as well as the support for high quality basic science, relying on world-class peer-review (Dosi et al., 2006). Moreover, European investment in large-scale, technologically ambitious missions justifiable in terms of their intrinsic social and political value, would enable the launch of heavy and concentrated incentives for science and technology (Dosi et al., 2006). On the one hand, researchers would have the means and incentives to be involved in challenging basic research. Moreover, researchers are found to be mobilised by incentives to deal with international technology races (Lee and Gaertner, 1994). On the other hand, by mobilizing considerable resources for high quality basic research, several outcomes (mostly unexpected) could be developed and lead to industrial opportunities. Indeed, the European industrial advantages in microelectronics have been associated with the great mission-oriented projects launched by national governments (Sharp, 2000; Dosi et al., 2006).

A third issue related to the performance of university industry interaction refers to the fact that industrial innovation is not only dependent on interactions with the university. The Community Innovation Survey (CIS) shows that fewer than 10% of firms collaborate with universities and public research organisations, while other market actors, in particular customers, suppliers and competitors, are more important for the daily innovative activity of firms (Tether, 2002; Badas Freitas et al., 2008). Moreover, analysing in detail firms that collaborate with university, Levi et al (2009) find that only some firms do that on a regular basis. Indeed, Bodas Freitas et al. (2008) show that, even taking industry and country differences into account, novel product innovators as well as firms that innovate in both product and process tend to rely relatively more on customers than on public research organisations.

Additionally, national differences in the use of different channels of knowledge transfer seem to exist and seem reliant on the different national incentives and institutions such as academic career design, university financing
rules, and science and technology policies (Gittelman, 2006; Bodas Freitas and Verspagen, 2008). However, the channel used to transfer technological knowledge between university and industry do not seem to affect the performance of the transfer (Bozeman, 1994).

Furthermore, reduction of policy incentives for patenting and for commercialisation of university knowledge might be a good strategy for several reasons. Firstly, academics tend to use patents as signallers, devices, and consequently, most European universities were found not to benefit from licensing activities (Geuna and Nesta, 2005; Bodas Freitas and Nuvolari, 2008). The immediate consequence is that university is deviating research funds to pay for patenting its research results. Secondly, patents are an instrument to protect and foster innovation. If the patenting knowledge is very basic, it will most likely slow down the development of related knowledge. Moreover, the excessive fragmentation of IPR among too many owners can slow down research activities and product development because all owners can block each other (Heller and Eisenberg, 1998; Dosi et al, 2006). Therefore, national policies encouraging university patenting might be ineffective or prejudicial to innovation development, for research financing, as well as for the accounting balance of universities, and even for university-industry collaboration.

In summary, Europeans’ performance seems to be constrained by problems affecting both the demand and supply of high-quality public research rather than (only) the transfer process between university and industry, as the apologists of the European Paradox believe (Dosi et al., 2006).

4.4. Interdependence between knowledge transfer channels used and their incentives

As we have stated in Section 2, interaction between university and industry is done through a wide diversity of channels, which tend to be complementary rather than substituting each other (Bekkers and Bodas Freitas, 2008). For example, the wider the informal contact network or the publication record of a scientist, the more the scientist is likely to engage in collaborative and contract research (D’Este and Patel, 2007). Moreover, the effect of publication productivity on patent productivity is found to be significant and positive (Geuna and Nesta, 2005; Stephan et al., 2007). Again, we stress that evidence suggests the relationship between scientific productivity and interaction with industry depends on both the content and the size (in terms of research funds), and the variety and length of this interaction. In particular, scientific productivity increases from interaction with industry only when this interaction represents less than 15% of the scientist research funds, and it refers to high scientific activities (Manjarrés et al., 2008).

The reason why several channels overlap, relates to the inherent self-reinforcing incentives that underly the skewed distribution of research resources and productivity (Lotka, 1926; Merton 1968). The more a scientist produces high quality research, the more important it is for him/her to maintain and increase his/her productivity performance, to keep up a wide network of contacts with other researchers, to invest in supervision of bright students, and to participate in challenging collaborative research projects. Moreover, especially in some disciplinary areas, involvement with industry is important in order to access specific production technologies and infrastructures, as well as materials and tests environments.

Thus, policies should see technology transfer not as a one-off, but as a long-term activity in which a great number of scientists develop to proceed with their research agenda (Lam, 2005; Balconi and Laboranti, 2006; D’Este and Patel, 2007). Indeed, the opposite worlds of university and industry no longer exist or even never existed as conceptualised by policy-makers (Lam, 2005). Increasingly, collaborative teams are the mode of organisation in industry, and this relates to issues of complexity and multidisplinarity of used technologies (Wang and von Tunzelmann, 2000). In particular, from the 1990s, firms seem to have been developing flexible organisational structures to facilitate university knowledge development and transfer (Lam, 2005). ‘Within the firm, researchers are “research gatekeepers” who connect firms’ R&D projects to state-of-the art knowledge inputs from the outside research communities. Externally, they protect the firms’ proprietary knowledge resources and investment in collaborative projects, while at the same time engaging in open knowledge exchange with their external colleagues in order to explore and identify new scientific advances’ (Lam, 2005, p. 264). Hence, industry and university collaboration sets a type of market in which academic researchers and firms bring in their motivations, expectations and resources (Lee, 2000; Lam, 2005; Bodas Freitas and Verspagen, 2008).

Role of open knowledge creation

Therefore, the economic advantage of universities and the reason why firms collaborate with university relates to the quality of their research and to the research skills of their staff and students. Involvement in low-scientific intermittent services to industry is shown to have a negative effect on the productivity and focus of scientists. In other words, universities are not business services providers. Accomplishment of their first mission objective is a necessary condition for them to be able to provide support to national economic development. Hence,
preserving the curiosity-driven peer reviewed research is important for scientist capability, and incentives to engage in research can contribute to long-term technological progress. Given its unpredictability, curiosity-driven peer reviewed research has the potential to open up new research avenues for applied research and technology development (Strandburg, 2005).

5. Summary and conclusions

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References and consulted literature


Lessons from NSF’s Industry/University Cooperative Research


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<td>Tijssen, R.J.W., T.N. Leeuwen and E. van Wijk (2009). Benchmarking university-industry research cooperation worldwide: performance measurements and indicators based on co-authorship data for the world’s largest universities. Journal of Research Evaluation (Forthcoming in March/April, 2009)</td>
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