Paper to be presented at the DRUID Academy conference in Rebild, Aalborg, Denmark on January

15-17, 2014

Does Inventor Royalty Share matter in low license income countries?

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Abstract

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The purpose of this paper is to investigate whether a monetary incentive, the royalty share on patented inventions, offered by Spanish and Portuguese universities to the faculty involved in those inventions, has been a positive incentive to rise university patenting and licensing in both countries. In these countries university patenting is very recent and licensing revenues are very low, the recent dramatic increase in the quantity of patents might not have been matched by a corresponding increase in the ?quality? of patents produced, and Technology Transfer Offices (TTOs) are still in an early stage of their learning curve.

According to Lach, & Shankerman (2008) royalty share has been playing a positive role in USA. The Bayh-Dole Act (1980), assigning the Intellectual Property Rights (IPR) of inventions funded by Federal funds to the Universities where they had been produced, and the offer of a royalty share to inventors, who should disclose their inventions to University TTOs, contributed significantly to the dramatic increase in the number of patents awarded to universities after 1980. TTOs have existed in many US universities for several decades now. This is not however the case in Spain and Portugal. In Spain, TTOs were set up in the late 1980s, in parallel with a 1986 Law which set a faculty royalty share. In Portugal, the trend for setting up university TTOs has been more recent, as only in the early 2000s a network of TTOs was set up, although in a few cases a less formal TTO was already operational since the 1990s. IPR codes of conduct were approved after TTOs were set up, so, with one exception, a faculty royalty share has been in place for less than 10

years now. In parallel to the creation of this IP framework in the universities, university patent application and licensing rose significantly in Portugal after 2000, and a similar trend developed in Spain a few years before.
The methodology adopted to tackle the research question was twofold: on the one hand, a survey was performed on all university inventors who had previously patented, in both countries, asking them whether they were aware of the value of such a royalty share, what role did it play as an incentive to invent and whether they were happy with its current value. This Survey had been preceded by a Survey to every TTOs on the size and year of implementation of a royalty share. On the other hand, an econometric study was performed, using patent applications as the dependent variable for both countries (and additionally licensing revenues for Spain only, as such values have not been disclosed by Portuguese universities), and Faculty Royalty Share as the independent variable, controlling for university characteristics such as Faculty size, TTO age and personnel, dependent variable pre-sample average values and R&D expenses.
Only 28% of university researchers in Spain and 48% in Portugal knew the Royalty Share value in effect in their universities. Among those who knew the royalty share value, 62-63% found that share high enough to motivate invention and disclosing for patenting. Further, about 58 to 62% of the researchers accepted that there is a minimum threshold for the royalty share above which it is worthwhile to increase the effort to produce patentable inventions, but the average value suggested by them for this threshold is significantly under the current average value for the royalty share in both countries. We could thus conclude that the royalty share is only partially acknowledged and plays a minor role in the decision to generate patentable inventions in Portugal and Spain.
The results of the econometric study for both countries are fully aligned with the Survey results, as the effect of the Faculty Royalty Share in patent applications is rejected at the usual significance levels. Additionally in Spain the effect on licensing revenues is equally rejected.
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Lach, S., Shankerman, M., 2008. Incentives and invention in universities. Rand Journal of Economics 39, 403-433.
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Jelcodes:I23,O32

ABSTRACT

The purpose of this paper is to investigate whether a royalty share on patented inventions, offered by Portuguese and Spanish universities to the faculty involved in those inventions, has been a positive incentive to rise university patenting and licensing in both countries. The methodology adopted to tackle the research question is twofold. On the one hand, a survey was performed on all university inventors who had previously patented, in both countries, asking them whether they were aware of the value of such a royalty share, what role did it play as an incentive to invent and whether they were happy with its current value. This survey had been preceded by a survey to all Technology Transfer Offices (TTOs) on the size and year of implementation of a royalty share, in both countries. On the other hand, an econometric study was performed, using patent applications as the dependent variable for both countries (and additionally licensing revenues for Spain only, as such values have not been disclosed by Portuguese universities), and faculty royalty share as the independent variable, controlling for university characteristics such as faculty size, TTO age and personnel, dependent variable pre-sample average values and R&D expenses. We could conclude from the university inventors' survey results that the royalty share is only partially acknowledged and plays a minor role in the decision to generate patentable inventions in Portugal and Spain. The results of the econometric study for both countries are fully aligned with the survey results, as the effect of the faculty royalty share in patent applications is rejected at the usual significance levels. Additionally in Spain the effect on licensing revenues is equally rejected.

1. Introduction

It has become generally accepted that knowledge produced by faculty in universities can have a real effect in the economy. University technology transfer can be performed using different mechanisms, such as hiring of students, sponsored research, licensing and spin-off firms (Bercovitz and Feldman, 2006) or simply by knowledge spill-overs. The magnitude of the effects is not homogeneous across universities, it depends on universities' ability to transfer the generated knowledge into the economy.

In this context, increasing the number of university patents and licenses has thus become a goal for policymakers in the latest years. The purpose of this paper is to investigate whether a monetary incentive, the royalty share on patented inventions, offered by Spanish and Portuguese universities to the faculty involved in those inventions, has been a positive incentive to rise university patenting and licensing in both countries. It has to be taken into account that in these countries university patenting is very recent and licensing revenues are very low, the recent dramatic increase in the quantity of patents might not have been matched by a corresponding increase in the "quality" of patents produced, and TTOs are still in an early stage of their learning curve.

Lach, & Shankerman (2008) note the dramatic increase in the number of patents awarded to universities from 500 in 1982 to 3255 in 2006 in the USA and state that part of this rapid growth is due to the passage of the Bayh-Dole Act (1980), assigning the IPR of inventions funded by Federal funds to the Universities where they had been produced. Further, they provide econometric evidence that the offer of a royalty share to inventors, who should disclose their inventions to University TTOs, contributed significantly to that great increase.

TTOs have existed in many US universities for several decades now. This is not however the case in Portugal and Spain. In Spain, TTOs were set up in the late 1980s, in parallel with Law 11/1986 of Patents of Inventions and Utility Models which ruled that universities are the owners of the patents but researchers have the right to participate in the benefits. In Portugal, the trend for setting up university TTOs has been more recent, as only in the early 2000s was a network of TTOs set up, although in a few cases a structure similar to a TTO was already operational since the 1990s. IPR codes of conduct were approved after Portuguese TTOs were set up, so, with one exception, a faculty

royalty share has been in place for less than 10 years now. In parallel to the creation of this IP framework in the universities, university patent application and licensing rose significantly in Portugal after 2000, while a similar trend developed in Spain a few years before.

The methodology adopted to tackle the research question was twofold. On the one hand, a survey was performed on all university inventors who had previously patented, in both countries, asking them whether they were aware of the value of such a royalty share, what role did it play as an incentive to invent and whether they were happy with its current value. This Survey had been preceded by a Survey to every TTOs on the size and year of implementation of a royalty share.

The response was overwhelming as we got answers from all university TTOs in Portugal and 89% in Spain. The response rate concerning the inventors' survey was also very good: 40% of all university inventors in Portugal and 20% in Spain! Only 28% of university researchers in Spain and 48% in Portugal knew the royalty Share value in effect in their universities. Among those who knew the royalty share value, 62-63% found that share high enough to motivate invention and disclosing for patenting. Further, about 58 to 62% of the researchers accepted that there is a minimum threshold for the royalty share above which it is worthwhile to increase the effort to produce patentable inventions, but the average value suggested by them for this threshold is significantly below the current average value for the royalty share in both countries. We could thus conclude that the royalty share is only partially acknowledged and plays a minor role in the decision to generate patentable inventions in Portugal and Spain.

On the other hand, an econometric study was performed, using patent applications as the dependent variable for both countries (and additionally licensing revenues for Spain only, as such values have not been disclosed by Portuguese universities), and faculty royalty share as the independent variable, controlling for university characteristics such as faculty size, TTO age and personnel, dependent variable pre-sample average values and R&D expenses. The results of the econometric study for both countries are fully aligned with the Survey results, as the effect of the royalty Share in patent applications is rejected at the usual significance levels. In Spain, the effect on licensing revenues is equally rejected.

The paper is structured as follows. In Section 2 a brief literature review on the role of monetary incentives in university patenting and licensing is highlighted, combining with data and information on the contextual framework (patents, laws, university regulations) in Portugal and Spain. In section 3 we present the data we have collected while in section 4 we highlight the analytical framework and the econometric specification. In section 5 we analyze both results of the econometric estimations and the results and key points from the surveys. In section 6 we present and discuss our main conclusions. Additionally, we highlight in the Appendix the process of data collection.

2. Literature review and contextual framework

2.1. Literature review

Many papers have analyzed university technology transfer (UTT) and university patents in the last two decades. Verspagen (2006) surveys the literature on university patenting while Baldini (2006) provides a review of the literature on patenting and licensing in universities. In special thematic issues Grimaldi et al. (2011) review the effects of Bayh-Dole Act of 1980 on academic entrepreneurship and Lissoni (2013) reviews the academic patenting in Europe.

Some papers have addressed the issue of incentives in UTT. Friedman and Silberman (2003) study whether incentives, as well as management and location, matter in the increase in University patenting in the 90's in USA. They highlight the dramatic increase[1] in technology transfer in the period 1991 to 2000 and use statistic data from the period 1997 to 1999 to conclude that 4 factors contribute to enhance UTT: greater rewards for faculty involved, location in a region with a concentration of high technology firms, a clear university mission in support of TT and the experience of the UTT office. The authors stress that the findings on the impact of royalty share were not as strong as anticipated and that the strongest impact of the variable was on the license income

[1] AUTM Licensing Survey FY 2000: 79% increase in invention disclosures (n=76), 230% increase in patent applications (n=73), 159% increase in licenses executed (n=75) and 611% increase in gross license income executed (n=78) in the period 1991 to 2000.

received[2]. They also found that a department RS works in the opposite direction, as it seems there to be a kind of a "zero sum game" with respect to the inventor. In other words, a split of the RS between the inventor and his department reduces the income available to the inventor and has a negative impact on TTO performance.

Markman et al. (2004) claim that less than 50% of the inventions are not disclosed to the TTO, as high quality faculty might be more interested in academic achievement and publishing their research. Further, they point out that there is an inherent misalignment between tenure requirements and universities' objective to support entrepreneurial activity. It is also argued that many of the disclosed inventions are of questionable value. Using a sample of 128 USA universities with 1999/2000 data, the authors tried to explain university entrepreneurial activities using different dependent variables[3]. They came to the conclusion that, opposite to their theoretical predictions, incentives to scientists and their departments were negatively related to entrepreneurial activity while pay to UTTO personnel, consistent with theory-based predictions, was positively related to this entrepreneurial activity.

Lach and Schankerman (2008) use similar data to Friedman and Silberman (2003), the AUTM Annual Licensing Surveys for the year 1991-1999, to study the impact of inventors' RS on license revenue. Their main conclusions are:

1. Royalty share affects the level of license income generated by Universities
2. Incentive effect of RS appears to work both through the effort and sorting channels, i.e., a larger RS incentivizes not only the effort of the faculty in a given university as well as it attracts more productive scientists. The incentive effort is thus split in i) pure effort and ii) sorting (competing to attract the most commercial oriented inventors).
3. Response to incentives is much stronger (and more significant) in private universities.

[2] Actually the RS is statistically significant only for licensing income and not for other TTO outputs: i) licenses executed ii) licenses generating income iii) cumulative active licenses. In all cases the sign of the parameter is positive (weak impact, according to the authors).
[3] Number of equity licenses to new ventures, number of university business incubators and number of startup ventures that are based on university technology.

The authors defend that there is also a "Gatekeeper" effect, an interaction between the incentive effect and the effectiveness of the TLO. If the TLO is not effective at all, RS has no impact at all.

Belenzon and Schankerman (2009) shift the focus from inventors/faculty to TTO personnel, using panel data on U.S. universities for 1995-99. Effectiveness of commercialization of inventions by university's TLOs is conditioned by i) university objectives ii) government constraints and iii) incentives (within the TLO). Performance pay to TLO's personnel increases licensing income per license in 30 to 40% and, when this exists, ownership (private vs public universities) doesn't influence performance. Universities with strong local development objectives see their licensing income reduced.

Baldini (2010) uses a dataset of Italian universities' patents between 1988 and 2002 to study the impact of the inventors' RS in patenting activity. Baldini stresses the role of TTOs, namely their engagement on running seminars and raising awareness on TT, on site scouting (identify inventions) and training (inform academics) and on lowering the cost of the faculty's engagement in patenting activity. He finds that the patent activity indeed depends on "equo premios" (RS) as well as on the existence of a TTO in the university, on the existence of a fixed lead time from disclosure to filing (deadline) and on the kind of commitment to patenting in the university to exploit the invention, i.e, whether patenting is seen by the university more as a "duty" as opposed to a mere "right".

Caldera and Debande (2010) use the data of a confidential survey[4] of the Spanish TTO network to study the transfer activities of 52 out of 71 universities in Spain, over 2001-2005. The authors find that university RS policy affects licensing income, but has no effect on the number of licenses. This effect is such that an increase in 10 percentage points in the inventor's share should generate, on average, about 80% increase in license income. The authors also find that TTO size has a positive and a significant effect on the number of licenses but it has no effect on licensing income. As expected, larger universities generate more licenses and more licensing income. They also find that technical universities produce a higher licensing income and more licenses, reflecting the

[4] RedOTRI technology transfer survey

fact that technical universities mainly produce applied research with a higher commercialization potential.

Geuna and Rossi (2011) study the changes to university IPR regulations in Europe and their impact on academic patenting and namely the moving away in the 1990s from inventor ownership of patents rights ("professor's privilege") towards different systems of institutional ownership. They stress the increased autonomy of most European universities, allowing them to devise bylaws that apply to the management of knowledge transfer. They note that the royalty share, the rights of Ph.D. students involved in the inventions, the baseline for TTO activities and the timing of patent filing procedures can vary widely among universities in the same country. They highlight some common developments in most European countries:

1. the total number of patents owned by universities increased rapidly in the 1st 10 years of the new millennium due to the entry of new actors (more universities with active TTOs)
2. the increase has been larger in countries which were late in developing an infrastructure for knowledge transfer
3. patenting and licensing performance of European TTOs appear to be lower than that of the US organizations

They conclude that empirical analyses seem to suggest that the key determinant of increasing enforcement of IPR ownership is the creation of an infrastructure for knowledge transfer involving an active role of university institutions.

At last, Toivanen and Vaananen (2012) study the financial returns of employee inventors, using a dataset of individuals where they observe USPTO patent grants, in the period 1991-1999, for their inventions, and the annual evolution of their salaries in the year of granting and in the following years (6years max.). They address two different kind of returns, the direct incentive schemes and indirect, translated in improved positions in the labor market. The authors note that only the highest quality patents, measured by number of citations, yield positive returns for inventors.

2.2. Contextual Framework for Portugal and Spain

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 in 1980 in the United States, which gave universities the property rights to university patents derived from research financed with federal funds. In Europe, with the purpose to create the right economic incentives for individual scientists to undertake more "patentable" research, some countries, such as Germany and Italy, changed the Intellectual Property Rights (IPR) system governing university researchers' inventions (Geuna and Nesta, 2006; Breschi et al., 2007; Verspagen, 2006; Geuna and Rossi, 2011). In general there has been a convergence of European IPR laws towards the US model trough the abolition of the professor's privilege and the increasing autonomy granted to universities (Lissoni, 2013).

Although there are still substantial differences in European countries in the systems governing research activities and patents in universities, the most common system currently is of institutional ownership (Geuna and Rossi, 2011). In this case, the university retains the ownership of the results of publicly funded research although generally the researcher has the right to a share of the possible profits derived from the exploitation of the patent. The alternative is the inventor ownership system where the university researchers are the owners of patents derived from their research activities.

Context for Portugal – Patenting at universities in Portugal was not an issue until the 1990's. Actually it was not until 1998 that the 1st University patent was awarded and only in 2001 did the stock of awarded patents to universities come to a double digit figure[5]. The share of university patenting in Portugal in the overall patenting rose steadily from very low figures up to a stunning 41% in 2009 and 2010. This share dropped to 28% in 2011, with a small recovery to 31% in 2012, in line with the evolution of the absolute number of university patenting.

The lateness of university patenting take-up could have a possible explanation in i) the fact that the research level and orientation did not provide any patentable matter ii) that the Portuguese Law which regulates the whole of the Industrial Property Rights, the

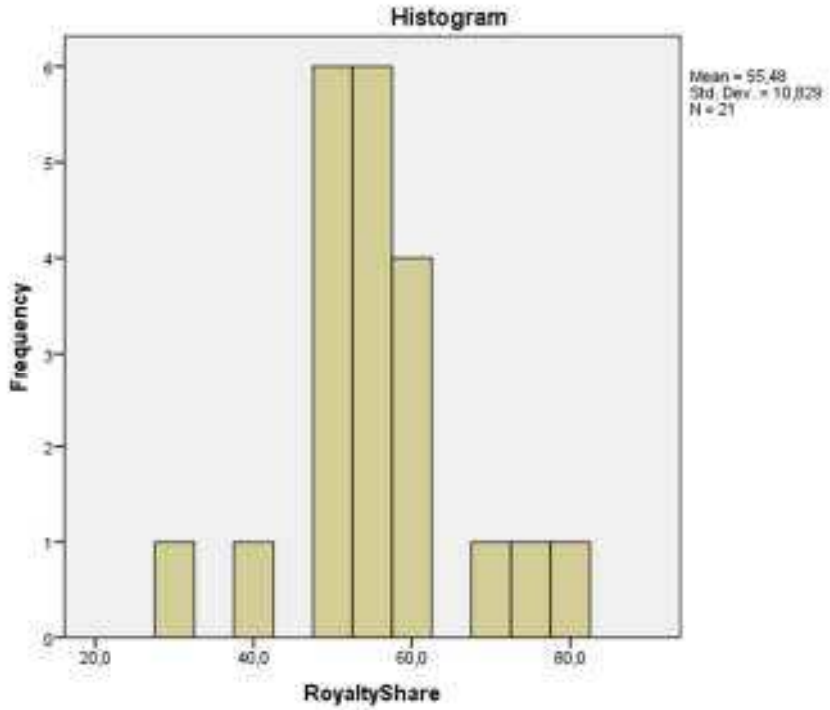
[5] http://pordata.pt/

"Código da Propriedade Industrial"[6] has been void of any specific reference to university Intellectual Property, iii) the fact that universities had been the sole proprietors of the inventions generated by faculty as statutory legislation on the High Education sector (HES) and on the University faculty career didn't foresee any faculty participation on licensing revenues. This latest aspect is in contrast with the fact that Public Researcher Organizations (non HES) researchers were entitled to 50% of revenues under 1999 regulation on Researchers´ careers[7].

Only in 1998 was an Intellectual Property Regulation (RPI) settled in Instituto Superior Técnico (IST), a polytechnic school[8], establishing that the school was the owner of the Intellectual Property Rights with a licensing revenue share by faculty of 50%. This was later followed by the 1st adoption of a RPI in an University, in 2003 (University of Coimbra), with an inventor royalty share of 55%, and by a wave of other university IP regulations (IPR) in 2005, when 6 universities adopted their RPI, with inventor royalty shares ranging from 45 to 60%. The number of universities adopting RPI, covering royalty share fixation, rose steadily until 2011, where another big wave of RPI adoption occurred, in such a way that in 2013 the vast majority of public Universities and "Institutos Politécnicos" [9] (IPs) had a RPI in place, while others were in the process of setting one. All of them establish that the university is the owner of the IPR.

The average value for the inventors' royalty share was in 2012 just over 55%: 55.5% for the mean, 55% for the median. Values are highly concentrated in the interval 50-60%. The remaining share is in most cases split between the university, the school or department to which the inventors belong and the Research Unit where the inventors perform their research.

[6] http://www.marcasepatentes.pt/files/collections/pt_PT/43/199/Decreto-Lei%20n%20%C2%BA%20143-2008%20de%2025%20de%20Julho.pdf
[7] Estatuto da Carreira de Investigação Científica
http://alfa.fct.mctes.pt/apoios/unidades/estatutocarreirainvestigacao.phtml.pt
[8] In the sense it is used in Spain: engineering school.
[9] These were established originally in Portugal as High Education courses, more focused on practical and technical matters and on shorter duration of B.A. or M.A. courses, which exclude Medicine and Law, for instance. They are mostly focused nowadays on technologies, arts and education and they don't award any PhD degrees. These IP don't coincide with the Spanish concept of PI, which are actually engineering schools. IST in Portugal is clearly a PI, in the Spanish sense.



Under the law on faculty´s career (Estatuto da Carreira Docente)[10], faculty have 4 main tasks: i) research and technological development, ii) teaching, iii) scientific diffusion and university extension and iv) management. Patenting is not specifically valued by this Law as a criteria or a positive factor for academic promotion and it is not even mentioned. Nonetheless, in the wake of the latest changes on this legislation, dated 2009, universities passed their own regulations on the evaluation of their faculty performance as of 2010. In a small number of cases patents are not referred at all. Some other regulations refer nothing on patents and defer detailed regulation to schools and departments, while others explicitly value patents, some of them in detail. Most of the times patents are undervalued if compared with international publication, mostly because patents are filed in the "extension/transfer of knowledge" task, not on research and technological development. "research" is clearly the task which is more valued, sometimes tied to "teaching", and "extension" is usually the least valued, sometimes neck to neck to "management". In most cases a clear distinction is made between the value of a national and of an international patent. Only in a minority of cases are patents in similar grounds with articles/papers[11].

[10] http://www.unl.pt/data/docentes/legislacao-alteracao-ao-ecdu.pdf

[11] If this is the case an international patent is usually valued as an article of A class (highest ranked Journals), and a national patent as an article B class (Journals ranked after A Class). There is still another class of pair reviewed Journals, C class.

In Portugal, 2 different type of TTOs coexist: GAPIs, which are technology licensing offices (TLOs), and OTICs, technology transfer offices (TTOs)[12].

GAPI were initially funded by the Portuguese patent and trademark office, INPI, as of 2000, within universities, technology centres and business associations, with the aim of promoting the use of intellectual property. Another type of structures, OTICs, was established as of 2006 by a government organization, the Innovation Agency (AdI) and these have been exclusively implemented in higher education institutions. GAPIs and OTICs activities are mostly complementary, though often their goals are partly overlapping. They are both rather small, usually employing up to two or three technicians. As some of the GAPI and OTIC were incepted in previously existent entrepreneurship offices, or, in a minor name of cases, were instrumental in the birth to such structures, technology licensing and transfer activities can coexist with tasks such as entrepreneurship, training, research management, scholarships, etc. When this occurs, and this is more frequent outside of the capital (Lisbon) and particularly where universities are closely rooted in the economy of the regions they are located in, they employ a larger number of people, which can go up to 10 people, but in these cases the figure of up to only 2 or 3 technicians engaged in technology transfer activities is also valid.

Context for Spain –

Although there are still substantial differences in European countries in the systems governing research activities and patents in universities, the most common system currently is of institutional ownership (Geuna and Rossi, 2011). In this case, the university retains the ownership of the results of publicly funded research although generally the researcher has the right to a share of the possible profits derived from the exploitation of the patent. The alternative is the inventor ownership system where the university researchers are the owners of patents derived from their research activities.

[12] For more details on the Portuguese TTOs see Godinho and Cartaxo (2011) **University patenting, licensing and technology transfer: how organizational context and available resources determine performance.** IEB Working Papers http://www.ieb.ub.edu/en/2012022157/ieb/latest-publications#.Upu8-8RdWSo

Spain was, among the European countries, an early adopter of the institutional ownership system such as the United Kingdom and Switzerland (Azagra-Caro, 2011; Geuna and Rossi, 2011). In Spain, universities are the owners of the inventions generated by university researchers but the inventors have the right to a share of the royalties derived from their patented discoveries.

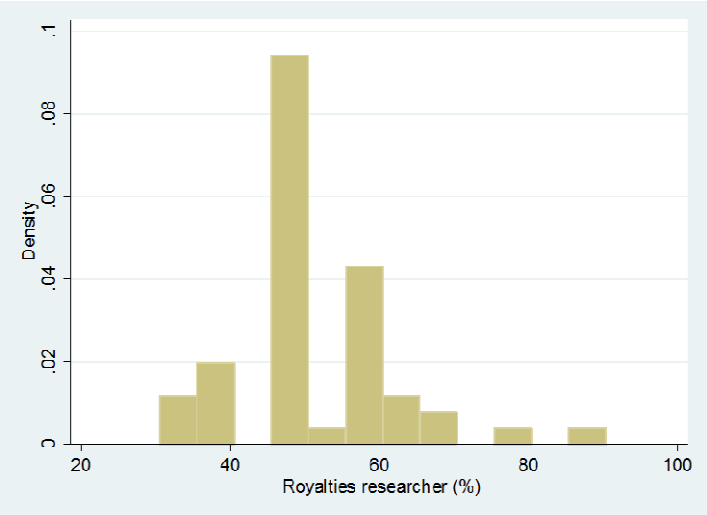
The Spanish Law of Patents (Law 11/1986 of Patents of Inventions and Utility Models), that regulates patenting activities to every type of institutions, gives both the university and the specific researcher incentives to patent the results of their research. Specifically, the Article 20 states that "the 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 than "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 Spain was an early adopter of the institutional ownership, patenting at Spanish universities were, similarly to Portugal, not very frequent and only concentrated in some specific universities until the 1990's. Since this date, the number of university-owned patents has experienced a continuous growth. While in 2000 universities applied for 210 national patents, in 2012 this figure rose to 496. Currently, the share of university patenting in the overall patenting is almost 15% while in 2000 it was 7.8%. Although the distribution of patents is strongly skewed and some universities are especially active, patenting is not restricted to a specific group of universities and in recent years almost all public universities have applied at least for one patent every year.

Parallel with the increasing involvement in patenting, Spanish universities have established internal rules for distributing any eventual royalties. Currently almost all the universities have their own regulation. The rules are freely decided by each university and have to be approved by the management bodies of the universities. 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 45-55%, while the university itself obtains around 30-35%. The rest is allocated to the department to which the researcher belongs while the share of the research group is marginal. In spite of these averages, the distribution of profits established by each university has given rise to significant differences among universities in the percentage of royalties assigned to universities and scientists. While some assign 80-90% of the profits to the university researcher, in other universities this percentage is situated at lower levels of around 35%.

Figure 1. Histogram royalty shares (% of the profits of the researcher)



The management of the different phases of university patenting, from the disclosure of the invention to the potential licensing of a university-owned patent, corresponds in Spain to the TTOs, called Offices for the Transfer of Research Results (OTRI). All the public universities in Spain have a TTO which are the main institutions responsible for the transfer of university research.

Spanish R&D policy experienced a substantial boost with the passing in 1986 of the Law for the Promotion and General Coordination of Scientific and Technological Research (the "Science Law"). This Law considered an important objective the promotion of the collaboration in R&D activities between firms and universities. In this context, the OTRIs were created at the end of 1988 with the support of the public policy as a structure to promote co-operation between university research and firms. In 1996, they acquired an

official character with the creation of an official registry. OTRIs are organised since 1997 in the OTRI network of universities and have undergone very significant growth in the last years. Although they are still much focused on administrative functions and the management of contracts continues to be one of the main tasks, they are increasingly playing a more active role in more sophisticated ways of transferring technology, such as the creation of spin-offs and licensing patents.

3. Data

In order to study the impact of inventor royalty shares on university technology transfer outcomes we use three self-constructed datasets (for each country): a university-level dataset, a survey to all Portuguese and Spanish TTOs and a survey to a representative sample of inventors in Portugal and Spain. We in turn describe each of these datasets.

University-level dataset – This dataset is used to carry out econometric regressions. It contains information on the inventor royalty share, the number of patent applications (in the respective national offices), license income (for Spanish universities only), size and age of the university TTOs, faculty size and the volume of R&D expenditures (for Spanish universities only). Table 1 provides descriptive statistics for each of these variables.

[INSERT TABLE 1]

TTOs' survey – The objective of this survey is to: 1) learn the inventor royalty share in each university (and whether it has experienced significant changes over time); 2) understand the process by which the royalty share was approved in each university; 3) understand the goals pursued by each university with the established royalty shares.

The survey was sent to all Portuguese and Spanish TTOs during 2011. The response rate was very satisfactory. All Portuguese TTOs (meaning 22 TTOs) filled the survey between June 2011 and April 2012. Similarly, 47 Spanish TTOs filled the survey between January 2011 and December 2012 (a 89% response rate).[13]

[13] Red-OTRI (the network of Spanish TTOs) counted 87 members in its 2010 directory. Most of them were TTOs ascribed to a university but some were universities without TTO or TTOs ascribed to centers other than universities (such as scientific institutes and research centers). Most of the scientific research, virtually

Inventors' survey – The main goal of this survey is to have direct feedback from university inventors on the effectiveness of the inventor royalty shares at stimulating their effort.

The target of the survey was all Portuguese and Spanish inventors that applied for at least one patent between the years 2005 and 2009 (both inclusive) at the USPTO, the EPO or the respective national offices (the INPI for the case of Portugal and the OEPM for the case of Spain). In order to come as close as possible to this target population we first retained all the patent applications (to the offices mentioned above) with the assignee being a Portuguese or Spanish university. We then searched for the email of the inventors of these patent applications through personalized Google searches. This yielded 534 email addresses in Portugal and 3,033 in Spain (after dealing with multi-applicant inventors). We invited all the inventors for which we had an email address to answer an online survey in January (Portugal) and November (Spain) 2012. We obtained 212 complete responses for Portugal and 606 for Spain (meaning a 40% and 20% response rate respectively).

4. Analytical setting and empirical specification

To study the effect of inventor royalty shares on universities' technology transfer outcomes we draw on the framework proposed by Lach and Schankerman (2008). In this model scientists make three types of effort: basic research (e), applied research devoted to starting new projects (z) and applied research aimed at improving the quality of each project (q). The number of new research projects $n(z)$ is of course increasing in z. Scientists derive utility from both publications and license income. The number of publications is increasing in the three types of effort $p(e,z,q)$ while expected license income only depends on the last two types of effort plus on the effectiveness of the TLO $r(z,q,\theta)$. If the TLO is extremely bad at commercializing licensed inventions the inventor will get zero revenues irrespectively of the effort devoted at obtaining high quality inventions. The license revenue the scientist is able to appropriate depends on the inventor royalty share (s): $sr(z,q,\theta)$. The first order conditions of the scientist's utility

all the patents and license income is generated by 53 public universities. Therefore, the survey was sent to the TTOs of these universities which form our relevant population (47 of which filled it).

maximization problem with respect to the three types of effort shows that optimal z and q are increasing in the inventor royalty share s and TLO effectiveness θ. This implies that license revenue and the number of new research projects per faculty are both also increasing in inventor royalty shares and TLO's effectiveness: $r(s,\theta)$ and $n(s,\theta)$.

University license revenue and number of projects equals the scientist expected license income and number of projects times the faculty size (F) up to a multiplicative measurement error (e^u): $R = Fr(s,\theta)e^u$ and $N = Fn(s,\theta)e^u$. Taking logs and linearizing yields the following empirical equation

$$y_{it} = \delta s_{it} + x_{it}\beta + u_{it} \tag{1}$$

where y_{it} stands for either $\ln R_{it}$ (the log of the university licensing income) or $\ln N_{it}$ (the log of the university patent applications), δ represents the effect of royalty shares on the corresponding dependent variable (through their incentive effect on scientist's research effort) and x_{it} includes (the log of) faculty size, proxies for θ such as TTOs' size and age plus a number of explanatory variables that capture differences across universities in their ability to license and patent.

Lach and Schankerman (2008) highlight two sources of unobserved heterogeneity that are likely to be correlated with s. First, researchers with more commercial orientation or more valuable inventions may be able to lobby their universities for more favorable royalty shares (a reverse causality problem). In this case, OLS estimates of δ would be upward-biased in a way that we could find an incentive effect when there is none. The results of the survey to the TTOs (which are discussed in detail in section 5) reveal that inventors play indeed a marginal role in the choice of the royalty shares both in Portuguese and Spanish universities. This suggests that our estimates are unlikely to be affected by this reverse causality problem. In any case, we will control for the pre-sample patenting of the university to address the potential problem of revere causality.

Second, higher inventor royalty shares may attract more innovation-oriented faculty (a sorting problem). In this case, the estimated δ would be an upward biased estimate of

the pure effort component of the royalty shares, but it would remain a consistent estimate of the overall incentive effect (including both the effort and sorting components). It is important to distinguish between effort and sorting as they have different policy interpretations: the effort channel would imply that higher royalty incentives increase aggregate inventive output whereas the sorting channel would imply that increases in the royalty shares only redistribute inventive outputs across universities. Unlike in the US, The sorting channel is likely to play a minor role in Portuguese and Spanish universities where workers' mobility is relatively low and earnings from inventions represent a small share of inventor's total earnings. The inventor's survey (which results are presented below) reveals a sticking unawareness of the royalty shares in force in their university by the inventors. This suggests that inventors are very unlikely to sort on the basis of differences in the royalty share across universities.

5. Results

5.1. Econometric evidence

Table 2 shows equation (1) estimates based on the unbalanced panels of Portuguese and Spanish universities (described in Table 1). [14] The dependent variables used in the regressions are the number of patent applications in the corresponding national patent office and license revenue (only for Spain since this information is not available for Portugal). While we observe most universities over several years it is important to notice that we cannot use within estimators because the royalty share displays little variation over time (only a few universities change the royalty shares over the sample period). Thus, the incentive effect of the royalty share will be identified from the cross-sectional variation in the data.

[INSERT TABLE 2]

For each country and dependent variable we begin with a parsimonious specification that only includes the royalty share, pre-sample information on patenting to control for

[14] These panels only include universities for which all the relevant explanatory variables are available at some point in time (12 universities for Portugal and 39 for Spain). We experimented with a simpler specification with fewer explanatory variables (the royalty shares, pre-sample patenting and time dummies) that allowed for broader panels but the results remained unchanged.

unobserved heterogeneity and time dummies (columns 1, 3 and 5). The coefficient associated to the inventor's royalty share is insignificantly different from zero in all cases. Next we expand this specification with a series of additional explanatory variables (columns 2, 4 and 6). Again, the coefficient associated to the inventor's royalty share is insignificantly different from zero in all cases except for column (4) where it is significant at a 10% only. This set of results suggests that royalty shares play a negligible role at stimulating patenting and license income at the university level in Spain and Portugal.

Since all the potential sources of correlation between the royalty share and the error term would introduce an upward bias in our estimates our finding of no incentive effects of the royalty share should be regarded as highly reliable. The next step consists in understanding why royalty shares are ineffective. This is an important point because Portuguese and Spanish universities are clearly playing with the inventor's royalty share in pursue of better outcomes. What prevents royalty share based policies from being effective?

5.2. Evidence from the TTOs' survey

Table 3 shows that the average royalty share (RS) values are quite similar in the two countries (53.5% and 55.0%) with similar standard deviations as well. As pointed out above (2.2) RS values are highly concentrated in the 50 to 60% range for both countries. The extreme values are very close in the two countries: minimum of 30 for Portugal and 33 for Spain, maximum of 80 and 90% respectively.

[INSERT TABLE 3]

The process of approval of an inventor royalty share was, in both countries, a "centralized" process, as it was up to the Rector to decide (Portugal, 41%) or propose (Spain, 64%) on the value of the royalty share. In over a quarter of the cases in both countries, the most distinctive feature was the fact that researchers were heard, in the Scientific Council (Portugal) and in the Research Commission (Spain). The most "decentralized" process, with researchers actively participating in the process, was mentioned by 7 Universities in Portugal and by only one University in Spain. It can be

concluded that, with the exception of this last aspect, the process leading to the decision of which RS to adopt was quite similar in both countries.

It is clear that in both countries when approving an inventor royalty share the most important goal was to incentivize an increase in university patenting, as it was overwhelmingly (93%) noted by the Spanish TTOs, while 50% of Portuguese Universities shared this goal as well. Both countries highlight next the improvement of the scientific production in the university (40% and 36%), followed by the goal of maximizing total income from patents (31% and 27%) and by the development of spin-offs, which was also referred by a significant part of TTOs, namely in Portugal.

5.2. Evidence from the inventors' survey

The objective was to know whether i) this RS had had any influence on their decision to generate patentable inventions and ii) whether they felt the RS was high enough to incentivize the effort aimed at producing patentable inventions. Table 4 shows that only a minority of the researchers who have already patented (28% for Spain, 48% for Portugal) were aware of the value for the RS of their universities.

[INSERT TABLE 4]

As regards i) only a small minority of respondents values it as of high importance (11% in Spain, 14% in Portugal). The majority of respondents (67%, 57%) values it as of low or even no importance. Concerning ii) the majority of them (62%, 63%) thinks the current royalty share is high enough to incentivize their effort to produce patentable inventions. It is thus clear that university inventors in the case that they are aware of the royalty share value, they give it only a moderate importance and they are happy with its level.

Another issue is that concerning those who are not aware of the RS value and those who are aware and think it is not high enough, we wanted to know i) whether there would be a given threshold, above which they would find it worthwhile to devote effort to produce patentable inventions and ii) which would be the value for this threshold.

The majority (62%, 58%) of these inventors agrees with the idea that this threshold does exist. When confronted with a choice for this number, the mean answer is 30% for Spain and 46% for Portugal. Paradoxically, In the case of Portugal, only two universities have a royalty share which is inferior to this value, while in the case of Spain all universities have an inventor royalty share which is above the average threshold mentioned by the respondents.

6. Conclusions

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. However there is still little known about the influence that incentives have on researchers to generate patentable research. Detailed country-level studies are useful to analyse IPR regulation effects (Geuna and Rossi, 2011).

The objective of this paper was to investigate whether a royalty share on patented inventions, offered by Portuguese and Spanish universities to the faculty involved in those inventions, has been a positive incentive to rise university patenting and licensing in both countries.

The **Inventors Survey** show that he Royalty Share value in effect in their universities is known by a minority (28-48%) of the researchers. For a sound majority (62% in Portugal, 63% in Spain) of those who know the royalty share value, the current share value is high enough to motivate invention and disclosing for patenting. About 58 to 62% of the researchers accept that there is a minimum threshold for the royalty share above which it is worthwhile to increase the effort to produce patentable inventions. The average value suggested by them for this threshold is significantly under the current average value for the royalty share in both countries. We could thus conclude that the royalty share is only partially acknowledged and plays a minor role in the decision to generate patentable inventions in Portugal and Spain.

The results of the **econometric study** for both countries are fully aligned with the Survey results, as the effect of the Faculty Royalty Share in patent applications is rejected at the

usual significance levels. Additionally in Spain the effect on licensing revenues is equally rejected.

These results are somewhat counter-intuitive and in contradiction to the findings of Lach and Schankerman (2008), Baldini (2010) and Caldera and Debande (2010) which cover the reality of various countries in Europe who are trying to replicate the effects of Bayh-Dole in their countries. The quality and comprehensiveness of the surveys performed, covering i) all TTOs in Portugal and the vast majority in Spain and ii) getting answers from a staggering 40% of university inventors in Portugal and 20% in Spain make us believe that the phenomenon of UTT might otherwise be in still a juvenile phase in the Iberian peninsula as shown by the fact that university licensing revenues are still very low in Spain[15]. This fact coupled with the Survey and econometric results seem to indicate that university licensing in these two countries is still in a too early stage for this monetary incentive to be effective. It might also be that either i) quality of inventions is low, or ii) TTO are still very early on their learning curve or are not effective enough (gatekeeper effect), or both.

Further, the university patenting surge in the last decade in these two countries could in some cases also be linked to a strategy of some universities to raise their notoriety through the creation of a significant patent portfolio, although the economic value of their patents could be very low. In contrast, in the latest years some universities may have been following a different strategy by restraining the number of applications to limit application and maintenance costs, but expecting higher returns per application.

TTOs are clearly underfunded and understaffed in both countries Also, the message for the need to disclosure their inventions or the advantages of patenting and licensing is most probably not being sent across the wide audience of faculty and other researchers. The valuation of patenting for academic career is still timid and too recent to seriously impact on disclosing, patenting and licensing.

[15] We believe this figure could be probably even lower in Portugal, as Portugal has entered this path some years later than Spain. The fact that Portuguese universities are not willing to disclose licensing revenues reinforces this belief.

The results have some implications for R&D and innovation policy. Firstly, it is convenient that TTOs play a more strategic role and not, as currently happens, be mainly focused on administrative tasks. This strategic role should be addressed to increasing the quality and internationalisation of the university patents and their possibilities of being licensed. Secondly, 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. Therefore, to increase patents and licensing it would be not enough with changes in royalty arrangements between universities and researchers.

Avenues of thought to explore:

It could be interesting to analyse whether researchers would respond differently in cases where patenting might be connected with academic evaluation and career advancement. This could take into account the traditional Merton thesis that researchers do not seek monetary compensation but, above all, they seek recognition through academic reputation.

The institutional configuration of universities may matter. Outside the polytechnics group the "generalist" universities may have a significant activity in the biosciences areas, which also offer an important patenting potential. It could be interesting to analyse the relative importance of scientific publication in engineering areas plus biosciences. We admit that universities with more publication weight in these two areas would have a higher patenting propensity.

The fact that the vast majority of the Universities analyzed is public, as private universities in both countries don't invest considerable resources on R&D might also play a role.

Another aspect to further explore in the future analysis is the role of public policies, namely monetary incentives to make patenting cheaper to academics, the provision of resources for universities establishing TTOs, support for academics to seek protection in foreign offices etc.

In Portugal, the activites of the University Technology Entreprise Network (UTEN)[16], bringing together the most active university TTOs and strongly focused on training TTO officials in Technology Transfer activities in US Universities, have contributed to the reinforcement of the UTT community. Might this be a symptom of a future enhanced co-operation, maybe sharing resources across universities and TTOS and possibly rendering it easier to build a critical mass?

We might also explore whether the external links that universities establish are in any way correlated with their patenting propensities, namely the number and revenue from contracts with industry, involvement in international partnerships or participation in the EU RTD FPs etc.

[16]UTEN is a network of 15 professional Technology Transfer Offices (TTOs) focused on the commercialization and internationalization of Portuguese Science and Technology (S&T)", involving a partnership with University of Texas at Austin. http://utenportugal.org/;

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TABLES AND FIGURES

Table 1. Descriptive statistics

	Spain				Portugal			
	Mean	S.d.	Min	Max	Mean	S.d.	Min	Max
	License revenue regression							
	(N=155, N*T=39)				(N=0)			
License income (in thousands of Euros)	66.32	99.59	0	600				
Royalty share	53.87	10.71	33	90				
Average patent applications	8.20	8.06	1	36				
Size of the TTO	17.31	15.71	3	83				
Age TTO in 2006	14.95	3.52	4	20				
Faculty size	2,812	4,565	546	40,879				
R&D (in thousands of Euros)	33,243	25,676	3,825	119,000				
	Patent application regression							
	(N=39, N*T=188)				(N=12, N*T=50)			
Patent applications	11.95	11.47	0	72	10.30	10.10	0	54
Royalty share	53.67	11.43	33	90	54.80	9.03	30	80
Average patent applications	7.74	7.66	1	36	9.87	13.36	0	48
Size of the TTO	16.35	14.96	3	83	4.76	2.81	1	9
Age TTO in 2006	14.74	3.65	4	20	4.80	4.69	0	16
Faculty size	2,617	4,192	546	40,879	965	434	424	1,924
R&D (in thousands of Euros)	31,225	24,627	2,575	119,000	na	na	na	na

Table 2. License revenue, patent applications and inventor royalty shares

	Portugal		Spain			
	Patent applications		Patent applications		License revenue	
	(1)	(2)	(3)	(4)	(5)	(6)
Royalty share	-0.00	-0.01	0.01	0.01*	0.01	0.01
	(0.02)	(0.02)	(0.01)	(0.00)	(0.02)	(0.02)
log(Average patent applications)	0.42**	0.19	0.78***	0.57***	0.88***	0.29
	(0.14)	(0.17)	(0.07)	(0.10)	(0.25)	(0.35)
log(TTO/Faculty)		-0.36		0.11		0.17
		(0.27)		(0.08)		(0.35)
Age TTO		0.08		0.04		-0.03
		(0.09)		(0.06)		(0.25)
Age TTO squared		-0.00		-0.00		0.00
		(0.01)		(0.00)		(0.01)
log(Faculty)		-0.16		0.42**		0.63
		(0.21)		(0.16)		(0.41)
log(R&D/Faculty)				0.24*		0.51
				(0.14)		(0.40)
Constant	1.29	1.23	0.01	0.01*	0.01	0.01
	(0.74)	(1.57)	(0.01)	(0.00)	(0.02)	(0.02)
Observations	50	50	188	188	155	155
Universities	12	12	39	39	39	39
R-squared	0.31	0.38	0.66	0.71	0.24	0.37

Notes: ***, ** and * indicate significance at a 1%, 5% and 10% level respectively. Clustered robust standard errors in parentheses. The dependent variable is the log of one plus the number of patent applications and total license revenue. All the regressions include a full set of time dummies. The sample used considers the period 2007-2011 (both years inclusive).

Table 3. TTOs' survey

	Spain	Portugal
1. Inventor royalty shares descriptive statistics (%)		
Mean	53.5	55.0
Standard deviation	11.5	10.6
Min	33	30
Max	90	80
2. Process by which the inventor royalty share was approved		
Unilateral proposal from the Governing Council (%)	64	41
Discussed in the Research Commission (%)	34	27
Researchers' participation was more intense (%)	2	32
3. Goals pursued with the established royalty share		
a. Incentivize an increase in university patenting (%)	93	50
b. Maximize total income from patents (%)	31	27
c. Maximize university (TTO) revenues (%)	5	9
d. Favor the development of "spin-off" (%)	10	23
e. Improve the scientific production of the university (%)	40	36
f. Attract high quality researchers (%)	2	9
Total number of respondents	45	22

Table 4. Inventors' survey

	Spain	Portugal
1) Do you know what the inventor royalty share is in your university?		
Yes (%)	28	48
No (%)	72	52
# Respondents	606	212
2) Which is the influence of the inventor royalty share on your decision to generate patentable inventions?		
High (%)	11	14
Medium (%)	23	28
Low (%)	34	27
None (%)	33	30
# Respondents	168	102
3) Is the inventor royalty share high enough to incentivize the effort aimed at producing patentable inventions?		
Yes (%)	63	62
No (%)	37	38
# Respondents	168	102
4) Is there a minimum threshold above which you would find it worthwhile to devote effort to produce patentable inventions? (Addressed to researchers who do not answer yes in question 3)		
Yes (%)	62	58
No (%)	38	42
# Respondents	500	149
5) Which is this threshold? (Addressed to researchers who aanswer yes in question 4)		
5.1) All researchers		
Mean	29.9	45.6
S.d.	19.8	20.7
# Respondents	249	86
5.2) Researchers who know the current royalty shares		
Mean	47.2	53.8
S.d.	23.1	17.3
# Respondents	35	19
5.3) Researchers who do not know the current royalty shares		
Mean	27.1	43.3
S.d.	17.8	21.1
# Respondents	214	67
Difference 5.2)-5.3)		
Mean	20.3	10.6
S.d.	3.4	5.3
p-value	0.000	0.025