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**The determinants of university patenting:
Do incentives matter?**

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THE DETERMINANTS OF UNIVERSITY PATENTING: DO INCENTIVES MATTER?

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Abstract:

In recent years various studies have examined the factors that may explain academic patents. Existing analyses have also underlined the substantial differences to be found in European countries in the institutional framework that defines property rights for academic patents. The objective of this study is to contribute to the empirical literature on the factors explaining academic patents and to determine whether the incentives that universities offer researchers contribute towards explaining the differences in academic patenting activity. The results of the econometric analysis for the Spanish universities point towards the conclusion that the principal factor determining the patents is funding of R&D while royalty incentives to researchers do not appear to be significant.

Keywords: patents, university, R&D

1. INTRODUCTION

Universities, as it is widely recognised, are increasing their contribution to commercial technology development (Etzkowitz et al., 2003). There is also significant evidence of growth in university patenting (Henderson et al., 1993; Geuna and Nesta, 2006; Zeebroeck et al., 2008), although this phenomenon is not homogeneous across universities. In recent years university patents have generated growing interest both on the part of academic researchers as well as from the point of view of policies designed to encourage innovation (Baldini, 2006; Baldini et al., 2006; Verspagen, 2006; Breschi et al., 2007). However, there are few empirical studies that analyze the university-patent relationship and the factors that affect academic patenting, particularly for European countries and universities. Therefore, as Azagra et al. (2006) point out, little is known about the mechanisms which favour university patenting, particularly at the micro level.

The objective of this paper is to contribute to the empirical literature that analyses the determinants of academic patenting. In comparison with previous studies (Coupé, 2003; Payne and Siow, 2003; Azagra et al., 2006) that focus their analyses mainly on the influence of R&D expenditures and Technology Transfer Offices (TTO) on academic patents, the purpose here is to examine the influence of incentives for university researchers to generate patents. As Lach and Schankerman (2008) have recently shown the universities in the United States that provide stronger royalty incentives to faculty scientists generate greater license incomes.

The influence of the institutional framework on the generation of university patents has been the object of growing interest since the changes introduced by the Bayh-Dole Act, which gave universities the property rights to university patents derived from research financed with federal funds. In European countries there are substantial differences in the systems of Intellectual Property Rights (IPR) governing research activities and patents in universities. While in some countries university researchers are the owners of patents derived from their research activities, in others the university retains the ownership although generally the researcher has the right to a share of the possible profits derived from the exploitation of the patent (Baldini et al., 2006; Geuna and Nesta, 2006; Verspagen, 2006). In addition, in order to create the right economic incentives for individual scientists to undertake more “patentable” research, some European countries, such as Germany and Italy, have changed the IPR system governing university researchers’ inventions (Geuna and Nesta, 2006; Breschi et al., 2007). However the legislative changes in these two countries have gone in opposite

directions. While in Germany the so-called “professor’s privilege”, through which university teachers retained all the property rights derived from their inventions, has been abolished, in Italy the “professor’s privilege” has been introduced so that the IPR on public employees’ inventions are now granted to the employees themselves although the universities have the right to receive a percentage of the net revenues that the commercial exploitation of the patented inventions generates (Baldini et al., 2006; Breschi et al., 2007). As Jaffe et al. (2007) point out the investigation of the role of policy levers such as the patent system or rules governing university licensing on the use of research with both scientific and commercial applications is an important research agenda that is in progress.

The IPR system for university researchers’ inventions and the rules for the sharing between universities and their scientists of the revenues generated by inventions deserve particular consideration in the analysis of the determinants of academic patents. Some authors have emphasized the importance of incentives for the efforts of scientists in the development of inventions (Jensen and Thursby, 2001; Thursby et al., 2007), for the results of technology transfer centres (Siegel, 2003) and in some analyses some evidence has been found for this importance for academic patents (Coupé, 2003) and for university license incomes (Lach and Shankerman, 2008). However there is still little known about the influence that incentives have on researchers to generate patentable research. In Spain, although the universities are the owners of the inventions generated by university researchers, the latter have the right to a share of the royalties derived from their patented discoveries. This distribution of profits is established by each university through an internal regulation, which has given rise to significant differences among universities in the percentage of royalties assigned to universities and scientists.

Therefore, in order to analyse the determinants of academic patenting at an institutional level, a data-base has been constructed for Spanish universities which includes the variables used commonly in the empirical analyses, but complements these with a variable on researchers’ incentives to patent. This has been done by compiling the information on the royalties assigned to scientists in each of the Spanish universities. The analysis of a specific country provides homogeneity in the institutional context in which universities carry out their activities as the legal and financial framework is an important factor explaining national differences in university patenting (Pavitt, 1998; Azagra et al., 2006; Verspagen, 2006).

The rest of the paper is organised as follows. Firstly, the model is specified and the variables and data are described, including references to the empirical literature and results on the determinants of academic patenting. Secondly, the determinants of university patenting are explored through an applied analysis. Finally, the conclusions obtained and some policy implications are presented.

2. MODEL SPECIFICATION AND DATA

In the same way as in the analysis of firm patenting, the theoretical framework used to analyse the determinants of academic patenting is the knowledge production function proposed by Griliches (1990). In this model the number of patents depends on the effort in R&D. This basic model has been extended with a set of other variables that may affect university patents. According to Henderson et al. (1998), three factors may explain the growth in the number of university patent applications that has been seen in the United States. These factors are changes in the law, the industry funding of university research and the increase in organised university technology offices. The last two factors have been included in the model in order to analyse the determinants that explain differences in university patenting while the first one has not been included because there have been no changes in the patent law since 1986.

Various indicators for the quality and for the orientation of research in universities have also been included. Furthermore, incentives for researchers to patent should also be an explanatory variable for differences in academic patenting.

Therefore the model using universities (i) as the unit of analysis is:

$$PAT_i = f(R\&D_i, TTO_i, Q_i, S_i, I_i) \quad (1)$$

where PAT_i is the number of university-owned patent applications, $R\&D_i$ is the university funding from all sources devoted to R&D activities, TTO_i is an indicator of technology transfer offices, Q_i measures the scientific quality of the universities, S_i captures research orientation and I_i measures the incentives for researchers to patent.

A data-base using different sources was constructed to carry out the estimations. This data-base includes information for all 47 public universities. Although there are currently 71 universities in Spain, the information for private universities is very scarce

and it has not been possible to include them in the analysis. It should also be pointed out that academic research in Spain is basically carried out by the public universities which cover 92.7% of the total university expenditure on R&D and employ 93.6% of all university researchers measured in full-time equivalent (INE, 2006).

Patent data per university were obtained from the Spanish Office of Patents and Marks (OEPM) and from the European Patent Office (EPO). The analysis is focused on the available data on university-owned patents with the objective of examining the influence of the distribution of incentives between the universities and their researchers. This approach underestimates university involvement in patenting because it does not take into account the non-university owned patents that have a university inventor (Geuna and Nesta, 2006, Verspagen, 2006). Nevertheless, a recent survey of six European countries, the Patval survey, shows that in Spain the fraction of university-owned patents is larger than the proportion of non-university owned patents, but where a university inventor is involved (Verspagen, 2006), which differs from the results of the other European countries analysed. Furthermore, in Spain, the two types of patents are covered by the same regulation with regard to the distribution of royalties between the researchers and universities. An agreement is required between the firm and the University for a university inventor to receive royalties for his or her participation in a firm patent. After this agreement the distribution of royalties between the University and the researcher follow the same rules as those for a university-owned patent.

As is common in analyses using patents as an indicator of innovation, we use applications for patents, specifically applications for national patents for the years 2002, 2003 and 2004. To check the robustness of the results, applications for European patents have also been used although these are much less frequent than applications for national patents. Although university patent applications in Spain are, in comparison with the advanced countries, a little-used way of protecting research results (OECD, 2003), there has been a significant increase in recent years, similar to that in other European countries (van Pottelsberghe, 2007). In each of the years 2002, 2003 and 2004 the number of university applications for national patents was close to 200 per year while in 2000 there were only around 130 applications. Although some universities are especially active, patenting is not restricted to a specific group of universities. Between 2002 and 2004, all 47 public universities applied for at least one patent in one year or another. The differences between universities in patenting are substantial and the distribution is considerably skewed. While some universities, such as the Polytechnic University of Valencia and the Polytechnic University of Catalonia, have applied for

more than 20 patents each year, a significant number of universities, especially the small or new ones, have applied for only one or two patents in these years.

The number of university patents is expected to depend on the resources devoted to R&D activities. Therefore expenditures on R&D have been used in the majority of applied studies of the determinants of academic patents (Coupé, 2003; Payne and Siow, 2003; Azagra et al., 2006; Acosta et al., 2008). In particular, Coupé (2003) examines the relation between expenditure on R&D and academic patents in detail and confirms that it is a significant variable.

In Spain, the annual statistics on R&D of the National Statistic Institute of Spain (INE) present information on R&D activities in the different sectors, including universities. This information is also presented in the OECD Statistics on R&D. Nevertheless, in order to safeguard confidentiality, the INE does not provide individual information. An alternative source that has been used in this analysis is new statistics on university budgets (CRUE, 2004) that provide very useful information for the analysis of R&D activities in the universities. Specifically, these statistics give information on the incomes received by the universities in the year 2002 for carrying out research and distinguish between basic and applied research. To use the year 2002 for R&D expenditures and the data from 2002, 2003 and 2004 for the dependent variable limits the existence of a potential endogeneity problem.

The distinction between basic and applied research in these statistics (CRUE, 2004) is not the usual one when following the recommendations of Frascati manual and depends on the type of financing. In the case of basic research, the financing comes from subsidies and grants for carrying out research projects, mainly after competitive calls by the public administrations at different levels, either European, national or regional. According to these statistics, 94% of the funds for basic research come from public institutions. The applied funds come from contracts with third-party institutions for the provision of research and consulting services. In this case, nearly 60% of the funds are from the private sector. Therefore, this distinction allows the analysis not only of whether the universities that receive more funds for research, but also whether those that receive more financing, under contract, and that are more commercially oriented, have a greater propensity to patent. This is an important distinction because as Henderson et al. (1998) point out one of the main factors that explain growth in the number of university patent applications is the increase in industry funding of university research, although

the results of the empirical analysis are not conclusive (Geuna and Nesta, 2006; Azagra et al., 2006).

The increase in organised university technology offices has also been, according to Henderson et al. (1998), one of the explaining factors of the growth in academic patents. This affirmation is supported by the empirical evidence (Foltz et al., 2000; Coupé, 2003). All the public universities in Spain have a technology transfer office (TTO) created with the support of the technology policy at the end of the 1980s. These TTO are organised in the OTRI (Offices for the Transfer of Research Results) network of universities. The TTOs, the mission of which is to promote relationships between the university and firms in the area of R&D, have undergone very significant growth in the last few years, reaching a total budget of €39 million in 2005, compared to €207 million in 2000 (CYD Foundation 2007). This sum corresponds to R&D contracts between firms and universities managed by the TTOs. The Spanish TTOs are of quite different sizes and most of them have less than three technicians, mainly devoted to the management of contracts. In the last few years, some TTOs seem to have begun to play a more active role in other and more advanced ways of transferring technology, such as the creation of spin-offs and licensing patents (CYD Foundation 2007).

To examine the influence of the TTOs on the number of university patents, their size as measured by the total number of employees and by the number of technicians has been included in the model as in Lach and Shankerman (2008). It should be pointed out that this is a proxy not exempt from limitations due to the fact that it does not capture all the factors related to the ability and effectiveness of the TTOs to transfer technology. The information has been provided by the TTO network of universities, which has carried out a survey every year since 2002 to gather information on the activities of the TTOs. Nevertheless, for the first years the information is not absolutely complete and therefore the year chosen was 2004.

Academic patenting is expected to be related to the scientific quality of university research. However the results of the empirical analyses are not conclusive. While Miyata (2000) and Azagra et al., (2006) find a positive relation between scientific quality and inventions and patents as dependent variables respectively, the parameter is not significant in explaining license incomes (Lach and Shankerman, 2008). To analyse this relation, the number of staff with a doctorate in each university, based on information from the National Institute of Statistics (INE), has been included as an indicator of scientific quality.

Recent analyses of academic patents have emphasized that one of the main factors contributing towards their rapid rise in recent years has been the growing technological opportunities in the fields of biomedical and pharmaceutical research (Mowery and Ziedonis, 2002; Geuna and Nesta, 2006; Rafferty, 2008). To capture research orientation, we use the number of publications in international journals per university in the Science Citation Index for the period 1996-2001. Other types of publication, such as those in social sciences, are excluded, as the purpose is to control for differences in research orientation that may affect the number of patents. Comparisons between the scientific fields of the publications and the technological fields of applications for patents in the period 1996-2001 show a high degree of similarity. The percentages of publications and patents belonging to bio-medical sciences and chemistry are 54% and 57% respectively of the totals for publications and patents in these areas (CYD Foundation, 2005). Using the previous period of years of applications for patents avoids a potential endogenous problem arising. Publications and patents seem to have some degree of complementarity and recent analyses point out that a high scientific performance in terms of publications increases the probability of applying for a patent (Azoulay et al., 2007; Breschi et al., 2007; Van Pottelsberghe, 2007).

The last variable is a measure of the researchers' incentives to patent. As has been explained above, both the university and the specific researcher in Spain are offered incentives to patent the results of their research. The Spanish Law of Patents (Law 11/1986 of Patents of Inventions and Utility Models), in Article 20, states that "the university possesses the ownership of the inventions made by university staff as a consequence of their research function in the university". Also, the same article states that "staff will have, in any case, the right to participate in the benefits obtained by the University for the licensing or cession of their rights over the inventions". Although regions develop their own innovation and university policy, the regulations on patents are the same for the whole country.

The universities have established internal rules for distributing possible royalties. These rules are freely decided by each university and have to be approved by their management bodies. These regulations were collected through a search in the web pages of universities and contacts with TTO managers. In these regulations, the percentages for the distribution of possible profits between the university and the researcher, and when applicable the department or research group to which the researcher belongs as well, are permanently established and to vary the royalty shares a change in the

regulations is required. In general terms, the greater part of the profits accrues to the researcher, an average of 56% for the 47 universities of the database, while the university itself obtains 29.5%. The rest is allocated to the department to which the researcher belongs (13.5%), while the share of the research group is marginal (1%), and in only three universities is it envisaged that these have a share in the profits. The compilation of this information shows that there are significant differences in the royalties assigned to researchers in Spanish universities. While universities such as Cantabria, Extremadura, Salamanca or Valladolid assign 80-90% of the profits to the university researcher, in other universities such as the Autonomous University of Barcelona, La Laguna, Girona or Jaume I de Castellón, this percentage is situated at lower levels of around 35%. This cross-university substantial variation allows an analysis to be made of whether incentives to researchers play a role in explaining differences in university patenting.

Table 1. Descriptive statistics

3. APPLIED ANALYSIS AND RESULTS

The estimations have been carried out taking into account the nature of the endogenous variable, the number of patents, which constitutes a typical example of count data. In this case, a specification like that of count data models is preferable to a linear regression model estimated by ordinary least squares (Hausman et al., 1984; Cameron and Trivedi, 1998). The basic model for count data is the Poisson model, where it is assumed that the endogenous variable (PAT_i) follows the Poisson distribution:

$$P(PAT_i) = \frac{e^{-\lambda_i} \lambda_i^{PAT_i}}{PAT_i!} \quad (3)$$

$$\lambda_i = e^{X_i' \beta} \quad E(PAT_i | X_i) = VAR(PAT_i | X_i) = \lambda_i$$

where X_i is a $k \times 1$ vector that collects the set of independent variables used in the model to explain the number of patents. In the Poisson model, the mean and variance of the random variable are assumed to be equal, which is a very restrictive assumption. Overdispersion occurs when the conditional variance $VAR(PAT_i | X_i)$ exceeds the conditional mean $E(PAT_i | X_i)$.

A common alternative to the Poisson model that allows for overdispersion is the negative binomial model. In this model an additional overdispersion parameter α is added, specifically we have used the model denominated NB2 by Cameron and Trivedi (1998). For this model, the endogenous variable PAT_i has variance $Var(PAT_i) = \mu_i(1 + \alpha\mu_i)$. Apart from the overdispersion test proposed by Cameron and Trivedi (1990), a Likelihood Ratio test is implemented in the Stata package to test the null $\alpha = 0$, (see Gutierrez et al., 2001 for details).

Table 1 presents the basic statistics of the 43 universities considered in the data base used for the estimations. Finally, 4 of the initial 47 universities were excluded due to the absence of information on one or more of the relevant variables of the model. The endogenous variable PAT does not have zero values; hence we have not been concerned with the possibility of having zero-inflated problems in the model. The calculus of the sample variance of the endogenous variable shows that it is greater than twice the sample mean and then it will be very likely that the data will be overdispersed after conditioning.

The results for the Poisson and the negative binomial model are presented in Tables 2 and 3. The empirical specification is similar to the ones used by Lach and Shankerman (2003, 2008) to estimate university license incomes and disclosures in the United States, which allows the results to be compared. Nevertheless, we tried other specifications with similar results to those presented in Tables 2 and 3. European patents were also used as an alternative to national patents with the same results. The estimations have been carried out for total university R&D income and splitting this variable between funding for basic and applied R&D. To control for the size differentials of the universities, the average numbers of faculty for the years 2002 and 2003 have also been included. The tests confirm the existence of overdispersion and the convenience of using the negative binomial models.

Tables 2 and 3. Results of estimations

The results of the estimations show that the share researchers have in the royalties does not have a positive effect on the number of university-owned patents. This result differs from the estimations of Lach and Shankerman (2008) that find that royalty shares have a positive effect on license revenues for US universities. Nevertheless, as Lach and Shankerman (2008) also emphasised for their results, further work is needed to establish or refute this link with greater confidence. Although we have tried to control for the

university characteristics, including most of the variables used in empirical analyses, that may affect the level of academic patenting some unobserved heterogeneity may remain related to specific historical and institutional features influencing patenting behaviour. To achieve more definite results would require long time series although it should be pointed out that because royalty shares are not expected to vary over time panel data estimation methods would not be very useful, as also Lach and Shankerman (2008) point out. Even with these cautions, the estimated parameter is not significant in any of the estimations carried out.

These results show that the effects of incentives may be quite different depending on the institutional framework and the individual university characteristics, as some reviews of the literature also suggest (Baldini, 2006). Despite the improvement of recent years, the effort of Spanish universities in R&D (0.33% of the GDP) is lower than the 0.39% of the OECD countries (OECD, 2008). Furthermore, in the early 1990s a very considerable expansion of the Spanish universities took place with the creation of new universities (Barrio-Castro and García-Quevedo, 2005). Although this may have favoured the relationship between universities and firms from a territorial point of view, the research capacity and the scientific level of a considerable number of universities in patentable fields is low. The analyses (CYD Foundation, 2006) of the different methods of technology transfer between universities and firms also show that Spanish universities have a demand pull behaviour and respond, in comparison with other European countries, quite well to the specific demands of firms while technology push, such as the creation or spin-offs or the licensing of patents, are less developed. This fact is connected with a low level of quality and originality in research in most universities but also with the limited absorptive capacity of firms. Finally, the Spanish university system is characterised, in comparison with the United States, by the very low mobility of faculty members, and therefore it is difficult to expect that the royalty formula would have some effect on the attraction of researchers by specific universities.

For the rest of the variables, the results show, as expected, a positive relation between the funding of R&D and the number of patents, as in other empirical analyses (Coupé, 2003; Payne and Siow, 2003; Azagra et al., 2006; Acosta et al., 2008). The results of the estimations show the convenience of splitting the funded R&D between the two sources of funding, income for basic research and contractual funding for applied research. While the first of these is not significant, the parameter for contractual funding is positive and highly significant.

This result supports the statement of Henderson et al. (1998) who suggest that the increase in industry funding of university research is one of the factors explaining the increase in academic patents. Nevertheless, the literature does not absolutely agree on this and some empirical analyses claim that funding in general is what matters rather than industrial funding specifically (Foltz et al., 2000; Azagra et al., 2006; Geuna and Nesta, 2006). The main reason for supporting this statement is that university patents are more related to long term research and scientific discoveries than with the outcomes of contracts with firms (Azagra et al., 2003). Nevertheless as has been mentioned above, in Spanish universities knowledge transfer is more demand pull than technology push. In this sense, as Stephan et al. (2007) point out, faculty interaction with industry can lead to new ideas and to an increased interest in patenting. This is not only because industry often has a patent focus but also because industry directs its research towards matters that are well suited to eventual patenting. The interviews carried out with some TTO managers, particularly in the polytechnic universities, lead to the same conclusion. They point out that university-industry relationships, in many cases with the support of public policy, have fostered new university-owned patents.

Henderson et al. (1998) also claim that an increase in the organised university technology offices has positive effects on academic patenting activity, a statement that is supported by some empirical evidence for the US (Coupé, 2003). Lach and Shankerman (2008) also found a positive effect of TTOs, measured by their size, on license incomes but only for private universities and not for public ones. In the estimations, the results for the effect of TTOs on patents are not significant, whether using the total number of employees or the number of technicians. Although the proxy used has some limitations, the results are coherent with the average situation and performance of Spanish TTOs. As the new Spanish R&D Plan 2008-2011 (FECYT, 2007) states, the TTOs are overloaded with work and much focused on administrative functions when they should behave as strategic bodies. It should be pointed out that the effects of the estimations are average effects and some evidence exists for specific TTOs of a positive effect on academic patents (Azagra et al., 2003).

Finally, none of the rest of the variables used to control for differences in university characteristics, particularly in quality and orientation of research, are significant. As has been pointed out above, the results of the empirical literature are not conclusive and our results coincide with these obtained by Lach and Shankerman (2008) that do not find a positive relation between the quality of research, measured by the number of citations, and research orientation and license incomes.

4. CONCLUSIONS

As Jaffe et al. (2007) point out patents are playing a growing role in the conduct of academic science and in the translation of academic research into industrial innovation and the rules governing university licensing is an important research agenda in progress. This paper has focused on the analysis of the determinants of academic patents and specifically on the effects of incentives to researchers on applications for university-owned patents. The empirical results show that the influence of royalty shares to university scientists on academic patents is not significant and that other university characteristics explain the distribution of patents in Spanish universities. Therefore, the results show that the effects of incentives may vary considerably depending on the institutional framework and the specific characteristics of the universities.

Another relevant result of the empirical analysis is that R&D funding is a relevant variable, particularly contractual R&D funding. This result is coherent with the affirmation of Henderson et al. (1998) who point out that the increase in industry funding of university research is one of the factors explaining the increase in academic patents. Both results show, as do some reports on the Spanish university system, that the behaviour of Spanish universities is more demand pull than technology push and that the university-industry interaction tends to direct the research towards solutions that are well suited to patenting. Finally, the results also support the view that in Spain the technological transfer offices are still playing a limited role in the more advanced ways of transferring knowledge from academic research to firms.

The results are not without limitations. Firstly income from licenses is a better indicator to use to analyse the effects of incentives to researchers. However, this information is incomplete and scarce for Spanish universities. Nevertheless, patents have been extensively used as an indicator of knowledge output and they are a first step on the way to obtaining licence incomes. Secondly, this analysis concentrates on the characteristics of the universities that determine their propensity to patent, although recent studies have also shown that the individual characteristics of the researchers influence patent applications (Azoulay et al., 2007; Stephan et al., 2007). Finally, further work with richer data is needed, as Lach and Shankerman (2008) also recognize, in order to analyse with absolute confidence whether or not there is a link between royalty shares

and academic patents production and to know in detail how royalties affect the behaviour of scientists and in consequence the rate of discoveries patented.

The results have some implications for innovation policy. Firstly, it is convenient to improve the utilisation of the existing infrastructure of intermediaries, as a recent diagnosis of Spanish technology policy stated (OECD, 2007). In particular to improve the low technological level of the Spanish economy it is necessary to reinforce the relationships between universities and firms. To achieve this goal, TTOs should play a more strategic role and not, as currently happens, be mainly focused on administrative tasks. This strategic role should be addressed not only to increasing the ability to patent but also to increasing the quality and internationalisation of the university patents and their possibilities of being licensed. Secondly, if policy has the objective of increasing the level of academic patenting in the belief that this will foster the rate of technology transfer it is necessary to devote more funds to research, to increase its quality and to improve the absorptive capacity of firms. Finally, the results on the effects of incentives and royalty shares on academic patents provide some information about how to design intellectual property rights in academic institutions. The results show, in comparison with the United States, that in less developed countries other characteristics of the institutional framework and the university system seem more important than incentives for academic patenting. Nevertheless, as the increasing debate (Geuna and Nesta, 2006; van Pottelsberghe, 2006; Jaffe et al., 2007) on this subject shows the role that patents play in academic science and finally in productivity and growth is a complex one. Further research that goes beyond the scope of this paper is needed in order to acquire accurate information on the different effects that should be taken into account in the design of innovation policy related with academic patents.

Table 1 Descriptive statistics

| Variable | Mean | Std. Dev. | Min | Max |
|----------|----------|-----------|----------|----------|
| PAT | 13.90 | 15.02 | 1 | 68 |
| R&D | 1.54e+07 | 1.28e+07 | 755438.3 | 5.17e+07 |
| R&DB | 1.07e+07 | 8641161 | 353048.8 | 3.66e+07 |
| R&DA | 4707286 | 5147647 | 402389.4 | 2.39e+07 |
| TTOPER | 12.65 | 10.28 | 1 | 43 |
| TTOTEC | 7.68 | 5.38 | 1 | 28.5 |
| FACULTY | 1628.51 | 1054.64 | 370 | 5102 |
| PHD | 1124.53 | 848.44 | 228 | 4297 |
| PUBFAC | 0.929 | 0.447 | 0.288 | 2.131 |
| SHRES | 56.70 | 13.63 | 33.0 | 90.0 |
| SHUNIV | 29.15 | 12.13 | 10.0 | 67.0 |

PAT: Total number of university-owned patents for the years 2002, 2003 and 2004

R&D: Total university incomes for R&D (in euro). 2002

R&DB: University incomes for basic R&D (in euro). 2002

R&DA: University incomes for applied R&D (in euro). 2002

TTOPER: Number of TTO employees. 2004

TTOTEC: Number of TTO technicians. 2004

FACULTY: Total number of university faculty. Average 2002 and 2003

PHD: University staff with a Doctorate. 2002

PUBFAC: Number of publications in the Science Citation Index (1996-2001) per faculty

SHRES: Inventor's royalty share (in %)

SHUNIV: University's royalty share (in %)

Table 2. Results of the estimations. Poisson model

| | $\hat{\beta}_j$ | $z_{\hat{\beta}_j}$ | p-value. | $\hat{\beta}_j$ | $z_{\hat{\beta}_j}$ | p-value |
|-----------------------|-----------------|---------------------|----------|-----------------|---------------------|---------|
| Ln (R&D/FACULTY) | 0.781** | 6.52 | 0.000 | | | |
| Ln (R&DB/FACULTY) | | | | 0.340** | 3.16 | 0.002 |
| Ln R&DA/FACULTY) | | | | 0.419** | 5.74 | 0.000 |
| Ln (PHD/FACULTY) | 0.527 | 1.36 | 0.173 | 0.551 | 1.42 | 0.155 |
| Ln (TTOPER/FACULTY) | 0.010 | 0.12 | 0.902 | 0.006 | 0.07 | 0.943 |
| PUBFAC | -0.236* | -2.01 | 0.044 | -0.143 | -1.18 | 0.239 |
| Ln FACULTY | 1.037** | 11.62 | 0.000 | 0.967** | 10.80 | 0.000 |
| SHRES | -0.187 | -0.50 | 0.615 | -0.204 | -0.55 | 0.583 |
| Intercept | -11.560** | -8.94 | 0.000 | -10.261** | -8.49 | 0.000 |
| Log likelihood | -213.44 | | | -206.52 | | |
| LR | 307.26 | | 0.000 | 321.11 | | 0.000 |
| Pseudo-R ² | 0.418 | | | 0.437 | | |

LR: Likelihood test ratio to test the null that all the parameters associated to the regressors are equal to zero

** , * , significant at the 1% and 5% level respectively.

Table 3. Results of the estimations. Negative binomial model

| | $\hat{\beta}_j$ | $z_{\hat{\beta}_j}$ | p-value. | $\hat{\beta}_j$ | $z_{\hat{\beta}_j}$ | p-value |
|-----------------------|-----------------|---------------------|----------|-----------------|---------------------|---------|
| Ln (R&D/FACULTY) | 0.586* | 1.99 | 0.046 | | | |
| Ln (R&DB/FACULTY) | | | | 0.103 | 0.37 | 0.713 |
| Ln R&DA/FACULTY) | | | | 0.452** | 2.65 | 0.008 |
| Ln (PHD/FACULTY) | 0.308 | 0.29 | 0.770 | 0.502 | 0.49 | 0.624 |
| Ln (TTOPER/FACULTY) | -0.051 | -0.28 | 0.779 | -0.021 | - | 0.904 |
| | | | | | 0.12 | |
| PUBFAC | -0.029 | -0.08 | 0.939 | 0.081 | 0.22 | 0.827 |
| Ln FACULTY | 0.960** | 4.43 | 0.000 | 0.942** | 4.49 | 0.000 |
| SHRES | 0.004 | 0.00 | 0.997 | -0.102 | - | 0.917 |
| | | | | | 0.10 | |
| Intercept | -9.936** | -3.14 | 0.002 | -8.708** | - | 0.003 |
| | | | | | 2.94 | |
| Log likelihood | -142.71 | | | -140.80 | | |
| LR $\alpha = 0$ | 141.46 | | 0.000 | 131.44 | | 0.000 |
| LR | 29.83 | | 0.000 | 33.66 | | 0.000 |
| Pseudo-R ² | 0.095 | | | 0.107 | | |

LR: Likelihood test ratio to test the null that all the parameters associated to the regressors are equal to zero

α parameter associated to over-dispersion in the negative binomial model $Var(PAT_i) = \mu_i(1 + \alpha\mu_i)$.

LR $\alpha = 0$, likelihood ratio test to test the null of $\alpha = 0$.

** , * , significant at the 1% and 5% level respectively.

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