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**University Research, Intellectual Property Rights and
European Innovation Systems**

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The Intellectual Property Rights (IPR) elements of the DIME Network currently focus on research in the area of patents, copy-rights and related rights. DIME's IPR research is at the forefront as it addresses and debates current political and controversial IPR issues that affect businesses, nations and societies today. These issues challenge state of the art thinking and the existing analytical frameworks that dominate theoretical IPR literature in the fields of economics, management, politics, law and regulation-theory.

University research, intellectual property rights and European innovation systems

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Abstract

This paper surveys the literature on university patenting. From the point of view of the economic theory of patents, it is argued that patenting knowledge developed by university researchers is paradoxical: patents are normally intended to stimulate knowledge development by providing property rights, but universities operate also under a different incentive scheme, i.e., they receive public funds to perform socially useful knowledge. In the debate surrounding the so-called Bayh-Dole Act in the United States, it has, however, been argued that patents on university inventions may be necessary to stimulate technology transfer from universities to private firms. The first part of the paper addresses two major questions. First, what is the economic logic of Bayh-Dole, and, second, what were the effects on universities and the knowledge they develop.

In the second part, the paper addresses the issue of whether “Bayh-Dole-like” legislation would be beneficial for European countries. In a number of European countries, a suggestion has been made that this could enhance knowledge transfer from the public to the private sector. Using a new database resulting from a survey among patent inventors in six European countries, an assessment is given of the degree of university patenting in Europe. Because university researchers are often involved in patented inventions without the university being listed as a patent applicant, statistics based on the patent office databases alone often underestimate university patenting in Europe. The paper ends with a discussion of how this “European practice” of university patenting affects public-private knowledge transfer in Europe, and how this compares to the effects of the Bayh-Dole Act in the U.S.



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1. Introduction – University patenting in the USA and Europe

While innovation was long seen as a ‘linear’ process in which ‘basic’ knowledge from academia automatically flows to the business sector in order to be applied in innovation, the emergence of the concept of ‘innovation systems’ (e.g., Freeman, 1986, Lundvall, 1992, Nelson, 1993) has put more emphasis on the circumstances in which knowledge can actually flow between researchers from the public and private sector. In the innovation systems perspective, interaction is important because the development of technology and innovation is a learning process, in which technology transfer is greatly facilitated by direct contact between researchers.

Interaction between researchers working in private firms and those working in publicly financed institutions such as universities is seen as particularly important because it may provide unique competitive advantages (e.g., associated with specific competencies of high-quality universities). The European Commission (2003) lists this as one of the six priorities for European universities in the immediate future, and concludes that “it is vital that knowledge flows from universities into business and society. The two main mechanisms through which the knowledge and expertise possessed and developed by universities can flow directly to industry are the licensing of university intellectual property, and spin-off and start-up companies” (European Commission, 2003, p. 7).

This quotation points to one of the prominent debates in the literature, i.e., the role of intellectual property rights in the process of public-private knowledge transfer. In the U.S., there is a longstanding policy debate on the potentially beneficial impact on public-private knowledge transfer of universities taking out patents on their research results (see Mowery and Sampat, 2001, for an overview starting in the 1930s). With the introduction in 1980 of the so-called Bayh-Dole act, which gave U.S. universities the right to patent discoveries resulting from federally funded research, this debate was decided in favour of those supporting active patenting by universities. The subsequent rise in university patenting observed in the U.S., and the success stories of some university discoveries that yielded high-income streams from licensing, have induced European policy makers to also consider Bayh-Dole-like legislation (OECD, 2003). This argument is made against a background of, often anecdotal, empirical evidence that European universities are not very active in patenting.

This paper intends to give an overview of the debates surrounding the introduction of the Bayh-Dole Act in the United States, and the possible adoption of similar legislation in Europe. The aim of the paper is not to provide the final answer to the question whether Europe needs legislation similar to the Bayh-Dole Act. Rather, the ambition is to provide an overview of the academic literature in economics that deals with university patenting, and to draw policy lessons from this. In this way, it is hoped that the general directions that the discussion on university patenting in Europe should take will become clear. The survey will focus on two main issues. First, which arguments can be given in favour of university patenting to facilitate public-private knowledge interaction, and what empirical evidence exists to support (or not) these arguments? Second, how do these arguments fit into the specific European context? This second issue is important because, as will be shown below, the European situation is different in many respects from the U.S. context.

The paper is structured as follows. Sections 2, 3 and 4 give an overview of the (economic) theory behind university patenting. Section 2 starts with a broad discussion of the economic characteristics of a patent system, and the specific considerations that play a role with regard to university patenting. This section concludes by summarizing the common arguments in favour of an active role of universities in patenting. Section 3 summarizes a less commonly found argument about university patenting. This section deals with the role of intellectual property rights in public-private research joint ventures (RJVs), and summarizes a model by Aghion and Tirole that argues that market failure may exist in these RJVs. Section 4 discusses the potential negative impacts of university patenting.

Section 5 broadly compares the U.S. and European institutional contexts in relation to the debate on university patenting. This section will highlight a number of crucial differences between Europe and the USA, and will summarize some of the variety of legislation that exists in Europe. This section also

reassesses the empirical evidence on patenting by European universities using a novel data source, and concludes that statistics based on official patent databases run a serious risk of underestimating university patenting in Europe. Section 6 summarizes the empirical debate after the introduction of Bayh-Dole, and asks what the impact of this legislation on university research in the U.S. has been. Section 7 summarizes the paper and discusses the implications for the European innovation system.

2. A tale of two paradoxes: patents, universities and technology transfer

The nature of knowledge as an economic good reminds us of the biblical story in which Jesus uses 5 loafs of bread and 2 fishes to feed a crowd of several thousands of people (John 6). When Jesus breaks the bread, it is not used up, and he can keep on distributing it until the whole crowd is fed. At that point, food is still left in abundance. Such wonders do not normally happen in economic production. When a consumer buys a loaf of bread at a bakery and consumes it, the baker will have to devote new resources to supply a different consumer with a similar loaf of bread. In other words, the normal state of affairs is that an economic good has a *rivalrous* nature: it cannot be consumed more than once.

Knowledge is completely different in this respect. Once a piece of knowledge has been developed, it can be used ('consumed') by a multitude of parties, without the use by one party hindering the use by other parties. This characteristic of knowledge is obviously the main principle on which any educational system must necessarily be based. It is also a potential source of welfare increases. Knowledge is an important factor of production, and leads to both a greater variety of consumption goods and increased productivity in producing them. The fact that this production factor is, in principle, non-rivalrous, leads to strong economies of scale. Using knowledge throughout the global economic system can in principle be realized at relatively little extra costs in addition to the costs induced by the original developer of the knowledge.

However, unlike in the case of Jesus at the Sea of Galilee, the nature of knowledge as a public resource also poses problems in terms of non-excludability. This becomes obvious when one considers the faith of a firm that develops a piece of knowledge by investing in R&D, and that is subsequently forced to put this knowledge into the public domain. This may, for example, happen if the knowledge is embodied in a product that can be reverse-engineered, and no patent or other form of intellectual property rights system exists. Competitors may use the knowledge embodied in the product at little or no costs, and hence put on the market a similar product as the original one, but at a lower price (they do not have to earn back R&D investments). If the originally innovating firm cannot exclude such competitors from using its knowledge in this way, it will be forced to leave the market. For a rationally behaving firm, such a prospect will, of course, be discouraging, and the R&D project leading to the new product will not be undertaken. In other words, the non-excludable nature of knowledge provides an incentive problem when profit-motivated firms are the main driver of technological change.

Several institutions have been used to solve this incentive problem. David (1993) distinguishes three broad forms of such institutions, and ranks them under three Ps: Property Rights (of which Patents are perhaps the most prominent form), Patronage and Procurement. Property rights or Patents will be the main topic of the analysis here, and hence will be discussed in more detail below. Patronage refers to a mechanism in which governments take financial responsibility for the development of new knowledge, by means of instituting a publicly financed system of research that is aimed at generating and diffusing new knowledge. Obviously, modern universities and other public and semi-public research organizations are the main example of such a system. In such a way, the incentive problem is solved in the same way in which markets for other so-called public goods (e.g., national defense or a tornado siren) are organized: the government institutes the productive system for the public good and finances it from tax income.

Procurement refers to a situation in which the development of a specific piece of knowledge is the topic of a contractual agreement between the producer of the knowledge and a party that is particularly interested in the knowledge, and hence is willing to act as a financier and procurer in the contract.

Such an arrangement is often used, for example, in the defense industry, where a ministry of defense may procure new weapon systems. We will discuss the mechanism of procurement in combination with property rights issues in the next section, and will continue here to focus on the patent system.

Patents are the main form of intellectual property rights employed for the production of new knowledge, although copyrights and trademarks may also play a role (see e.g., David, 1993, for a broad discussion of various form of intellectual property rights). A patent is a legal monopoly for the use of a specific piece of knowledge, to be awarded to the firm, person or organization that first develops the knowledge and is willing to apply it in a commercial way. All advanced economies in the world have instituted a patent system in some form, although there are still major differences in the exact rules under which inventions may be patented in the various systems.¹

The patent system embodies a major paradox. On the one hand, it is aimed at stimulating the development of new knowledge, as a result of the recognition that knowledge is a primary source of increased welfare and economic growth, but that a free enterprise system without intellectual property rights may generate too little incentives for the development of such new knowledge. But on the other hand, the legal monopoly that a patent constitutes is in essence a restriction on the free flow of knowledge, while such a free flow is in fact the actual source of the welfare enhancing effect of knowledge. When knowledge is restricted from flowing to users, it becomes much like any other (rivalrous) economic good.

The patent system recognizes the tradeoff between providing incentives and enabling the flow of knowledge. Thus, a major element of any patent system is that all patented knowledge must be made public (in the actual patent document), that not all knowledge related to the patent becomes the property of the patent holder, and that there is a maximum time length of the patent (after which the patented knowledge becomes public property).

The maximum time length of a patent (around 20 years in most patent systems) provides the most obvious restriction of rights for the patent holder, in favour of other users of the knowledge. But the publication of patented knowledge is also intended to provide a basis for further development of the area in which the patent is awarded, and thus potentially benefit others than the patent holder. Other researchers than those employed by the patent holder (including, for example, R&D workers at a competing firm) may thus use the knowledge described in the patent to develop new knowledge. In other words, patented knowledge may take the form of 'idea-creating' knowledge spillovers.

The restriction of patentable knowledge to only a part of the newly developed knowledge is the subject of patent design. Both *ex ante* written patent law and jurisprudence put important restrictions on patentable knowledge. For example, in the field of genetic research, European patent law (in the making) specifies that only a specific application of genetic code may be patented. This implies that a firm cannot simply patent a piece of genetic code as such, but must always write up a specific application using the genetic code (e.g., a therapy based on the genetic information). Applications that are not immediately discovered (i.e., are unknown at the time of patenting) do not fall under the patent, and are thus freely available for future research and commercial development. In the U.S. patent system, on the other hand, patents on genetic code are much broader, and may include a wide range of yet undiscovered applications. Such a broad patent obviously provides a higher reward (and thus incentive) for the patent holder, but also limits the benefits to society at large.

In summary, the patent system embodies a major paradox related to the tradeoff between providing incentives and enabling a free flow of knowledge throughout the economy. The design of the patent system must strike a balance between the two sides of the tradeoff. Striking such a balance is obvi-

¹ This is even the case among European countries. Although the existence of a European Patent Office (EPO) suggests that a single European patent may be obtained, the practical situation is that the EPO grants several national patents, and the applicant has to pay for each one of these. Current political discussions are about changing this situation and establishing a single European patent.

ously a delicate issue, for which, arguably, general principles are of limited value because of the highly differentiated nature of patentable innovations and inventions. While in some cases (e.g., the AIDS crisis in Africa) public interest may call for weak patents, other cases may call for broader protection of the patent holder.

A second paradox emerges when we consider more closely the issue of patenting by universities. As already argued, the university system is the prime example of a system of patronage, i.e., an alternative system to the patent system. The reason why such a system of patronage may co-exist with a patent system is that some forms of research, in particular basic research without immediate applicability, is not directly addressed by the patenting system. For example, Nelson (1959) and Arrow (1962) argue that private firms motivated by profit may severely under-invest in basic research, and hence an important role is reserved for universities and other public research organizations.² Along this line of argument, the innovation system consists of different types of actors, each of which have a particular role and derive incentives in different ways.

From such a point of view, the issue of university patenting is paradoxical because it implies that universities fall under two incentive systems that are normally seen as alternatives to each other (patronage and property rights). Why would it be necessary to provide an incentive, in the form of a patent, for research that has been financed by public money, and to which no individual person, firm or organization can hold any rights that restrict the free flow of knowledge through the economy? As argued by Mowery et al. (2001, p. 103):

“When a good is non-rivalrous in use ... [p]olicies impeding access to a scientific discovery by any party that can make use of it impose costs on that party and on the economy as a whole. Where private investors are the primary source of financial support for scientific research, as is the case with industrial R&D, granting a patent on the results of such work may be necessary in order to induce private R&D investment. But the economic theory of scientific research ... argues that patenting the results of publicly financed research is unnecessary to induce the research investment and that any restrictions on use associated with patents reduce the social returns to this public investment”.

Despite this economic logic, the already mentioned Bayh-Dole Act was passed in the USA in 1980 (Eisenberg, 1996, provides an overview of the debates surrounding the introduction of the Bayh-Dole Act). This law provides universities in the USA with the right to own patents on research that was sponsored from federal sources such as the National Research Foundation (NSF). What was the economic logic behind the introduction of this Act?

The main argument in favour of university patents is that these patents will facilitate technology transfer from universities to private firms. When university research generates knowledge that may be applied in commercial products or processes, private firms may be interested in this knowledge. But when it comes to making additional investments in order to transform the university-generated knowledge into a commercial application, the same incentive problem that was sketched above may pose itself. A firm that endeavours to undertake the additional R&D that is necessary to develop the commercial application will only consider this a useful undertaking when it has a prospect of deterring imitation by competitors.

The logic supporting the Bayh-Dole Act says that this is only warranted if the firm that develops the applied knowledge to turn the basic knowledge developed by the university into a commercial application has an exclusive right to do so. Otherwise competitors may move in and use the freely available university knowledge to develop a competing application, and this prospect is enough to discourage private investment following up university research. The only way in which the firm that develops

² On the other hand, Pavitt (1993) asks the question “what firms learn from basic research” and argues that there may be certain incentives for firms to invest in basic research.

the university knowledge may obtain exclusivity, is when the university patents its discovery, and grants an exclusive license to the firm.

Note that this argument rests on two implicit assumptions. The first is that the additional costs necessary to develop the university discovery into a commercial innovation are non-trivial. If these costs would be (very) low, simple competitive pressures might drive all firms in the industry in which the discovery can be applied to adopt it. This would be a matter of survival, and ultimately be to the benefit of the buyers (consumers) in the market. In other words, in such a case, the traditional competitive process would do its work and yield an optimal market outcome. Only in case development costs are non-trivial is the working of the competitive process ruled out because of an incentive problem (Mowery et al., 2001, p. 103).

The second implicit assumption is that the additional R&D work that is necessary to develop the university discovery cannot be patented separately, or alternatively, that there are many technical ways to develop the discovery and that a single firm cannot patent all of these. If this would not be the case, i.e., when the firm that develops the applied knowledge following up on the university discovery can apply for a patent on this knowledge, granting a patent to the applied part of the innovation only could solve the incentive problem.

These conditions may be warranted in many practical situations, which would indeed be an argument in favour of an active university patent policy on the grounds that it facilitates technology transfer to the private sector, and hence enhances welfare by means of stimulating technological progress. But surprisingly little case research exists to support the broad applicability of the argument that university patents facilitate knowledge transfer from the public to the private sector (Mowery et al., 2001, Geuna and Nesta, 2006, see also Section 6 below).

Additional arguments in favour of university patents may also be raised. Two issues that played a role in the early discussion in the 1930s in the USA, but did not re-enter the debate surrounding Bayh-Dole in the 1970s (Mowery and Sampat, 2001, pp. 384-5) are the potential 'pirating' of university discoveries, and the quality control of the application of university research. The latter of these points argues that if a university holds a patent to a discovery, it may control who develops the discovery further, and hence exclude applications with inferior quality, or unethical applications. The issue of patent 'piracy' argues that without a university patent to a discovery, opportunistic firms may move in to patent the knowledge developed originally by a university, and hence appropriate publicly financed research and limit its free applicability. Note that both these arguments imply that the university patent is licensed-out (at least potentially) in a non-exclusive way, something that runs against the above-used logic of technology transfer.

A final argument in favour of university patents is that the possibility of university patenting raises awareness of commercially useful research results in universities themselves. In the pre-Bayh-Dole era, so it is argued, many useful discoveries remained within the crochets of the ivory tower of the university, simply because the researchers who discovered them had no interest in commercial issues. Post Bayh-Dole, almost all U.S. universities have technology transfer offices (TTOs), who actively stimulate (and in many case oblige) researchers to disclose their useful discoveries so that they may be patented.

This argument is often used in combination with the financial benefits that may arise from licensing-out patented discoveries. As will be illustrated in Section 6, licensing income of some discoveries at U.S. universities is considerable. Being aware of useful knowledge by its employees thus becomes of potentially large financial value for universities. In this way, the issue of university patenting is also connected to the issue of financing of university budgets, and hence the political dimension of the issue is broadened to include aspects of government finance. While governments may consider any form of private financing of public tasks as a welcome relief to the expenditure side of their budget, the budgetary aspects of this are secondary to the main issue of this paper: the innovation system and

the role of universities in it. Hence we will only address this aspect of university patenting when it becomes relevant to the way in which universities perform their role in the innovation system.

3. Research joint ventures between universities and firms: a case of market failure?

Surprisingly, the Bayh-Dole debate has not focused much on the issue of research joint ventures (RJVs) between universities and private firms. The arguments given in favour of university patenting in the previous section all seem to assume implicitly a 'linear model' in which universities perform basic research that is an input into the more applied or experimental research that firms undertake to arrive at commercial products or services. But such a linear view has since long come under criticism (e.g., Kline and Rosenberg, 1986), and hence it may be more appropriate to consider the issue of university patenting in a context in which private firms and universities work together in a research project from the very start. This is where the theory of public-private RJVs becomes of interest.

Aghion and Tirole (1994) have suggested that the role of intellectual property rights in such public-private RJVs is crucial. They argue that in the case of joint research projects between universities and private firms, the assignment of property rights (patents) to the firm instead of the university may lead to market failure, i.e., the innovation resulting from the collaboration has a lower value than could have been the case if the university had owned the patent. Obviously, this is an additional argument in favour of Bayh-Dole-like legislation.

In the Aghion and Tirole model, a university undertakes a research project for a private firm. Both parties need to invest in the project, and the relationship between both investments and the probability of success (i.e., an innovation) is given by a concave function. Due to the uncertainty, the actual content of the innovation is non-negotiable *ex ante*. Therefore, the contract drawn up for the research project is incomplete: it specifies only the attribution of the property right (who owns the patent, the university or the firm?), the license fee that the university obtains in case the patent is assigned to the firm, and the amount of investment of the firm. As an assumption, only one of the two parties involved may own the patent resulting from the project. The model assumes profit/utility maximization by both parties.

In this setting, the pay-offs of the invention to the two parties are related to ownership. If the firm owns the invention, the university does not share in the profits from the invention. Instead, it is paid a pre-bargained fee that covers its research efforts. On the other hand, if the university owns the invention, both parties share the pay-off by means of a licensing fee levied by the university. The university and the firm bargain *ex ante* over ownership of the expected invention, taking into account these (expected) benefits. Then, the answer to the question who will own the patent depends on two factors: the relative marginal impacts of the research efforts of both parties, and the *ex ante* bargaining power of both parties. We discuss both factors in turn.

The relative marginal impacts of the research of the two parties are important because the university only has an incentive to make the maximum effort in case it owns the patent. Due to the incompleteness of the research contract, the firm does not have the means to control whether or not the university makes the maximum effort. Thus, if the university does not own the invention, its best strategy is to 'shirk', i.e., provide a minimal research effort. Such a shirking university is obviously a problem for the firm, because it will lead to a less valuable invention. If the relative marginal impact of the university's research effort is large, this becomes a serious problem, and the firm is therefore likely to leave ownership to the university.

In the formal model, Aghion and Tirole compare the pay-offs to the firm under both modes of ownership. If the firm owns the patent, it gets the full amount of pay-offs (net of the lump sum payment to the university). If the university owns the invention, the firm gets only part of the total payoff. Thus, the firm compares a shared pay-off under maximum effort by the university to the full pay-off with a 'shirking' university. Obviously, the higher the marginal impact of the university effort, the more likely it is that the first of these situations will lead to a higher pay-off for the firm. Thus, the higher

the marginal impact of the university effort, the higher the willingness of the firm to leave ownership of the invention to the university.

Bargaining power for the university also influences the assignment of the patent. For example, if the university has specific knowledge that makes it a research monopolist, the firm may have to choose between no project at all (and hence no pay-offs) and sharing pay-offs with the university. As long as the shared pay-offs are positive, the firm will then still undertake the research project and leave the patent to the university (which would be socially optimal).

A case of market failure may emerge when the university does not have strong bargaining power and the relative marginal impacts of the two parties are such that the firm is unwilling to leave the patent to the university. To see how this emerges, let us call the value of the innovation under firm ownership of the patent (i.e., minimum effort by the university) V^0 . Now assume that the extra effort that the university would be willing to make in exchange for ownership leads to an increase in the invention value equal to $\Delta > 0$. Obviously, as long as $\Delta > 0$, the social value of the innovation goes up with a transfer of the patent to the university. But, because in this case the firm only gets a share of the invention value, its private pay-off may be lower. Assume the firm gets a share σ (Aghion and Tirole assume $\sigma = 1/2$). Then, $\sigma(V^0 + \Delta) < V^0$, or $\Delta < V^0(1 - \sigma)/\sigma$ would be sufficient to withhold the firm from making the socially efficient decision to leave the patent to the university.

The extra effort of the university need not always lead to a larger value of the invention ($\Delta > 0$) because the effort of the firm is endogenous. Then, the optimal firm effort may go down as a result of increased university effort. In such a case, market failure does not take place, and the allocation of the patent to the firm is optimal.

Note that market failure only results if the university is cash constrained, which is an assumption of the model, and the firm has a large degree of bargaining power. If the university would not be cash-constrained, it would be able to pay the firm the difference $V^0 - \sigma(V^0 + \Delta)$ and still have positive pay-offs itself. Because the firm is not assumed to be cash constrained, market failure is not a possibility in case the university owns the patent (e.g., when it has high ex ante bargaining power).

Whether the strong assumption on pay-off maximizing and cash constrained universities is realistic, can be debated. As long as the firm behaves in a strictly profit-maximizing way, market failure due to a lack of university ownership of patents is a possibility. Arguably, in the framework of the Aghion and Tirole model, universities not being interested in monetary pay-offs only reinforce the possibility of market failure.

Market failure due to a lack of bargaining power on the side of universities may be solved by legislation that provides the university with this bargaining power. In this case, a law that specifies that the property rights of research in which universities (or publicly financed research institutes) are involved automatically lies with the university (or research institute) would rule out the possibility of market failure. Arguably, this is a stronger case than the Bayh-Dole Act in the U.S., or the legislation that exists on university patenting in European countries.

4. Potential negative effects of university patenting

The literature also points to potentially negative effects of increased university patenting (see e.g., Geuna & Nesta, 2006, Mowery & Sampat, 2001 for broad discussions of potential negative impacts). These disadvantages of increased university patenting can be categorized under three broad topics.

The first set of disadvantages is related to the impact that patenting has on the ‘culture of open science’. This refers to the fact that, contrary to much research that goes on in firms, scientific research usually works in an atmosphere of openness and sharing of knowledge, data, and research results. It is exactly this open nature of the scientific process that is responsible for much of its success: the devel-

opment of new knowledge flourishes because researchers build upon each other's results, cross-fertilize each other's perspectives by means of discussion of (early) research results, share data sources, etc. (Dasgupta and David, 1984).

Patents may turn this open culture into a more closed one for two reasons. First, when patents and their potential financial rewards are an important research aim, researchers may feel tempted to operate in a competitive mode, rather than the cooperative mode that characterizes the open culture of science. Second, an important aspect of patenting is the fact that any knowledge that is patented, cannot be published in any form before the application of the patent, implying that a university researcher who is interested in patenting a discovery, must keep all information related to the research project internal. Thus, when universities become more interested in patents as an output of their research, there is a danger that in the long run, the open nature of the scientific process is threatened, and hence scientific progress is hampered.

A second disadvantage of patenting lies in the potential blockade that patents may form for future research. This is especially relevant in areas where progress is to a large extent cumulative, i.e., where new results build upon old research in a strong way. A contemporary case is in the life sciences, where, for example, tools for genetic sequencing are of utmost importance for any research being undertaken in the area. Where these tools are patented, access to them will be restricted, and this will have a negative impact on scientific progress.

This is an issue that has implications beyond just university research and university patents (as is evident from discussions surrounding patents in genetic research that are owned by firms), but is especially relevant for our discussion when we realize that many university discoveries appear in basic research. Such 'basic' discoveries are more likely to have an impact on a whole range of subsequent 'applied' research topics, and thus have a strong potential for blocking such future research.

The third and final set of disadvantages is related to the strategic behaviour of universities. When patents are an increasingly important output for universities, there may be an incentive to do research in those areas where patents are easily obtained. It has been argued (e.g., Henderson et al., 1998, see also the discussion in Section 6 below) that especially applied research offers opportunities for 'quick patenting', and that universities would thus have an incentive to move away from basic research with long-run impacts (in favour of applied research with short-run impact). In other words, patenting may cause universities to behave more like firms, and hence, from an innovation systems perspective, important synergies between universities and firms would disappear.

Some of these disadvantages have been addressed in patent law and the discussion around it. With regard to the issue of research tools, many patent systems allow the use of patented knowledge in research (as opposed to commercial applications; the so-called 'research exception'), which implies that future research cannot be blocked by a patent. However, this is an exception that is in many cases weak, because the patent holder may challenge it in court (Geuna & Nesta, 2006).

A recent proposal to amend (European) patent law is to allow a 'grace period' for university researchers between the application for the patent and publication of the research (see, e.g., OECD, 2003). This means that in effect, university researchers may publish and speak about their invention in scientific circles without losing the right to patent the discovery afterwards. It may thus be possible to 'solve' some of the disadvantages to university patenting by specific parts of patent law, but this remains in many respects a solution that is inferior to the starting point of 'open science'.

5. The institutional context of university patenting in the USA and Europe

Mowery and Sampat (2001) describe how in the USA in the 1970s and 1980s, many different trends came together in the field of university-industry relations. They situate the start of these developments in the 1930s, when a first debate about university patenting emerged in the USA. During this period, U.S. universities were mainly financed from state resources, and the state governments that decided

on these resources pushed strongly for research that had an impact on local business. Hence the same questions that surrounded the introduction of the Bayh-Dole act in 1980 were debated in the 1930s.

This led many of the top-universities in the USA to adopt a university-wide patent policy in the 1930s, and to stimulate faculty to apply for patents on their discoveries. Many of these universities decided to leave the issue of the commercial management of these patents to independent third parties, which were often foundations with an explicit aim of fostering the useful and economy-wide application of university research. One of these 'patent managing' institutions was the Research Corporation, who managed patents of, e.g., the University of Wisconsin, Columbia University, MIT and Princeton (Mowery and Sampat, 2001, Table 1, p. 790).

After the Second World War, the involvement of federal financial resources in university research grew considerably. Especially the biomedical sciences attracted a lot of federal funding, mainly through the National Institute of Health. Molecular biology emerged as a field in which university research had many direct applications in medicine, and in which universities could earn significant income from licensing out their patented discoveries. More and more universities also decided to take the commercial management of their patent portfolio in their own hands, and hence institutions such as the Research Corporation became less important.

An important aspect of this process was that the federal funding of research posed important questions with regard to ownership of the rights to the research results. Funding bodies such as the NIH and NSF could legally claim rights because they (co-)financed the research, and universities could equally do so because they financed part of the research themselves, and because they employed the researchers and owned the labs in which the research was done. U.S. law did not provide an immediate and clear answer as to who held the rights to patent federally funded research. Hence the funding bodies and the universities usually engaged in complicated negotiations over these rights. First, these negotiations were taking place on a case-by-case basis, but later on so-called Institutional Patent Agreements (IPAs) were introduced by the larger funding agencies (National Science Foundation, NSF and the Department of Health, Education and Welfare, HEW).

The Bayh-Dole act was introduced in order to streamline the multiple arrangements in this field. Bayh-Dole entitled universities to patent all discoveries that resulted from federally funded research (so-called 'blanket permission'). The act was thus a great simplification of the intellectual property rights situation at universities. But as Mowery and Sampat (2001) argue, the Bayh-Dole act was not the starting point of increased university patenting in the USA. The act was a result of the desire of American universities to patent their inventions, and their efforts to do so. It facilitated the administrative procedures around university patenting, but was not the prime cause of the increase in university patents. Scientific developments in the field of biomedical research (in particular molecular biology) and the increasing role of federally funded research in this area had induced universities to patent more of their discoveries already long before the introduction of the Bayh-Dole act.

The U.S. specific issue of federal research funding does not arise to such a strong extent in the European context. Although the European Commission, which is the closest thing in Europe to a 'federal government', finances a considerable amount of scientific research at universities through its Framework Programmes, issues of intellectual property rights do not arise in this context because the European Commission does not claim rights on the outcome of the research that it finances.³

On the other hand, in some European countries, individual inventors, although they are employed by universities or public research institutes, are entitled to privately own the patents that emerge from their research in the service of the university (or public research institute) (OECD, 2003). In Europe, this is currently the case for Finland, Iceland, Italy and Sweden. In all these countries, as a result of legal arrangements, it is common for university-employed inventors to privately hold patents resulting from their work (OECD, 2003, Table 1.2, p. 26). In Switzerland, private holding of patents by univer-

³ The only country in the EU that has a federal structure, Germany, is discussed below.

sity inventors is legally possible, but less common (*ibid.*). In all other European countries included in the OECD (2003) study (Austria, Belgium, Denmark, France, Germany, Ireland, Netherlands, Norway, Poland, Spain, United Kingdom), universities generally have a right to own patents on the research that they conduct (*ibid.*). In Germany, a change of legislation implemented in 2001 gave ownership of patents to the university, while before it had belonged to university employees. Italy, on the other hand, changed the law in the other direction in 2001: whereas universities held ownership before, now employees generally own patents.

Private ownership of patents by university inventors, as found in some European countries raises specific questions with regard to the efficiency of technology transfer. As is argued in OECD (2003, p. 23), a situation in which individual researchers hold the right to their inventions may well be suboptimal, because individuals are generally less well-placed to exploit these rights than large institutions such as universities are. But exactly for this reason, university inventors may turn to firms to actually apply for the patent. In this way, because of the fact that individual inventors are first entitled to own patents from their research, such patents may relatively easily be transferred (whether formally in the patent document itself, or through some other means) to private firms, who are accustomed to dealing with patent applications.

This fits the discussion on RJVs in Section 3 above (Aghion and Tirole model) very well. When individual researchers own patents, university bargaining power in public-private RJVs is very low, and the risk of market failure as a result of a ‘wrong’ assignment of property rights becomes larger. Viewed from this perspective, the legal situation with regard to ownership of university patents in Finland, Iceland, Italy and Sweden is inefficient.

Apart from the legal possibility for universities to patent the results from their (publicly funded) research, the general awareness of universities of application-worthy research has been argued to be an issue in the European context. It was noted that in the U.S., an increased interest of universities in patenting preceded the introduction of the Bayh-Dole act, corresponding to an increased awareness of the opportunities for application of basic research in commercial innovations. Because this is seen by some influential researchers (Mowery and Sampat, 2001) as an important driving force behind public-private research interaction in the USA, it is interesting to investigate the European situation in some detail.

Unfortunately, the empirical basis for comparing awareness to commercial opportunities among university researchers in different countries, is very weak. The evidence is either anecdotal, or based on indirect indicators. The lack of patenting by European universities has been used as an indicator of the lack of general commercial awareness, for example by Michael Porter (2001, p. 37), in his ‘Innovation Lecture’ delivered at the Ministry of Economic Affairs in the Netherlands: “[u]niversities in the Netherlands have traditionally been much less commercially oriented than in the U.S., where commercial activities are more highly regarded. In the Netherlands, universities have little contact with companies, and filing patents and seeking to license technology to the private sector is not part of the culture”. Porter further presented empirical evidence that Dutch universities are not very active in patenting: on a list ranking Dutch firms and organizations with regard to the number of U.S. patents they obtained during 1996-2000, the first university (Leiden) ranked 45th, with only 13 patents. The largest U.S. university, the University of California, obtained 1558 U.S. patents during the same period.⁴

⁴ One may argue that Porter’s patent data are a bit selective. While Porter presents a ranking list of all Dutch firms/organizations, he only presents universities in the case of the USA. The USA list thus hides the rank of the universities. According to information of the US Patent and Trademark Office, in 2000 (the last year of Porter’s period), the first university is found at rank 32 (versus 45 for Leiden University in case of the Netherlands, 1996-2000). Moreover, the first U.S. university, the University of California, is in fact more a federation of universities, with campuses in all major cities in California. The next university on the U.S. list, MIT, has less than half the patents of the University of California (605), and does not rank in the top-100 in 2000.

But there are indications (e.g., Geuna & Nesta, 2006) that the (European) statistics on university-involvement in patenting are biased. The reason for this is that in many cases, university researchers are involved in the research that leads to a patent, but the university (their employer) does not appear as an applicant on the patent.⁵ This may, for example, be the case when the university researcher has a private consulting contract with a firm (which may be facilitated by legislation that gives individual researchers title to the patent resulting from their research), or when the university is involved in an RJV with a firm, and it has been (contractually) agreed that the firm will hold the intellectual property rights.

Geuna and Nesta (2006) cite evidence from Italy, Finland and Belgium that the number of university patents (in a broad sense) is severely underestimated when only patents with universities as applicants are counted.⁶ Similar evidence emerged in a case study of the French Université Louis Pasteur (ULP, Strasbourg).⁷ Comparative evidence for six European countries exists in the form of the ‘Patval’ survey (Giuri et al., 2005), which was conducted among inventors of European patents filed from the Netherlands. The survey was aimed at granted patents only (non-granted applications were excluded), with a priority date in the period 1992-1997.

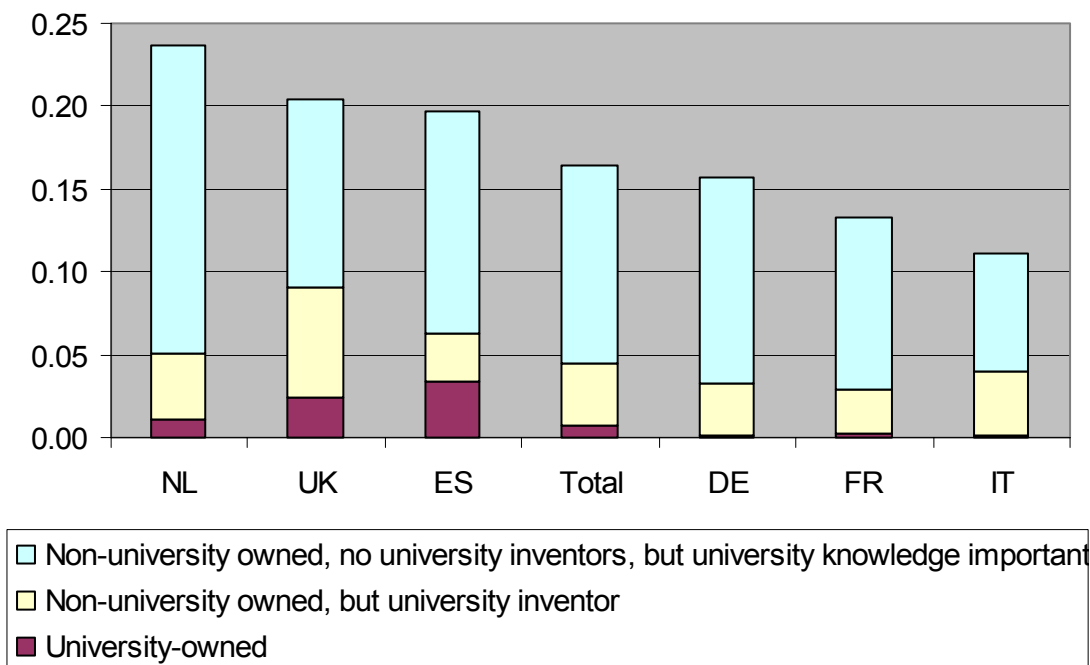


Figure 1. University patents in Europe, 1992-1997, % of all patents, various definitions of university patents

Using the ‘Patval’ data, one may distinguish two ‘types’ of university patents. The most narrow type is a patent that has a university as (one of) the applicant(s). These are the patents that would appear on Porter’s list that was referred to above. The second type of university patents are those that do not

⁵ A patent lists both the applicants (prospected owners) of the patent, and the inventors. Inventors are usually not listed with their affiliations, and there is nothing that prevents inventors from not being employed by the applicants of the patent.

⁶ The cited studies are Balconi et al. (2004) for Italy, Saragossi and van Pottelsberghe (2003) for Belgium and Meyer (2002) for Finland.

⁷ Calculations made by Patrick Llerena (ULP) show that more than half of all patents from research undertaken by university researchers at ULP in the period 1970- 2000 are owned by private parties. These data were presented officially to the French Ministry, but not yet published.

have a university applicant, but do have at least one inventor that was employed by a university. These patents (broadly) correspond to the case of the Aghion and Tirole RJV model, with the university leaving ownership of the project outcomes to the firm. Additionally, the Patval survey allows distinguishing patents in which university knowledge played an important role as an input. We define the latter as those patents in which the inventor ranked university knowledge as “important” or “very important” for the patent.

Figure 1 displays the share of these three types of patents in the total sample of patents in the Patval survey, for the Netherlands (NL, United Kingdom (UK), Spain (ES), Germany (DE), France (FR) and Italy (IT), as well as the (weighted) average for these six countries (Total). Note that the category are additive, i.e., a patent can never fall into more than one category, and will be categorized in the ‘first’ category that it fits in (i.e., first as university-owned patents, then as patents with a university inventor, and finally as patents in which university knowledge is important).

In terms of the total of the three categories, the countries differ substantially, with the Netherlands leading with a percentage that is about twice as large as the country with the lowest value, Italy. In all the countries, the fraction of patents in which universities are involved actively (i.e., the first two categories) is small compared to the third category. This may indeed point to low commercial awareness of university researchers, but unfortunately, no reference material exists to make a comparison with, for example, the U.S.

The figure also confirms the impression (Geuna and Nesta, 2006) that statistics with regard to university-ownership of patents under-estimate university-involvement. In all countries, patents in which university inventors are involved but which are not owned by the university, form a substantial (compared to university-ownership) category. Only in Spain is the fraction of university-owned patents larger than the fraction of non-owned, but university-inventor-involved patents. In Germany, France and Italy, university-owned patents are a very minor fraction of the total ($< 0.8\%$)⁸, but the fraction of non-owned, university-inventor-involved patents is larger than 2.5% in all three cases.

Thus, the Patval data point out that at least in Europe (we have no comparable data for the U.S.), universities are more often involved in patenting as a result of some kind of cooperative work with the private sector (indicated by non-university ownership of the patent), than by patenting results from their independent research. This suggests that the type of market-failure that has been pointed by Aghion and Tirole in the context of public-private RJVs may be an important phenomenon, although this has been largely overlooked until now in the discussion on university patents.

In conclusion, the institutional context in the U.S. and Europe with regard to patenting of university inventions is quite different. Issues with regard to federal sponsoring of research do not arise as strongly in Europe as in the U.S. On the other hand, Europe may have its ‘own’ issue in university patenting in the form of potential market failure in public-private RJVs. This implies that arguments from the U.S. debate may not be readily transferable to the European discussion.

6. The effects of Bayh-Dole – an empirical assessment

Although patenting by U.S. universities was already on the rise before the Bayh-Dole act (1980), the data show an acceleration after 1980, both in terms of the total number of university patents and university patents as a percentage of total domestic U.S. patents. This is evident from Figure 2, which summarizes the trends in U.S. university patenting over the period 1969 – 2000. Towards the end of the period, university patenting comprises around 2% of total patenting in the U.S. Comparing this percentage to the data in Figure 1, European university patenting as a % of all patents does not seem

⁸ Interestingly, only in Germany can this low fraction be explained by the legislation that gives private researchers the right to own patents. At the time to which the Patval survey refers, such legislation was effective in Germany, but not yet in Italy.

to be much below the U.S. numbers, if the non-university owned patents with university inventors are included in definition of university patents (but we have no data on this phenomenon for the U.S.).

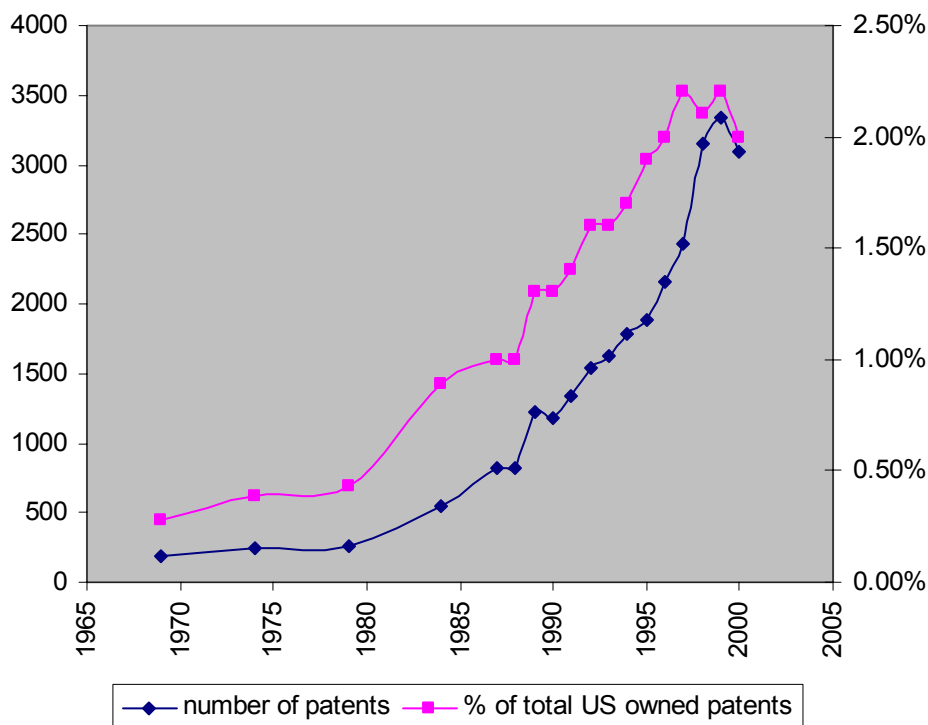


Figure 2. Patenting by U.S. universities, total number of university patents and university patents as a % of all domestic U.S. patents (source: USPTO and Mowery et al., 2001)

The topic of U.S. universities patenting after the Bayh-Dole act has attracted relatively much recent empirical research. Two results stand out in the descriptive statistics: the large share of a limited number of technology fields in total university patenting, and the fact that a small share of patents is responsible for a large share of the total licensing income (and a large share of patents yields only very low licensing income).

Henderson and Trajtenberg (1998) find that at the end of the 1980s, drugs and medicines is the largest field in which U.S. universities patent (around 35% of all university patents). Chemicals (20-25%), electronics (20-25%) and mechanical technologies (10-15%) are the next largest fields. Compared to the total sample of patents, this implies a strong over-representation of medical technology, and an under-representation of mechanical technology. Relatively little work has been done on the explanation of this finding, but it seems likely that the major explanatory factor is the fact that medical technology is a field in which the science base is very strong, as a result of recent scientific advances in, among others, molecular biology.

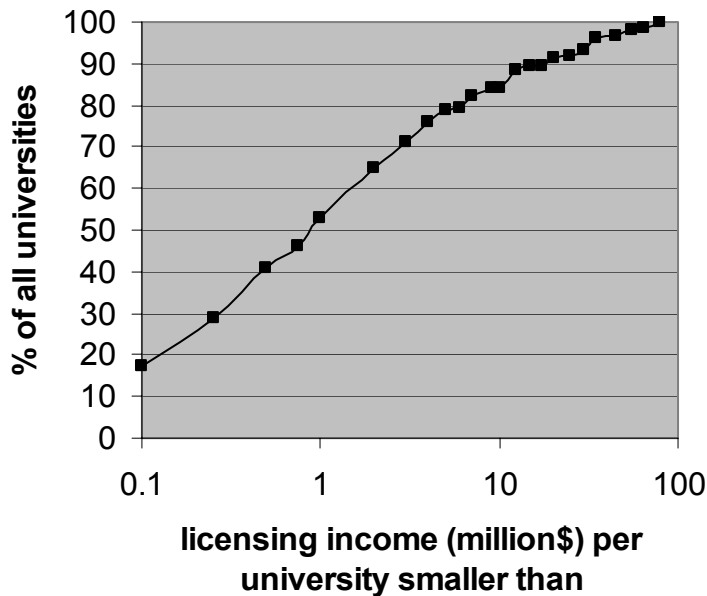


Figure 3. The (cumulative) distribution of licensing income over U.S. universities, 2002 (source: AUTM, 2002)

The second finding that stands out from the descriptive statistics on U.S. university patenting is the fact that the majority of patents generates only comparatively little licensing income, while there is a small number of patents that is responsible for the bulk of licensing income. Figure 3 displays the distribution of licensing income in 2002 over 150 U.S. universities. The figure shows that roughly half of all universities has licensing income below 1 million US\$ (per year). Only about 10% of universities has licensing income above 10 million US\$.

The same skewed distribution is found at the level of individual patents. Mowery et al. (2001) present data for Columbia University, Stanford University and the University of California. Their most recent data are for 1995, and in this year, the top-5 patents in terms of licensing income were responsible for 94%, 85% and 66% of gross total income (respectively for Columbia, Stanford and the University of California, Mowery et al, Table 2, p. 107). All three of these universities are at the top of the list of big earners: their total gross licensing income in 1995 was 32 million, 36 million and 59 million (respectively, with the same order of universities), which implies that the top patents of these universities are indeed responsible for a very large share of total licensing income at U.S. universities.

Together, these findings show that only a few universities can be expected to ‘get rich’ from selling their patents to the private sector. Without a medical school, the chances of hitting the license jackpot are low, and even in medical research, there are few opportunities for discovering ‘cash-cow’ patents. Overall, it cannot be expected that licensing income will soon become a major source of income for universities, whether in the U.S. or in Europe.

A different part of the research following the introduction of the Bayh-Dole act has focused on the ‘basicness’ of university patents. Henderson and Trajtenberg (1998) proposed to use patent citations as a yardstick for the basicness of patents. In Trajtenberg et al. (1997), it had been shown that university patents have quite different citation profiles than corporate patents. Specifically, university patents seem to be cited more often, especially so by others than the original inventor, and university patents seem to be cited in more distinct technology fields than corporate patents.

Henderson and Trajtenberg (1998) investigate the change in these citation measures over time, and conclude “that the relative importance and generality of university patents has fallen at the same time

as the sheer number of university patents has increased. This decrease appears to be largely the result of a very rapid increase in the number of ‘low-quality’ patents being granted to universities” (p. 126). This finding would seem to indicate that with the rise in university patenting following the introduction of the Bayh-Dole act, universities have shifted their research more in the direction of low-impact, possibly more applied, research. In other words, university patents are becoming more and more like corporate patents, possibly as the result of a tendency to focus on research that is easier to patent.

However, in a series of patents, Mowery et al. (2002), Mowery and Ziedonis (2002) and Sampat et al. (2003) qualified the conclusions of Henderson and Trajtenberg (1998). Mowery and Ziedonis (2002) investigate citation patterns of individual universities. They conclude that for two important cases, Stanford and the University of California, no significant changes in the ‘basicness’ of patents were observed after 1980. The fall in ‘basicness’ observed by Henderson and Trajtenberg is addressed to the effect of universities who started to patent after 1980. It is argued that these ‘entrants’ have lower patent ‘quality’. Mowery et al. (2002) further find that the patent ‘quality’ of these entrants improved during the late 1980s and 1990s. Finally, Sampat et al. (2003) find that when a longer stream of citations is used, no significant decline in ‘basicness’ of university patents can be observed.

In summary, it can be concluded that the evidence with regard to a shift of university patents to more ‘applied’ research is mixed. The more recent evidence (based on the most advanced methods and most recent data) seems to suggest that such a shift did not happen, or at best was due to the fact that the universities that started to patent after Bayh-Dole, produced more ‘applied’ patents than the universities who were already engaged in patenting before Bayh-Dole.

Although the statistical analysis of patenting data can reveal much about the impact of Bayh-Dole, the perhaps most crucial question, i.e., whether or not the increased level of university patenting has led to more efficient technology transfer from universities to the private sector, remains to an important extent outside the realm of patent data. This broad question has been addressed from multiple perspectives, ranging from case studies of individual discoveries or universities, to large-scale surveys among university researchers.

At the end of this spectrum covering the case studies, Colyvas et al. (2002) study 11 university discoveries, made at Stanford or Columbia. The cases are spread over a number of technology fields, and, most importantly, can be divided into the two categories “useable without further development Yes/No”. This means that an important aspect of the invention that was stressed in Section 2 above is controlled for. It was argued there that patents do not seem to be necessary, and in fact may hinder knowledge diffusion, in cases where a university discovery can be used without much further development by the private sector. Seven of the case studies by Colyvas et al. (2002) required further development by the private sector (so-called ‘embryonic inventions’), four did not (so-called ‘off the shelf inventions’).

In line with the discussion in Section 2, Colyvas et al. conclude “that intellectual property rights are likely to be most important for embryonic inventions, and unimportant for inventions that are useful to industry ‘off the shelf’. For the inventions ... that were licensed nonexclusively, patents allowed the universities to collect revenues, but did nothing to facilitate technology transfer” (p. 67). This conclusion re-iterates the point stressed in Section 2 that a general policy of strong patents for university research will not fit all research projects, and may hinder knowledge diffusion in some cases just as well as it may facilitate technology transfer in other cases.

A different research methodology has been used in studies by Cohen et al. (1998), Cohen et al. (2002) and Agrawal and Henderson (2002). These studies employ various data sources to assess the relative importance of various channels of technology transfer from universities to firms. Agrawal and Henderson (2002) focus on MIT, and collect publication and patent data, and conduct interviews with MIT faculty members. Their results show that MIT faculty sees patents as a relatively unimportant aspect of their research, and publications in high-ranking journals are the preferred research output type.

The interviews with MIT staff identify consulting activities as the most important source of knowledge transfer, followed by publications, the recruitment of graduates, and collaborative research. Patents and licenses rank low as important means of knowledge transfer (Agrawal & Henderson, 2002, Figure 5, p. 52). An analysis of collaborative publishing between MIT faculty and researchers employed in the private sector, and an analysis of citations of MIT papers and patents, reveals that there is only a small overlap between firms that cite papers or patents, and firms who collaborate on papers or patents. This implies that the firms for whom patents are an important form of knowledge transfer, are quite different firms than those for whom publication is an important source. Thus, focusing on patents as the sole source of knowledge transfer will reveal a biased picture. Hence, Agrawal and Henderson (2002, p. 45) conclude “that patenting may play a relatively small role in the transfer of knowledge out of the university”.

A much similar conclusion is reached in the papers by Cohen et al. (1998) and Cohen et al. (2002) that make use of the Carnegie Mellon Survey on Industrial R&D. This survey is undertaken at the ‘demand side’ of public-private knowledge transfer, i.e., R&D managers in the private sector. The results of this survey underline that the impact of university research on business innovation is highly different between economic sectors, and that the ways in which this impact is realized again differs between sectors. As in the research by Agrawal and Henderson, patents emerge as a relatively unimportant source of knowledge transfer. Publications, meetings & conferences, informal interaction and consulting all rank as clearly more important mechanisms than patents. The results also show that large firms are more likely to use the results of public research in their own R&D projects.

A last type of analysis aimed at directly assessing the intensity of technology transfer from universities to private firms deals with the possibility of market failure in RJVs (as in the Aghion and Tirole model). This has been addressed by Crespi et al. (2006), who use the Patval data of Figure 1 above to assess whether university-owned patents resulting from university-firm RJVs are more often applied, or are more valuable, than privately owned patents resulting from these RJVs. They apply various matched sampling techniques, but always conclude that university-owned patents do not differ significantly from privately-owned patents. Hence they conclude that there is no evidence for market failure in European public-private RJVs.

Summarizing, the studies that have addressed directly the question whether university patenting has fostered knowledge transfer from the public to the private sector, tend to show that patenting is one of the potential sources of knowledge transfer, but other sources as probably more important.

7. Conclusions and discussion

The European Commission has put increased emphasis on public-private research interaction in its strategic policy for Europe’s role in the ‘knowledge economy’. Observing what happened in the USA, the economic and technological leader of the world, suggests that university patenting may play an important role in this interaction process. The U.S. adopted legislation (the so-called Bayh-Dole act) that allows universities to patent the results from federally funded research. At the introduction of the Bayh-Dole act in 1980, it was believed that university patents would facilitate technology transfer to the private sector because firms interested in developing university discoveries into commercial innovations could now obtain the exclusive right to do so (by taking an exclusive license from the university).

Following suggestions in the policy debate, this paper asked the question whether it would be beneficial for the European innovation system if there would be a ‘European Bayh-Dole act’. This question is rooted in the general (policy) awareness that public-private research interaction is relatively weak in Europe, and that university patents may stimulate this, by facilitating institutional arrangements for knowledge transfer as well as by increasing the awareness of European universities for the commercial potential of some of their research.

Intellectual property rights are a rather special and difficult policy field. The patent system, both in a broad sense (where issues of patent scope are important) and in the specific sense of university patenting, is a system that must strike a balance in a tradeoff between granting rights (and thus incentives) to an inventor, and leaving enough scope for positive benefits (technology spillovers) to society at large. Obviously, stronger patents are not always better. Because it is not always easy to identify on which side of the optimal tradeoff the current situation lies, it is difficult for policy makers to design an optimal policy. This holds *a fortiori* for the topic of university patents. The issue of whether university patents facilitate technology transfer is hard to investigate in a quantitative way, and it is again likely that the answer differs on a case-to-case basis. The potential disadvantages of university patents are equally difficult to quantify. We are thus left with the impression of a policy field in which ‘muddling-through’ is the way in which policy must proceed: any decisions are necessarily based on incomplete information, and will be hard to evaluate. This does not imply that no policies should be made, or that existing policies should not be changed. On the contrary, it implies that policy makers must be like entrepreneurs, ready to implement new ideas, willing to take the risk of failure, and able to admit when this has happened.

In line with this, the debate cannot easily be concluded at a theoretical level. Arguments against and in favour of increased university patenting both exist. On the ‘positive’ side of the scales is the potential beneficial impact on technology transfer. On the negative side, several arguments can be raised: the danger to the ‘open culture of science’, a potential incentive for universities to perform more applied (less ‘basic’) research (to become more like firms), and the potential of ‘strategic’ patents to block future progress in an area.

At the institutional level, it was noticed that the European innovation system is quite different from the U.S. one. In the U.S. the specific issue of federal funding provided the context for the Bayh-Dole Act, and this issue is largely absent from the European context. On the other hand, in some of the European countries, individual university researchers are entitled to the patents emerging from their (university-funded) research, which leads to a lack of bargaining power of universities in these countries in negotiations over ownership of their inventions. More specifically, it was argued on the basis of empirical survey evidence that in Europe, research joint ventures (RJVs) between universities and private parties are relatively frequent. This is indicated by the fact that patents in which university researchers are listed as inventor, but in which the university is not the owner of the paper, are more common in Europe than patents in which the university is the owner.

In the case of such public-private RJVs, there is a risk of market failure, as indicated by the theoretical model introduced by Aghion and Tirole (1994). A lack of bargaining power of universities with regard to the ownership of patents may lead to lack of university commitment in joint projects with firms, and this may lead to less valuable innovations. Such market failure is asymmetric: it may exist if private parties own the patent from a public-private RJV, but not if the university owns the patent. Given the European context in which such public-private RJVs seem plentiful, this may amount to a strong argument in favour of legislation that facilitates universities to own patents from their research, but whether or not such market failure actually exists is an empirical matter (the little available evidence seems to point out that it does not).

More broadly, the empirical research again arrives at mixed results with regard to the potential of increased university patenting. On the one hand, there does not seem to be convincing evidence that universities change their research strategy, and hence one of the potential dangers of university patents does not seem to have happened in the post-Bayh-Dole-era in the USA. But on the other hand, the evidence that patents actually facilitate knowledge transfer is mixed, and patents appear to be a relatively unimportant source of knowledge transfer. The effects of patents on the open culture of science is still ill-researched area, although some evidence on ‘data-withholding’ exists (Campbell et al., 2000).

We may thus conclude that the theoretical debate and the empirical research that is related to it, does not give us a clear-cut conclusion. A prudent policymaker may conclude that as long as the benefits of increased university patents are not clearly demonstrated, a policy effort like Bayh-Dole is undesirable. But the data suggest that European universities are already more heavily engaged in patenting than was believed on the basis of official patent statistics. This implies that the discussion about European university patents may to an important extent be outmoded. More knowledge may be flowing from European universities to the private sector than policymakers are aware of. But it may also be the case that the negative effects of university patenting, such as a negative impact on the open culture of science, may already be a reality in the European university system.

More research on the links between university researchers and the private sector is necessary to further enlighten these issues. In this respect, two lines of research might prove particularly useful. Firstly, the study of individual cases of successful and unsuccessful cases of technology transfer may highlight the factors that may play a role in this process. Case studies would be particularly helpful in this respect, and they might lead the way for subsequent surveys aimed at reaching more representative results.

Second, a closer study of the networks in which university researchers are embedded may enlighten the different mechanisms of technology transfer between the public and private sector. University researchers use firms as the subject of their study, they supervise undergraduate and graduate students who do practical work in firms, they do consultancy, they visit conference and workshops at which businesses are also represented, etc. In short, the university researcher operates in a network, in which firms are one important other type of player. More knowledge about the nature of these networks, and the role that university researchers play in them would be valuable for the study of public-private knowledge transfer. Both quantitative data (at the micro-level), such as publications and citations, and more qualitative data on network relations may be helpful in painting a more complete picture of this network.

One issue remains, and this is the role of patents as a source of finance for universities. When universities patent their discoveries, and license them to firms, license income may become an important source of finance. In an era when governments budgets are squeezed, especially so in higher education, this may be a welcome prospect for both university officials and government policymakers (European Commission, 2003, p. 13). However, the available evidence shows that the payoffs are so hugely varying between inventions, that it can hardly be imagined that licensing income is a stable source of finance for universities. In the U.S. context, half of all universities has less than 1 million US\$ licensing income per year (which is a relatively small amount, even when compared to the budget of an average European university). Moreover, only a few patents are responsible for the majority share of licensing income, suggesting that this source of finance has important characteristics that are similar to a lottery.

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