



# Recognising the value of business patents with university inventors

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EUR 23761 EN - 2009

European Commission  
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JRC 51645

EUR 23761 EN

ISSN 1018-5593

Luxembourg: Office for Official Publications of the European Communities

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**Joaquín M. Azagra-Caro**

## Background

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This work was initially a report for Directorate-General for Research. The Institute for Prospective Technological Studies (IPTS) is one of the seven institutes of the European Commission's Joint Research Centre (JRC). ERAWATCH is a long-term initiative jointly carried out by the Directorates-General for Research and JRC - IPTS. The ERAWATCH Intelligence service aims to provide regular and ongoing analyses of issues relevant to research policy-making.

## Executive summary

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Support to university patent ownership is a popular R&D policy initiative to promote effective knowledge sharing. Yet the broader, unintentional, consequences of such support on the link between public funding of university R&D and increased university-industry cooperation have not been studied. Through regression models on the determinants of university-owned patents in the EU and US, tentative results illustrate that the risk of negative consequences exists. Complementing current metrics about university performance with statistics about business patents with university inventors would help avoid such a risk and find definitive quantitative evidence.

## Acknowledgements

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To Xabier Goenaga and René van Bavel for their contributions to raise the quality of the work. To Denis Dambois and Jan Larosse for their careful revision of the paper. To Elena Castro for inspiring discussion. To Sachi Hatakenaka and Paul Cunningham for their exhaustive revision and detailed comments.

## Introduction: the extent of the promotion of university-owned patents and their use for indicators of university activities

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Universities apply for different forms of intellectual property right (IPR) protection, like patents, and obtain their ownership according to the respective national regulations. The trend for universities to apply for patents has been increasing in the European Union (EU) for the last thirty years, popularising their use to build indicators about the technological production of universities and their potential contribution to industrial applications.

Current opinion recognises that owning IPR and – more concretely – patents, is an important asset for sharing knowledge between universities and industry<sup>1</sup>. Patent ownership (as a precondition for licenses) is one of the criteria advocated for further justifying the allocation of funding for universities in addition to other, traditional, criteria such as teaching output, publications and research grant income generated.<sup>2</sup>

The issue of how to manage intellectual property rights (IPR) once university research produces patentable results is a matter of debate. Some suggested measures are the harmonisation of national legal frameworks regarding the litigation system, grace period, joint ownership regime, research exception, etc.<sup>3</sup> In some countries, this strategy is even linked to national key challenges for R&D and growth. For instance, this is how Germany justified abolishing professors' privilege to use the results of R&D for patent applications and establishing agencies, located in universities, for utilising patents.<sup>4</sup> The same applies to Denmark in 1999 with the passage of the Act of Inventions at Public Research Institutions.<sup>5</sup>

Therefore, university patent ownership has received support in the form of merit valuation in researchers' CVs (for example, exploited patents count for the improvement of salary conditions in Spain<sup>6</sup>), monetary incentives (revenue sharing between the institution and the researcher) or managerial advances (knowledge transfer offices often justify their mission showing patent counts as one of their outputs).

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<sup>1</sup> Commission Green Paper 'The European Research Area: New Perspectives', COM(2007) 161, p.16.

<sup>2</sup> Commission communication 'Delivering on the modernisation agenda for universities: education, research and innovation', COM(2006) 208, p.7-8.

<sup>3</sup> Commission Green Paper 'The European Research Area: New Perspectives', COM(2007) 161, p.17.

<sup>4</sup> ERAWATCH Research Inventory: Germany

<http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=24&parentID=624&countryCode=DE&UUID=26F3D32F-9352-6F34-89BCF14243F5D7E5&hwd=patent>, last access: 12/08/2008.

<sup>5</sup> ERAWATCH Research Inventory: Denmark

<http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=49&parentID=44&countryCode=DK&UUID=26EAF9CA-089F-899A-CB0BE83C35A2F0E3&hwd=patent>, last access: 12/08/2008.

<sup>6</sup> Spanish Official Bulletin, 'Resolución de 11 de noviembre de 2008, de la Presidencia de la Comisión Nacional Evaluadora de la Actividad Investigadora, por la que se establecen los criterios específicos en cada uno de los campos de evaluación', BOE 282: p. 46906-46913.

<http://www.boe.es/boe/dias/2008/11/22/pdfs/A46906-46914.pdf>, last access: 09/01/2009.

One reason for this support is the assumption that, by owning IPR, universities may play a bigger role in innovation and economic development (through, e.g. the creation of spinoffs. In the current policy context, the ownership of IPR by universities is the result of effective knowledge sharing, i.e. university-industry cooperation in the form of shared principles for knowledge transfer<sup>7</sup>. Nevertheless, there is no single policy objective regarding university-industry cooperation. Actually, university-industry cooperation lies behind the objective of ‘strengthening research institutions’<sup>8</sup>, which prompts the question, does university-industry cooperation towards ‘strengthening research institutions’ also lead to university patent ownership?

An intuitive reaction would give a positive reply, but there are some reasons to argue the opposite. In the next sections we disentangle what university-industry cooperation represents for the objective of ‘strengthening research institutions’ and present the reasons why (and some evidence that) it may not be always compatible with the objective of ‘effective knowledge sharing’ through university patent ownership.

## ‘Strengthening research institutions’

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Universities are increasingly being encouraged to recognise that their relationship with the business community is of strategic importance and forms part of their commitment to serving the public interest.<sup>9</sup> If research institutions in Europe are to become stronger, public-private cooperation should take the form of routine interaction and durable partnerships between research institutions, notably universities, and the world of business<sup>10</sup>. This interaction will strengthen research institutions in at least two ways: they will allow universities to cope with different sources of funding and they will encourage their performance. Table 1 sums-up these objectives and advances some possible measures, in order to facilitate the reading of the document. More in-depth explanations follow.

Strong research institutions will forge sufficient links with business and society, adapting to the intensified competition for funding<sup>11</sup>. An indicator of progress could be the composition of university R&D by source of funding<sup>12</sup>. When looking at university-industry cooperation, *the proportion of business funding of university R&D over total university expenditure on R&D* appears to be an adequate indicator.

In second place, strong research institutions need to forge innovative public-private partnerships, which link public funding to output and performance, (labelled ‘encouraging performance’ here)<sup>13</sup>. An indicator of progress should measure the success of such

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<sup>7</sup> Commission Green Paper ‘The European Research Area: New Perspectives’, COM(2007) 161, p.8.

<sup>8</sup> Commission Green Paper ‘The European Research Area: New Perspectives’, COM(2007) 161, p.8.

<sup>9</sup> Commission communication ‘Delivering on the modernisation agenda for universities: education, research and innovation’, COM(2006) 208.

<sup>10</sup> Commission Green Paper ‘The European Research Area: New Perspectives’, COM(2007) 161, p.8.

<sup>11</sup> Commission Green Paper ‘The European Research Area: New Perspectives’, COM(2007) 161, p.14.

<sup>12</sup> EC, 2008. A more research-intensive and integrated European Research Area: Science, Technology and Competitiveness key figures report 2008/2009. Belgium: European Commission, p. 96-97.

<sup>13</sup> Commission Green Paper ‘The European Research Area: New Perspectives’, COM(2007) 161, p.15.

collaboration. A possible candidate, the proportion of business funding of university R&D over total university R&D, is insufficient for that. Instead, *the proportion of business patents with university inventors over total business patents* is an interesting alternative. A business patent with university inventors indicates that the collaboration has been successful enough for the firm to engage into the further cost of protecting the results, as well as the fact (recognised by law) that the collaboration has produced an invention of potential industrial application.

Table 1. Policy sub-objectives of ‘strengthening research institutions’ linked to university-industry cooperation

Sub-objective	Definition	Possible measure
Coping with diversification of funding	Improving the compatibility of the diversification of sources of funding for universities (especially increasing business funding) with the maintenance of academic output and its orientation towards more technological applications	Proportion of business funding of university R&D over total university expenditure on R&D
Encouraging performance	Increasing the actual incorporation of university knowledge into business technology	Proportion of business patents with university inventors over total business patents

Business funding of university R&D, which this work used as a measure of the objective of ‘coping with diversification of funding’, can partly capture this collaboration, and therefore there is an overlap with the objective of ‘encouraging performance’. However, business patents with university inventors can be the result of joint research without business funding of university R&D, for instance when a public programme funds both the university and the firm. Moreover, joint research may not lead to business patents with university inventors but to other types of outputs, not to say that it may be unsuccessful.

Hence, business patents with university inventors measure a particular type of university-industry cooperation – one that accounts for the *actual incorporation of university knowledge into business technology* better than business funding of university R&D.

## Advantages and disadvantages of the objectives of ‘coping with diversification of funding’ and ‘encouraging performance’ for university patent ownership at aggregate level, with an empirical test

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Some policy documents argue that there is complementarity between several objectives regarding knowledge transfer, including those related to the promotion of university patent ownership<sup>14</sup>. In this section, we try to find the grounds, together with possible caveats that would justify some debate<sup>15</sup>, and present some empirical evidence. Table 2 supplements the reasons given in the main body text, without aiming at being exhaustive.

Structured partnerships with the business community bring opportunities to improve “the sharing of research results, IPR, patents and licenses”<sup>16</sup>. Therefore, the sub-objective ‘coping with diversification of funding’ should have a positive impact on university patent ownership. One assumption is that private involvement in university R&D may increase the number of patents owned by universities<sup>17</sup>. For instance, the 2006 collaborative research initiative in Latvia aims at fostering private R&D funds and university owned patents simultaneously since ‘the selection criteria [for universities to be eligible for funding] include the level of experience of the research organisations in the commercialisation of their research results’.<sup>18</sup> The determinants of ‘commercialisation’ in this initiative are the ‘number of patent applications, the amount of funding attracted from the private sector, [and] the number of co-operation agreements’.<sup>19</sup> Another assumption is that the cultural differences between the business and the science communities hinder efficient knowledge transfer. Actually, member states may consider it necessary to act simultaneously on both,

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<sup>14</sup> For instance, the Commission Green Paper ‘The European Research Area: New Perspectives’, COM(2007) 161 finds complementarity between ‘strengthening research institutions’ and ‘effective knowledge sharing’. The Commission communication ‘Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation’, COM(2007) finds complementarity between ‘creating the conditions for successful knowledge transfer’ and ‘promoting an entrepreneurial mindset’. The Commission recommendation ‘on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations’, COM(2008) 1329 finds complementarity between ‘developing knowledge transfer policy’ and collaborative and contract research, etc.

<sup>15</sup> Such debate has been very vivid in the academic world. As a few examples, take:

Geuna, A., Nesta, L.J., 2006. University patenting and its effects on academic research: The emerging European evidence. *Research Policy* 35: 790-807.

Mowery, D. C., Nelson, R. R., Sampat, B. N., Ziedonis, A. A., 2001. The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole Act of 1980. *Research Policy* 30: 99-119.

Rappert, B., Webster, A., Charles, D., 1999. Making sense of diversity and reluctance: academic-industrial relations and intellectual property. *Research Policy* 28: 873-890.

<sup>16</sup> Commission communication ‘Delivering on the modernisation agenda for universities: education, research and innovation’, COM(2006) 208, p.6.

<sup>17</sup> Commission communication ‘Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation’, COM(2007) 182, p.4.

<sup>18</sup> ERAWATCH Research Inventory: Latvia

<http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=59&parentID=329&countryCode=LV&UUID=3E071F4D-BCDC-BBA0-DE984326D2D746BB&hwd=patent>, last access: 12/08/2008.

<sup>19</sup> Op. cit.

e.g. the Greek Patent Office has reduced patenting and search fees, and is trying to raise awareness among public researchers and private firms about the benefits of patenting.<sup>20</sup>

Table 2. Selected types of expected impact of ‘coping with diversification of funding’ and ‘encouraging performance’ on university patent ownership

Sub-objective	Reasons for a positive impact on university patent ownership	Reasons for a negative impact on university patent ownership
Coping with diversification of funding	<p>(i) Possibility of extending protection from a national patent office to an international patent office through the addition of a business firm in the international co-application<sup>21</sup>, even in the absence of scientific knowledge exchange</p> <p>(ii) Chance to learn about specific technological content/issues, application potential of various technologies and IPR management models, typically from the private sector, which universities will use to claim ownership of the research results from publicly-funded projects (subject to the existence of national legislation which permits it)</p>	Business funding of university R&D results in business patents with university inventors or in results not protected by patents
Encouraging performance	<p>(i) Virtuous circle of high quality research that promotes synergies between university-owned patents and business patents with university inventors</p> <p>(ii) Universities and countries may be able to have some research groups specialised in university-owned patents and some others in business patents with university inventors</p>	If the incentive for participating in inventions patented by firms is high, university researchers will devote less of their limited amount of time and resources to research leading to university-owned patents

However, the objective of ‘coping with diversification of funding’ rarely discusses the mechanisms through which private involvement in university R&D results in university-owned patents. In the US case, it is true that MIT owns almost all of its inventions and

<sup>20</sup> ERAWATCH Research Inventory: Greece

<http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=15&parentID=12&countryCode=G&R&UUID=26EBDE7D-C488-52FA-7C26D8051A70BA08&hwd=patent>, last access: 12/08/2008.

<sup>21</sup> European Commission, 2008: ‘CREST report: Intellectual property: Cross-border collaboration between publicly funded research organisations and industry and technology transfer training’. EUR 20796.

many other US universities manage to do the same. However, many European universities have found it difficult to negotiate IPR ownership for contracted activities. An exception is the UK, where Lamberts model contracts were drawn up specifically for this reason to guide universities and industry (including model agreements in which universities are to own IPR). Overall, at aggregate level, what happens at individual universities or even countries is not determining. Certainly, business funding may have indirect, positive, effects on the university, for instance those reported in Table 2.

Some evidence to verify whether the objective of 'coping with diversification of funding' complements university-owned patents at aggregate level is therefore welcome to better tailor policies in this area.

The following evidence presents the results of estimating the impact of a measure of the objective of 'coping with diversification of funding' on the production of university-owned patents in the 27 EU Member States plus the United States (US).

We measure the objective of 'coping with diversification of funding' through business funding of R&D. The estimated impact takes into account differences across countries in terms of the scale of university R&D and other inventive inputs. Details on the data and methodology appear in the annex.

In Figure 1, the blue line represents the impact of an increase in the variable used to measure the objective of 'coping with diversification of funding', i.e. the percentage of business funding of university R&D over total university R&D expenditure: the higher this share, the greater the number of patents owned by universities. University patent ownership and the objective of 'coping with diversification of funding' supported by university-industry cooperation are therefore complementary.

The expectation of a positive impact of the sub-objective of 'encouraging performance' on university patent ownership relies on the idea that public-private research partnerships and excellent research can take place simultaneously through instruments such as the EU R&D Framework Programme<sup>22</sup>. Further increasing complementarity would be desirable in order to overcome the perception that industry has not developed sufficient absorptive capacity to harness the potential of university-based research.<sup>23</sup> Actually, many pleas for the benefits of improving internal IP (and IP transfer) policies at universities come with objectives to enhance joint research resulting in business patents with university inventors<sup>24</sup>.

In theory, both goals may occur simultaneously, since universities or countries should be able to organise their researchers to achieve them at the same time, and policy documents suggest it is possible. At individual level, though, some reasons indicate the opposite: for researchers, the time devoted to the generation of inventions that will lead to a university-owned patent is time that could equally be spent on joint research that could lead to a business patent with university inventors, and vice versa. Do countries overcome this individual trade-off effectively at aggregate level?

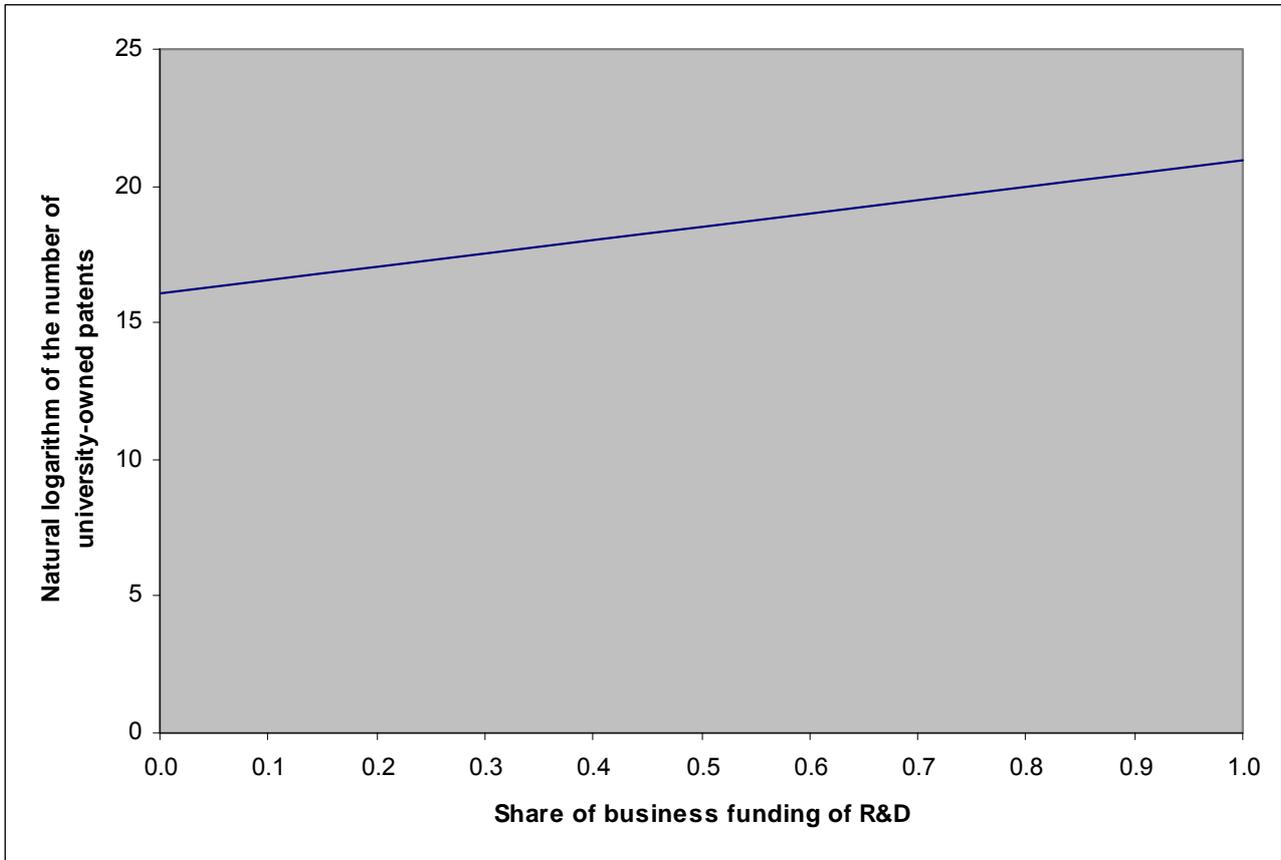
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<sup>22</sup> Commission Green Paper 'The European Research Area: New Perspectives', COM(2007) 161, p.14.

<sup>23</sup> Commission communication 'Delivering on the modernisation agenda for universities: education, research and innovation', COM(2006) 208.

<sup>24</sup> Commission recommendation 'on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations', COM(2008) 1329, p.5.

Figure 1. The impact of the objective of ‘coping with diversification of funding’ (measured through business funding of R&D) in the production of university-owned patents in the EU and US



Again, some aggregate evidence to determine whether the objective of ‘encouraging performance’ complements university-owned patents would therefore be welcome to better tailor policies in this area.

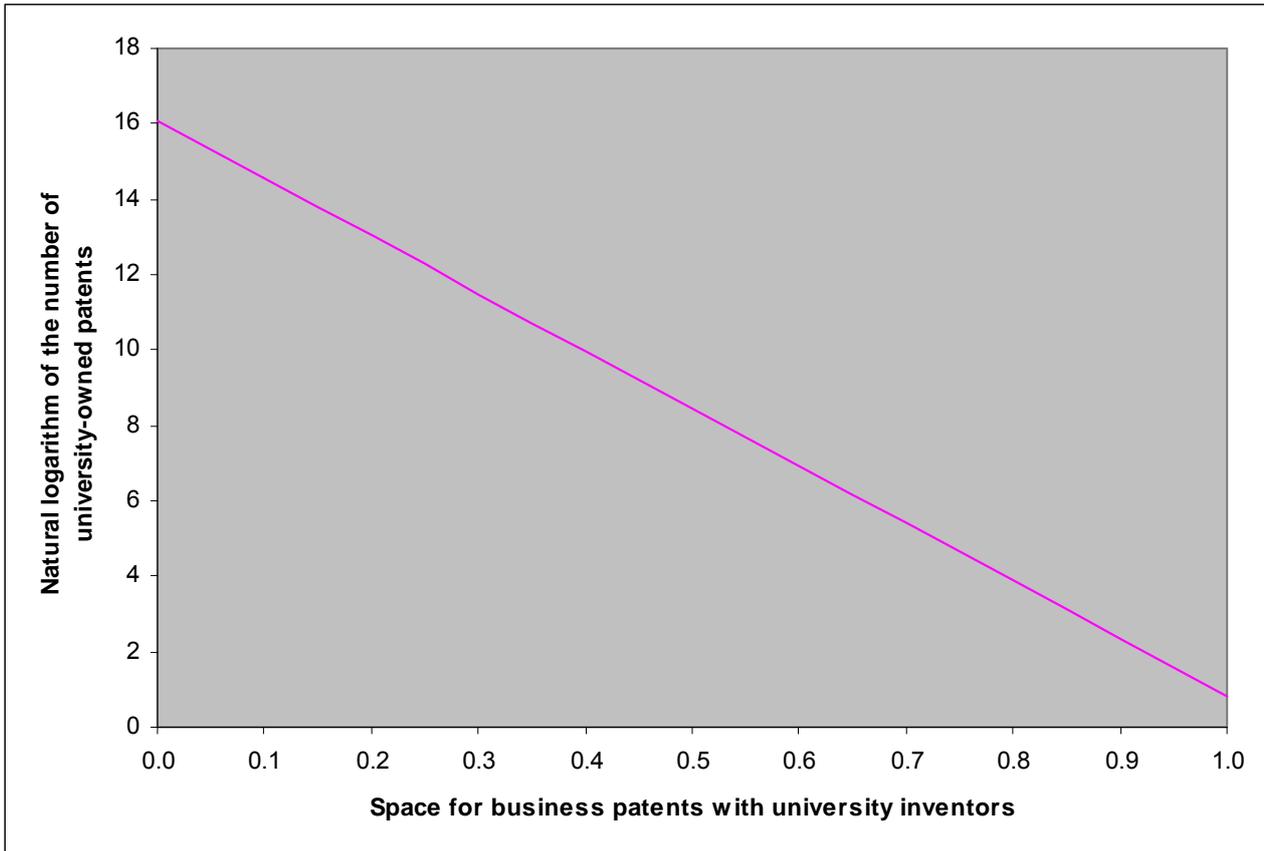
As aforementioned, university inventions patented by firms can be a measure for the objective of ‘encouraging performance’. However, these data do not exist and a proxy expressing *potential* university inventions patented by firms is used instead (see annex for details about how the proxy is derived).

Such a proxy, so-called ‘space for business patents with university inventors’, is equal to the proportion of business patents over the sum of business patents and university patents, a share that ranges from 0 to 1. The pink line in Figure 2 shows that the higher the space for business patents with university inventors, the lower the number of university-owned patents. In other words, the more R&D policy supports the objective of ‘encouraging performance’, the less university patent ownership will increase.

In other words, the negative relation found in the econometric estimation between the space for business patents with university inventors and the number of university-owned patents means that, for a given country, the more universities are interested in owning patents, the fewer the penetration of university research in inventions by firms will be in that country. This is a problem because currently R&D policies have given incentives to promote university-owned patents and this negative relation with the penetration of

university inventive activity in firms is unexpected. One possible solution could be giving incentives to value also business patents with university inventors, a measure of the penetration of university inventive activity in firms.

Figure 2. The impact of the objective of ‘encouraging performance’ (measured through business patents with university inventors) in the production of university-owned patents in the EU and US



## Conclusions: complementing current metrics about university performance with statistics about business patents with university inventors

Policy metrics often depend on policy objectives. In the EU, there is a diversity of policy objectives regarding the role of university patents and university-industry cooperation: ‘effective knowledge sharing’, ‘strengthening research institutions’ and two of the sub-objectives lying behind ‘strengthening research institutions’ – ‘coping with diversification of funding’ and ‘encouraging performance’. Hence, policy makers are increasingly using a broad range of metrics and there has been much debate about what metrics to be

included: number of university-owned patents, licensing income, contract incomes, consultancy incomes, etc.

University-owned patents are thus not the only data for indicators on the collaborative activities between universities and industry. This work has attempted to provide an analytical framework to test how university-owned patents relate to some of these other indicators suggested as measures of the sub-objectives 'strengthening research institutions' related to university-industry cooperation: 'coping with diversification of funding' and 'encouraging performance'.

According to the results at aggregate level, the more R&D policy supports the objective of 'coping with diversification of funding', the more university patent ownership will increase but the more R&D policy supports the objective of 'encouraging performance', the less university patent ownership will increase.

The indicator on business patents with university inventors uses very little actual data because data do not exist, so the work does not provide definitive evidence about the latter negative relationship. However, the correct proxy design and its correlation to other experimental evidence justify its exploratory use for illustrative purposes (see discussion of limitations and advantages in the appendix). This work alerts about the possibility of an unintended policy consequence and therefore makes a plea for the generation of better data.<sup>25</sup> While the data do not exist, the use of proxies is a fair attempt to produce quantitative results at aggregate level, which qualitative studies could complement.

Current R&D policy can place considerable emphasis on having well endowed technology transfer offices to make good use of patents and on incorporating university-owned patents in the evaluation of researchers' performance. Certainly, not all performance measurement systems monitor or incorporate such measures – indeed, in the UK, for example, the overemphasis on publications and the neglect of the measurements of technology transfer activity forms the basis of debate over the efficacy of current and proposed research assessment metrics. The situation, however, is somewhat different at the aggregate (institutional) level where metrics related to patents, licenses, etc. are important. In any further support to university-owned patents, governments could attempt to implement policies that promote complementarity between university patent ownership and the objective of 'encouraging performance' at aggregate level, since it is as desirable as the objective of 'coping with diversification of funding'. Including business patents with university inventors in the debate about metrics to evaluate the performance of universities would be one way to achieve this goal.

## Appendix: Methodology and data

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We have gathered panel data on the number of university-owned patents and university R&D expenditure in millions of Purchasing Power Standards (PPS) at 1995 prices from

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<sup>25</sup> An undergoing project recommended by the European Science Foundation in 2008 aims at producing such data: 'Academic patenting in Europe: database sharing, applications and extensions', led by Francesco Lissoni, Bruno van Pottelsberghe de la Potterie and Peter Lotz.

Eurostat's online public database<sup>26</sup>. Since there are regular updates, it is worth noting that the data extraction dates from March to May to 2008.

Data on patents refer to applications filed under the Patent Cooperation Treaty (PCT), at international phase, designating the European Patent Office (EPO). Years are those of the priority date, which are more meaningful from a technological or economic point of view than the application or the grant date<sup>27</sup> (OECD, 2001). Although the information dates back to 1977, the period of observation starts in 1982 to match the available information for the R&D variable. The year 2004 is the last one available with information on patents. It is therefore a 23-year period. Countries included in the sample are the 27 EU Member States and the US, i.e. 28. The panel has therefore 644 observations, but 38 percent are missing for university patents. The distinction among institutional sectors such as universities is possible after Eurostat's project on Data Production Methods for Harmonised Patent Statistics<sup>28</sup>.

A limitation of using EPO patents is the possible home advantage effect that will underestimate the number of US patents<sup>29</sup>. However, the numbers show that even at the EPO, US universities take out more patents than any single EU member state. In any case, in the broader context of firms, patents admit several critiques, such as being a mixture of discoveries with very heterogeneous impacts on innovation. One counter critique is that, if the number of patents is related to the equally dispersed value of R&D – as done here –, differences cancel out<sup>30</sup>. In the specific case of universities and EPO patents, there are additional justifications. First, university patents are not a proxy of innovation but of the ownership of scientific results. Second, heterogeneity is less than for firms, because patents are more concentrated in science-based sectors<sup>31</sup> and universities only apply through the EPO for their (potentially) most valuable inventions<sup>32</sup>.

In order to find the determinants of the numbers of university-owned patents, we made an econometric estimation of the following function, with four independent variables:

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<sup>26</sup>

[http://epp.eurostat.ec.europa.eu/portal/page?\\_pageid=1996.45323734&\\_dad=portal&\\_schema=PORTAL&\\_sc reen=welcomeref&open=/&product=EU\\_science\\_technology\\_innovation&depth=2](http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996.45323734&_dad=portal&_schema=PORTAL&_sc reen=welcomeref&open=/&product=EU_science_technology_innovation&depth=2).

<sup>27</sup> OECD, 2001. Using Patent Counts for Cross-Country Comparisons of Technology Output. STI Review 27.

<sup>28</sup> Van Looy, B., du Plessis, M., Magerman, T., 2006. Data Production Methods for Harmonized Patent Indicators: Assignee sector allocation. Eurostat Working Paper and Studies, Luxembourg.

<sup>29</sup> Criscuolo, P. 2006. The 'home advantage' effect and patent families. A comparison of OECD triadic patents, the USPTO and the EPO. *Scientometrics* 66 (1): 23–41.

<sup>30</sup> Patel, P., Pavitt, K., 1995. Patterns of technological activity: their measurement and interpretation. In: Stoneman, P. (ed.), *Handbook of the Economics of Innovation and Technological Change*, ch. 2. UK: Blackwell.

<sup>31</sup> Pavitt, K., 1998. Do patents reflect the useful research output of universities? *Research evaluation* 7 (2): 105-11.

Meyer-Krahmer, F., Schmoch, U., 1998. Science-based technologies: university-industry interactions in four fields. *Research Policy*, 27: 835-51.

<sup>32</sup> Azagra-Caro, J.M., Yegros-Yegros, A., Archontakis, F., 2006. What do university patent routes indicate at regional level? *Scientometrics*, 66 (1): 219-230.

$$\begin{aligned} \text{Ln number of university-owned patents} &= \alpha_0 + \\ &+ \alpha_1 \text{ Ln university R\&D expenditure in millions of PPS} + \\ &+ \alpha_2 \text{ Share of business funding of university R\&D expenditure} + \\ &+ \alpha_3 \text{ Space for business patents with university inventors} + \\ &+ \alpha_4 \text{ Ln firm patent/R\&D ratio} \end{aligned}$$

Similar methodologies appear in the academic literature, mostly focused on the US<sup>33</sup> and occasionally on the EU, for national or case studies<sup>34</sup>.

The first independent variable is:

- Ln university R&D expenditure in millions of PPS: data refer to the extensively used measure that Eurostat compiles from national surveys, following the Frascati Manual. In order to put it in relation to the number of patents, there is a lag of one period in order to prevent some endogeneity. Endogeneity, in econometric terms, would happen if R&D expenditure were a determining factor of the number of patents at the same time that the number of patents was a determining factor of the level of R&D expenditure. It would be a problem for the econometric estimation because there would be a vicious circle. Through the one-year lag, the problem decreases.

A one-year lag does not mean that it takes one year between spending money in R&D and applying for a patent, which we know is not necessarily the case. Rather, the assumption is that one year lagged R&D expenditure is a sufficiently good predictor of what will happen to patents in the next period, because one-year-old R&D expenditure already incorporates information from older R&D expenditure.

A limitation of matching the patent and R&D databases is the sectoral distribution of hospitals. While patent statistics classify all hospitals into a single category, R&D statistics classify them among the remaining categories: business enterprise, government, higher education and private non-profit. Therefore, relating university patents to university R&D expenditure means that we will not include patents applied for by public, non-university, hospitals but we will count their R&D expenditure. In any case, the number of hospital patents is around 7 percent of academic patents, thus the difference is not likely to be dramatic.

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<sup>33</sup> Among others:

Coupé, T. 2003. Science is Golden: Academic R&D and University Patents. *Journal of Technology Transfer*, 28, 31–46.

Foltz, J., K. Kim and B. Barham 2003. A Dynamic Count Data Analysis of University Ag-Biotech Patents. *American Journal of Agricultural Economics* 85 (1): 187-197.

Payne, A.A., Siow, A., 2003. Does Federal Research Funding Increase University Research Output? *Advances in Economic Analysis & Policy*, 3 (1): 1-22.

Stephan, P., Black, G., Gurmu, S., 2006. The Knowledge Production Function for University Patenting. Andrew Young School of Policy Studies Research Paper Series 07-06.

<sup>34</sup> Among others:

Azagra Caro, J.M., Fernández de Lucio, I., Gutiérrez Gracia, A., 2003. University patents: output and input indicators... of what? *Research Evaluation*, 12 (1): 5-16.

Azagra-Caro, J.M., Carayol, N., Llerena, P., 2006. Patent Production at a European Research University: Exploratory Evidence at the Laboratory Level. *Journal of Technology Transfer*, 31 (3): 257-268.

Azagra-Caro, J.M., Plaza-Gómez, L., Romero-de-Pablos, A., 2007. The origin of public research organisation patents: an economic approach. *Research Evaluation* 16 (4): 271-282.

Instead of expenditure on R&D, we have also used alternatively numbers of R&D personnel. The fit was always better for expenditure rather than personnel. We have used other human capital variables, like number of researchers or ratios of R&D expenditures over R&D personnel or researchers, but they did not affect the overall conclusion.

The second and third independent variable included in the equation, which will be used to produce Figure 1 and Figure 2, are:

- Share of business funding of university R&D expenditure: this corresponds to the breakdown of university expenditure on R&D according to its source of funding: share of business funding of university R&D, share of government funding of university R&D, share of other funding of university R&D. In the estimations, the share of business funding of university R&D is included and the sum of the other two shares (government and other funding) is the benchmark –because the effects of the share of government funding and the share of other funding are not significantly different one from each other
- Space for business patents with university inventors: a proxy for the appearance of university staff as inventors of intellectual property expressed in patents not owned by universities but by business firms, calculated as:

$$\text{Space for business patents with university inventors} = \frac{\text{Business-owned patents}}{\text{Business-owned patents} + \text{university-owned patents}}$$

The rationale behind this formula is that the denominator expresses the maximum number of patents in which university researchers can appear as inventors, whereas the numerator expresses the maximum number of business-owned patents in which university researchers can appear as inventors. Thus, the more business-owned patents has an economy, in relation to the total number of patents held by both business enterprises and universities, the more opportunities university staff have to appear in patents applied for by firms.

The ratio would be equal to one if university staff only appeared as inventors in business patents and zero if they only appeared as inventors in university-owned patents. I.e. by design the variable works, as it should to express the potential proportion of business patents with university inventors: higher values of the variable indicate higher potential proportion of business patents with university inventors.

Of course, this ratio is not a perfect measure, but the problem is that there are no data about the actual number of business patents with university inventors for the time and geographic scope we intend to analyse. We compared it to another attempt to measure the proportion of such patents in six European countries and obtained similar results for universities, as we can see in Table 3. The country ranking provided by both measures is the same, which gives some validity to our proxy.

Table 3. Two measures of business patents with university inventors in six European countries

Country	Share of business patents with university inventors over all university patents <sup>35</sup>	Space for business patents with university inventors
France	88.33%	99.29%
Germany	96.30%	99.76%
Italy	96.00%	99.52%
Netherlands	79.66%	98.85%
Spain	47.06%	97.12%
UK	67.63%	97.30%

One could intuitively argue that since the proxy is an inverse ratio dependent on the number of university-owned patents, one would expect nothing else but a negative relation. This would happen, only if we hold everything else constant. The example of Table 4 shows that this is not necessarily the case.

Table 4. Hypothetical scenarios to understand how it works the relation between the number of university-owned patents and the space for business patents with university inventors

Year	Variable	Number of university-owned patents	Number of business-owned patents	Space for business patents with university inventors	Type of relation between 'Number of university-owned patents' and 'Space for business patents with university inventors'
2009		1	1	0.5	
2010a		2	1	0.33	Negative
2010b		2	2	0.5	None
2010c		2	3	0.6	Positive

Following Table 4, let us consider that a given country has one university patent and one business patent in 2009. In 2010, the number of university patents increases to two. According to whether the increase of business patents is lower, equal or higher than two, the relation between the number of university-owned patents and the space for business patents with university inventors will be negative, none or positive, respectively.

The same range of possibilities exists for a given year across countries. The fact that, in the econometric estimations, there is a one-year lag between the number of university-owned patents and the space for business patents with university inventors enhances randomness in the relation. The empirical evidence actually confirms that the pairwise

<sup>35</sup> Crespi, G.A., Geuna, A., Verspagen, B., 2006. University IPRs and Knowledge Transfer. Is the IPR ownership model more efficient? SPRU Working Papers 154.

correlation is close to zero (and even positive), which reinforces the argument against an intuitively expected negative relation.

Finally, the equation that we will estimate also includes as a fourth independent variable:

- Ln firm patent/R&D ratio: it expresses firms' propensity to patent, measured through the ratio of the number of patents owned by business firms over the business firms' expenditure on R&D. 'Firms' here are all firms in a given country and year

To produce the estimations, we have run panel regressions, testing classical regression models against fixed effects models and random effects models. The preferred model was a fixed effects one, with country and year effects. The results are in Table 5.

Table 5. Determinants of university-owned patents in the EU and US

Ordinary least squares regression with country and year effects	
Dependent variable	Ln number of university-owned patents
Number of observations	290
R <sup>2</sup>	.95
Adjusted R <sup>2</sup>	.95
Variable	Coefficient (t-ratio)
Constant	16.07 (13.19)
Ln university R&D expenditure in millions of PPS	.30 (3.49)
Share of business funding of university R&D expenditure	4.88 (3.63)
Space for business patents with university inventors	-15.24 (-13.01)
Ln firm patent/R&D ratio	.88 (11.10)

Notice that 4.88 and -15.24, in the shaded areas, are the coefficients used to draw Figure 1 and Figure 2.<sup>36</sup>

<sup>36</sup> For explanations about the other results and further work, see Azagra-Caro, J.M., 2008. Patents owned by public research centres: EU vs. US, universities vs. PROs, 3<sup>rd</sup> Annual Conference of the EPIP Association, Bern (Switzerland), 3-4 October, in: [http://www.epip.eu/conferences/epip03/papers/Azagra-Caro\\_Euracapat%201%20-%20EPIP.pdf](http://www.epip.eu/conferences/epip03/papers/Azagra-Caro_Euracapat%201%20-%20EPIP.pdf), last access: 26/05/2009.

European Commission

**EUR 23761 EN – Joint Research Centre – Institute for Prospective Technological Studies  
Directorate General Research**

Title: Recognising the value of business patents with university inventors

Authors: Joaquín M. Azagra-Caro

Luxembourg: Office for Official Publications of the European Communities

2009

EUR – Scientific and Technical Research series – ISSN 1018-5593

Abstract

Support to university patent ownership is a popular R&D policy initiative to promote effective knowledge sharing. Yet the broader, unintentional, consequences of such support on the link between public funding of university R&D and increased university-industry cooperation have not been studied. Through regression models on the determinants of university-owned patents in the EU and US, tentative results illustrate that the risk of negative consequences exists. Complementing current metrics about university performance with statistics about business patents with university inventors would help avoid such a risk and find definitive quantitative evidence.

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