How Inventor Royalty Share affects patenting and income in Portugal and Spain

Pere Arqué-Castells[*], Rui M Cartaxo[†], Jose García-Quevedo[‡] and Manuel Mira Godinho[§]

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Abstract

Portuguese and Spanish universities have adopted well-defined royalty sharing schedules during the last fifteen years. We investigate whether the specified inventor royalty shares in these two countries have been effective at stimulating inventors' efforts and ultimately improving university outcomes. We base our empirical analysis on university-level data as well as on new self-collected surveys to inventors and Technology Transfer Offices (TTOs). Econometric evidence on the university-level dataset indicates that royalty shares have no impact on patenting or licensing income. The same result emerges from the inventor's survey with most respondents claiming to be largely unresponsive to royalty sharing. Evidence from the surveys to the TTOs and the inventors suggests that inventors do not react to royalty sharing because inventions' poor commercial prospects leave little income to be shared. The explanation for the poor commercial prospects is twofold. First, TTOs might not be sufficiently focused on commercializing inventions. Second, inventors apparently are not producing potentially licensable inventions.

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[*] Searle Center on Law, Regulation and Economic Growth (Northwestern University) and Barcelona Institute of Economics (IEB). e-mail: pere.arque@law.northwestern.edu
[†] Instituto Superior de Economia e Gestão/Universidade de Lisboa, UECE – Research Unit on Complexity and Economics. e-mail: r.car@sapo.pt
[‡] Department of Public Economics and Barcelona Institute of Economics (IEB), University of Barcelona (Av. Diagonal 690. 08034 Barcelona). e-mail: jgarciaq@ub.edu. Phone 34 934021988
[§] Instituto Superior de Economia e Gestão/Universidade de Lisboa and UECE – Research Unit on Complexity and Economics. e-mail: mgodinho@doc.iseg.utl.pt

1. Introduction

It is well documented that the so-called third mission of universities, consisting of transferring knowledge to industry, has real effects on local economic development (Etzkowitz, 2002; Jaffe, 1989). Knowledge transfer can take place via alternative routes such as the hiring of students, sponsored research, licensing, the creation of university spin-off firms or simply knowledge spill-overs (Bercovitz and Feldman, 2006). One mechanism that has become increasingly important for researchers and policymakers is patent licensing (Geuna and Rossi, 2011; Perkmann et al., 2013).[1]

A question that has aroused considerable interest lately is whether pecuniary incentives to inventors are a useful tool for improving licensing outcomes. In both the US and most European countries university intellectual property policies grant the university control rights over inventions (see Sampat et al., 2003 and Geuna and Rossi, 2011). The royalty income from inventions is then shared between the inventor and the university according to royalty shares generally specified by the university. This naturally allows (and even forces) universities to decide which pecuniary incentives, in the form of inventor royalty shares, are to be offered to inventors. If inventors care about royalties then universities can conveniently set inventor royalty shares so as to incentivize their effort. Available research presents mixed results as to whether royalty sharing arrangements are effective at incentivizing academics' efforts (Sauermann et al. 2010, Perkmann et al. 2013). This suggests that inventor royalty shares might effectively incentivize inventors' efforts in certain institutional contexts but not in others (Sauermann at al. 2010).

The purpose of our paper is to investigate the role of inventor royalty shares at incentivizing patenting and licensing in Portuguese and Spanish universities. These two countries present several specificities that make them an interesting case. First, university patenting and licensing are recent and remain low. Second, Technology Transfer Offices (TTOs) are relatively young and still in an early stage of their learning

[1] Patenting and licensing are an important component of university technology transfer which has been the focus of many papers in the last two decades. Verspagen (2006) surveys the literature on university patenting. Baldini (2006) provides a review of the literature on patenting and licensing in universities.

curve.[2] Third, inventor's quality at doing applied research might not be as good as in the US.[3] Four, both countries have been particularly active over the last years in developing the appropriate infrastructure for improving knowledge transfer (Geuna and Rossi 2011, Lissoni 2013, Cartaxo and Godinho 2014). Among the many measures taken is the adoption of well-defined royalty sharing schedules by universities. Have the specified inventor royalty shares successfully incentivized inventors' efforts in the described context? And, if they have not, what prevents inventor royalty shares from being effective in Spain and Portugal?

We build on the framework proposed by Lach and Schankerman (2008) to discuss the conditions under which inventor royalty shares are likely to be effective. Intuitively, inventors will only care about royalty sharing if the revenues to be shared are expected to be non-trivial. There are three factors that moderate the inventor's expected license revenue: the inventor royalty shares themselves, the effectiveness of the university TTO at commercializing patented inventions (the so called gatekeeper effect) and the ability of the inventor at doing applied research. Higher inventor royalty shares will generate a greater incentive effect if the right interplay between the three moderators exists (i.e. inventor royalty shares are sufficiently high, TTOs are good at commercializing inventions and inventors are good at generating licensable inventions). On the contrary, inventor royalty shares will not matter if the licensing game is blocked by a poor interplay between the three moderators (i.e., inventor royalty rates are too low or TTOs are bad at commercializing inventions or inventors produce inventions with little commercial value).

Based on this framework we put forward two research questions. First, is the interplay between moderators in Portugal and Spain such that inventor royalty shares are effective at stimulating inventors' efforts and improving university outcomes? Second, if it is not, what prevents inventor royalty shares from being effective? More specifically: are inventor royalty shares poorly chosen by universities, are TTOs bad at commercializing inventions, are inventors bad at generating licensable inventions?

[2] See Macho-Stadler et al. (2007) for a theoretical model on the role of TTOs in licensing university inventions.

[3] Both because universities recruit researchers with basic, rather than applied, research profiles and because recruitment practices are not always oriented at recruiting the best available candidates.

In order to empirically answer the two research questions of interest we rely on a mix of objective evidence from university-level data and subjective evidence from new self-collected surveys to TTOs and inventors. We exploit the content in the different datasets by combining descriptive statistics and econometric analyses.

The paper is structured as follows. Section 2 presents the analytical setting and derives the research questions of interest. Section 3 offers a review of the institutional context in Portugal and Spain and describes the datasets used in the empirical analysis. Section 4 empirically answers the research questions posed in Section 2. Section 5 concludes.

2. Analytical setting and research questions

In a traditional Mertonian world scientists' main goal is to establish priority of discovery by being first to communicate an advance in knowledge (Stephan, 1996; Lam, 2011). Accordingly, the great majority of scientists seem to be motivated by the traditional reputational and career rewards awarded by the scientific community that come in the form of eponymy, prizes and publication (Stephan, 1996; Lam, 2011). In line with this traditional view of scientists' motivations some studies have found reputation to be at the heart of scientists' decision to patent.[4]

While it is widely accepted in the literature that academics respond to non-pecuniary incentives, recent research has inquired whether academics also care about monetary incentives. The growing interest in understanding whether scientists react to monetary incentives is narrowly related to the invigorated interest in improving university technology transfer. Pecuniary incentives are regarded as a potentially effective mean of getting scientists involved, not just in discovery, but also in the transfer of the generated knowledge beyond the boundaries of academy (Markman, 2004).

Lach and Schankerman (2008) develop a simple model that captures the dual purpose of scientific research with scientists caring about both reputation (publications) and royalty income. They derive the sufficient conditions under which the inventor's royalty share stimulates the inventor's effort. As Geuna and Rossi (2011) point out, universities have an increasing amount of autonomy that allows them to devise bylaws affecting research

[4] See Bodas Freitas and Nuvolari (2012), Goktepe and Mahagaonkar (2010), Baldini et al. (2007) and Owen-Smith and Powell (2006).

activity and the management of knowledge transfer. Therefore, whether a measure works or not might depend on university-specific environmental parameters. Lach and Schankerman (2008) pay particular attention to one such university-specific environmental parameter: the effectiveness of the TTO at commercializing inventions (the so called gatekeeper effect). We "augment" their model to account for another environmental aspect: the ability of inventors at doing applied research.[5] This dimension is likely to modulate the incentive effect of the royalty shares in Portugal and Spain where academic inventors might have too low quality in applied research to produce licensable inventions.

Basic setup – Scientists derive utility from both scientific publications and license revenue. Scientific publications can be obtained through three types of effort: basic research, applied research devoted to starting new projects and applied research aimed at improving the quality of each project. License revenue (denoted by r) can be obtained through applied research devoted to starting new projects (new projects are denoted by n) and applied research devoted to improving the quality of these projects (to make sure that the new projects are sufficiently good for the TTO to commercialize them). Notice that the distinction between basic and applied research (together with the fact that basic research only affects publications but not license revenue) imposes a possible tradeoff between the two through the allocation of effort.

Importantly, the scientist's license revenue not only depends on her individual effort, but also on the pecuniary incentives offered by the university (the so called inventor royalty share $s \in [0,1]$), the TTO's effectiveness at commercializing inventions (the so called gatekeeper effect $\theta \in [0,1]$) and the scientist's ability at doing applied research (which we denote by $\lambda \in [0,1]$). This last dimension is not explicitly taken into account in Lach and Schankerman (2008) who assume scientists to have a sufficiently high level of ability ($\lambda = 1$) to generate inventions that will be licensed by the TTO with some probability. We want to consider an additional scenario with low ability scientists (

[5] We use "ability at doing applied research" to refer to the capacity of doing applied research that is suitable for economic exploitation through patenting and licensing. We could have also used the terms "ability at doing relevant or commercially oriented applied research". We admit that scientists can do quality applied research which simply may not be suitable for economic exploitation through patenting and licensing.

$\lambda = 0$) that produce inventions with no probability of being licensed by the TTO. The ability parameter λ can be accommodated within Lach and Schankerman (2008) setting as an interaction with the gatekeeper parameter θ. This implies that the expected commercial value associated to a given level of research effort can be attenuated either because the TTO is bad at commercializing ideas or because the inventor has low ability in doing applied research.

Lach and Schankerman (2008) show that optimal basic and applied research efforts (both devoted to starting new projects and to improving the quality of each project) are increasing in the inventor royalty share s, in the TTO effectiveness θ and in scientists ability at doing applied research λ.[6] This in turn implies that both license revenue and the number of new research projects per faculty are also increasing in s, θ and λ: $r(s,\theta,\lambda)$ and $n(s,\theta,\lambda)$.[7]

Moderators – Parameters s, θ and λ act as moderators of the scientist's research efforts. Sufficiently low values of any of these parameters would cause license revenue to drop the utility function thereby reducing scientists' incentives to make efforts in applied research (though not totally given that they could still want to make applied research to increase utility through publications). For instance, if the inventor royalty share is very low ($s = 0$) the scientist's license revenue is zero no matter the quantity or the quality of the inventions and the license revenue motive drops from the utility function. Similarly, if the TTO is very bad at commercializing inventions ($\theta = 0$), the scientist's expected license revenue is zero and all the scientist will care about is publications. Finally, scientists will not care about license revenue if their ability at doing applied research is so low that not even maximum applied research effort can raise the quality of their inventions above the minimum standards required for commercialization by the TTO ($\lambda = 0$). Scientists will therefore only play the licensing game if s, θ and λ take all reasonably large values and interact to create the appropriate incentives.

[6] These results only hold if diminishing returns to income in the utility function are not "too strong" and if there is complementarity between basic and applied research efforts. The results still hold for applied research (but not for basic research) even if there is no interaction between applied and basic research.

[7] Lach and Schankerman (2008) only provide results for s and θ. As mentioned above, one convenient way of accommodating parameter λ within their setting is to enter it interacted with θ (i.e. whenever we had θ now we have $\lambda\theta$). This implies that comparative statics results for θ naturally extend to λ.

Interaction effects – We are interested in assessing how inventors react to one of the three moderators of the inventor's efforts: the royalty shares (s). Of course, a first condition for the inventor royalty shares to be effective is that they need to take meaningfully large values. A second condition for the inventor royalty shares to matter is that both θ and λ need to be at least greater than zero. Otherwise, the expected royalties apportioned to scientists will always be zero regardless the inventor royalty share.

Research questions – If the right interplay between the "moderators" s , θ and λ exists the theoretical predictions in Lach and Schankerman (2008) should prevail and royalty shares should be effective. Whether they are is something that we want to test empirically. Our first research question is as follows:

> **Research question 1.** Are inventor royalty shares in Portugal and Spain effective at stimulating inventors' efforts and improving university outcomes?

All the empirical articles that have attempted to answer this question are summarized in Table 1. The literature provides mixed results that mirror substantial heterogeneity in the methodologies, datasets and geographical contexts analyzed (this is in line with the literature review by Perkmann et al., 2013). The variety in the results also suggests that the conditions for royalty shares to be effective might not hold everywhere. Understanding what contextual factors make royalty shares an effective pecuniary incentive has been the object of a reduced number of papers. Lach and Schankerman (2008) find royalty shares to be more effective in private universities (which are arguably more pro-active than public universities at commercializing inventions). Similarly, Belenzon and Schankerman (2009) find royalty shares to be substantially more effective in universities with TTOs under incentive pay. Both results can be taken as evidence that the gatekeeper effect matters. Walter et al. (2013) find that the extent to which financial incentives are effective at stimulating the inventor's propensity to disclose inventions depends on inventor characteristics such as academic field or patenting experience.

[INSERT TABLE 1]

Besides knowing whether inventor royalty shares are effective we want to know whether any of the "moderators" of the scientist's efforts is blocking the licensing game. First of all we want to know whether the inventor royalty shares are large enough for the licensing game to make sense. If they are, we want to study if the other two "moderators" are preventing the royalty shares from being effective. Our second research question can be formalized as follows:

> **Research question 2.** When inventor royalty shares are not effective, what prevents them from performing the role they were expected to play? More specifically: are inventor royalty shares poorly chosen by universities, are TTOs bad at commercializing inventions, are inventors bad at generating licensable inventions?

3. Institutional setting and data

3.1. Institutional setting

The Bayh–Dole Act of 1980 allowed US universities to retain intellectual property rights on patents resulting from government funded research and to license these patents on an exclusive or non-exclusive basis (Sampat et al. 2003). Most European countries have converged towards the US model trough the abolition of the professor's privilege and the adoption of institutional ownership (Geuna and Rossi, 2011; Lissoni, 2013). This is the case of Portugal and Spain where universities retain the ownership of inventions. We next describe the institutional environment in Portugal and Spain in some detail.

Institutional ownership – The Portuguese intellectual property law (Código da Propriedade Industrial) is void of any specific reference to university intellectual property. Universities have traditionally been the sole proprietors of the inventions generated by faculty with statutory legislation not foreseeing the participation of faculty on licensing revenues. The first explicit university-specific intellectual property right policy with well delimited inventor royalty shares was not adopted until 1998 in the Instituto Superior Técnico. Similar statues were gradually adopted over the next decade,

with the vast majority of universities having well defined royalty sharing schemes at present.[8]

Spain was one of the first European countries, together with the United Kingdom and Switzerland, to adopt the institutional ownership system (Azagra-Caro, 2011; Geuna and Rossi, 2011). The framework for scientific and patenting activities is well defined since the 1980s when the University Reform Law allowed university researchers to receive income from contracts with firms, including arrangements that led to patents and licensing (Azagra-Caro, 2011).[9]

TTOs – Both in Portugal and Spain the different phases of university patenting, ranging from the disclosure of inventions to licensing, are managed by technology transfer offices (TTOs).

In Portugal, two different types of TTOs coexist: GAPIs and OTICs. The former are technology licensing offices and can be found in universities, technology centres and business associations. The latter are technology transfer offices and are only operative in academic institutions (see Cartaxo and Godinho, 2011). GAPIs and OTICs are relatively young (most of them being created around or after 2000) and rather small usually employing up to two or three technicians.[10]

In Spain, TTOs go by the name of OTRIs (Offices for the Transfer of Research Results) and all public universities have one. OTRIs are responsible for the transfer of university research through a variety of forms including spin-off creation, R&D projects, patenting and licensing. The first OTRIs were created in 1988 via public policy initiative with the

[8] The University of Coimbra adopted explicit intellectual property right norms in 2003 and several other universities did so between 2005 and 2011.

[9] In particular, the Spanish Law of Patents (Law 11/1986 of Patents of Inventions and Utility Models) gives both universities and researchers incentives to patent the results of their research.

[10] GAPIs were created by the Portuguese Patent and Trademark Office (INPI) as of 2000 with the aim of promoting the use of intellectual property. OTICs were established as of 2006 by the Innovation Agency (AdI). Some GAPIs and OTICs were based in previously existing extension offices. In such instances, technology licensing and transfer activities coexist with other tasks (such as mentorship to spin-offs, training or research management). These GAPIs and OTICs tend to employ a larger number of people, but the figure of up to two or three technicians engaged in technology transfer remains valid for most universities.

aim to spur co-operation between university and industry.[11] OTRIs acquired an official character in 1996 and organized themselves in a network (known as RedOTRI) in 1997. The number of OTRIs grew substantially after these two events.

Royalty sharing schedules – Almost all universities in Portugal and Spain have their own regulation on the split of licensing income. The schedules are freely chosen by each university and have to be approved by their respective management bodies. Income is generally allocated either to universities or researchers, but on occasions can also be shared with the department or research group of the inventor. The royalty shares in force in each university are reported in the corresponding intellectual property rights rules of the university. Changes in their values have to be duly notified through changes in the intellectual property right statutes. As we will explain in more detail below, inventor royalty shares tend to concentrate around a 50% value and most universities specified their royalty sharing schedules after 2000.

Patenting and licensing trends – University patenting is a recent albeit increasing phenomenon in both countries. In Portugal patenting was not an issue until the late 1990's. Only in 1998 was the first university patent awarded and only in 2001 did the cumulative number of university patents come to a double digit figure. This late take up in university patenting could be partially accounted for by the failure of the intellectual property law to explicitly define norms with regard to university patenting. Despite the late start, the share of university patents in Portugal (over the total number of patents in the country) rose from almost zero in 2000 to more than one third in 2009. Little can be said about licensing as data on licensing income is not available for Portuguese universities. This already hints that licensing is not a prominent activity within Portuguese universities.

University patenting in Spain was not frequent until the 1990's. Since this date the number of university-owned patents has experienced a continuous growth with the number of university patent applications (in the national patent office) rising from 210 in 2000 to 496 in 2012. At present, patents awarded to universities account for almost

[11] The 1986 Law for the Promotion and General Coordination of Scientific and Technological Research (the "Science Law"), which emphasized the need to promote collaboration in R&D between firms and universities, set the basis for the creation of the first OTRIs.

15% of all patent grants (almost twice as much than in 2000). Although the distribution of patents is strongly skewed, with some universities being particularly active, patenting is not restricted to a specific group of universities and almost all public universities consistently apply for at least one patent per year nowadays. Total licensing income (from patented and non-patented technologies) has experienced a similar trend rising from €0.5 million in 2000 to €2.5 million in 2011. Licensing income from patents seems to account for slightly more than one half of total licensing income (with some variations over time). On average, each Spanish university generated €60,000 of license income per year during the period 2007-2011.[12]

3.2. 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 next describe each of these datasets.

University-level dataset – The university-level dataset is an unbalanced panel spanning the years 2007 to 2011 (both included) for 15 Portuguese and 39 Spanish universities.[13] The sampling criterion was to retain all university-years (over the period 2007 to 2011) for which all the following variables where observed: the inventor's royalty shares, the number of patent applications in the respective national offices, licensing income (only for Spain), size and age of the TTOs, faculty size and the volume of R&D expenditures (only for Spain). Naturally, the inventor royalty share had to be well defined for a university to make into the sample. Most of the instances in which we had to drop a university-year were due to information on the outcomes (patents or licensing) or the explanatory variable of interest (inventor royalty share) not being available. Therefore, we basically have all the available observations for the analysis we are interested in

[12] The numbers on licensing income can be found in the Red-OTRI Surveys for the years 2005 to 2011. Notice that the numbers reported for Spain are extremely low when compared to the US. According to Lach and Schankerman (2008) US universities generated on average $3.6 (€3) million of license income per year during the 1990s with the top 10% private universities earning over $11.5 (€10) million per year (almost five times more than all Spanish universities together).

[13] We restrict to post 2007 years because inventor royalty share schedules were not defined in several Portuguese universities in earlier years.

carrying out.[14] Table 2 provides descriptive statistics for each of these variables. Table 3 provides definitions and sources for the different variables.

[INSERT TABLES 2 AND 3]

The main outcomes of interest (licensing income and number of patent applications) take rather low values and its distribution is highly skewed across universities. Licensing income in Spain (no data is available for Portugal) ranges from a minimum of zero to a maximum of €600,000. Average licensing income is slightly above €60,000 per year, but the median is much lower staying at €29,600. The average number of yearly patent applications is around 10 for both Portugal and Spain. This number is also unevenly distributed across universities with the minimum and maximum values ranging from 0 to 54 in Portugal and 0 to 72 in Spain. The median number of patent applications is slightly below the mean (7.5 in Portugal and 9 in Spain).

Inventor royalty shares in Portugal and Spain present similar patterns. Figure 1 graphs the distribution of the royalty shares. The average and the median values for the inventor royalty share are around 55% in both countries. Most universities choose to set the inventor's royalty share between 50% and 60% with only a few universities choosing extremely low (close to 30%) or large (above 70%) royalty shares for the inventors.

[INSERT FIGURE 1]

TTOs' survey – The main objective of the survey to the TTOs was to learn the inventor royalty share in each university, the precise year in which royalty shares were set for the first time and whether they have experienced significant changes over time. We also were interested in understanding the administrative process by which the royalty sharing schedules were approved in each university and the goals pursued by each university with the specified royalty shares.

[14] The information dataset for Portugal contains information on 15 universities, which account for 97% of university patent applications in the period 2005-2012. Spain had 47 universities reporting information on patent applications and 44 universities reporting information on licensing in the 2010 Red-OTRI Survey. The university level dataset includes information on 39 universities. This accounts for 83% of the universities reporting patents and 89% of the universities reporting licenses.

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 and 47 Spanish TTOs did so between January 2011 and December 2012 (a 89% response rate).[15]

It turns out that most surveyed universities defined their royalty sharing schedules for the first time after 2000 (95% in Portugal and 73% in Spain). Once set, most royalty shares remained unaltered with only 14% of the surveyed Portuguese TTOs and 20% of the surveyed Spanish TTOs acknowledging variations over time. However, all these changes took place before the sample years taken into account in the econometric analysis (i.e., before 2007). Royalty sharing schedules generally resulted from a unilateral proposal by the governing councils of the universities, with researchers having almost no opportunity to influence the final decision. In most universities the main goal pursued with the established royalty sharing schedule was to incentivize patenting, but not so much licensing revenues. We will provide more detailed information in the TTOs' survey in the next section.

Inventors' survey – The main goal of the survey was to have direct feedback from university inventors on the importance of the inventor royalty shares. A second goal of the survey was to relate the effectiveness of the royalty shares to measures of quality of the inventors.

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 in Portugal and the OEPM in 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 (555 patent applications) or Spanish (5,148 patent applications) university. We then searched for the email of the inventors of these patent applications through

[15] 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 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).

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).

We asked inventors for some individual characteristics (field of research, age, gender, type of contract with the university, rank and measures of quality) and for their opinion on several aspects relating to the effectiveness of the royalty shares. Table 4 reports descriptive statistics of the inventor characteristics. Results on the inventor's perception of the royalty shares are discussed in the next section.

[INSERT TABLE 4]

4. Evidence

In what follows we try to empirically answer the two research questions posted in Section 2. We first study whether the inventor royalty shares are effective at stimulating inventors' efforts and improving university patenting and licensing outcomes. Next we analyze the role played by the moderators at attenuating the incentive effects that are to be expected from the inventor royalty shares. In order to tackle these two research questions we rely on the information in the university-level dataset and in the surveys.

Does the royalty share have an incentive effect in Portugal and Spain?

We first try to answer this question econometrically using the objective university-level dataset. 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): $R = Fr(s,\theta,\lambda)e^u$ and $N = Fn(s,\theta,\lambda)e^u$. Taking logs and linearizing yields the following empirical equation

$$y_{it} = \delta s_{it} + x_{it}\beta + u_{it} \quad (1)$$

where i indexes universities and t years. The dependent variable y_{it} stands for either $\ln N_{it}$ (the log of the university patent applications in the corresponding national patent office) or $\ln R_{it}$ (the log of the university licensing income, only for Spain since this information is not available for Portugal). The matrix of controls x_{it} includes (the log of) faculty size, proxies for θ such as TTOs' size and age, and proxies for λ such as R&D per faculty or the pre-sample number of patent applications that will capture differences in inventors' average quality across universities in doing commercially oriented research. The parameter of interest is δ, which captures the effect of the inventor royalty share s_{it} on the corresponding dependent variable. Positive values of δ would imply that inventor royalty shares are effective at stimulating inventor's efforts.

Lach and Schankerman (2008) highlight two sources of unobserved heterogeneity that are likely to be correlated with s_{it}. 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). This does not seem to be the case in Portuguese and Spanish universities according to the survey to the TTOs.[16] Second, higher inventor royalty shares may attract more innovation-oriented faculty (a sorting problem).[17] Unlike in the US, the sorting channel is likely to play a minor role in Portuguese and Spanish universities where faculty mobility is relatively low. In any case, we will rely on pre-sample information on patenting by universities to control for time invariant unobserved heterogeneity.

Table 5 shows equation (1) estimates based on the unbalanced panels of Portuguese and Spanish universities described in Table 1.[18] While we observe most universities over

[16] The TTO survey suggests that inventors play a marginal role in the choice of the royalty shares both in Portuguese and Spanish universities. The royalty share was a unilateral proposal from the Governing Council in 41% and 64% of Portuguese and Spanish universities respectively with no participation of the researchers. In about one third of universities in both countries the choice of the royalty share was discussed in the Research Commission giving researchers the opportunity to influence the final decision. Only in 32% of Portuguese and 2% of Spanish universities had the researchers a more active participation in the royalty share decision.

[17] 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).

[18] 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.

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 time and none of these changes take place during the sample period). Thus, the incentive effect of the royalty share is identified from the cross-sectional variation in the data. We use clustered-robust standard errors to allow for heteroskedasticity and autocorrelation within universities.

For each country and dependent variable we begin with a parsimonious specification that only includes the royalty share, pre-sample information on patenting by universities to control for 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. Regarding the other regressors, the pre-sample average number of patent applications enters significantly most of the regressions. This implies that the pre-sample number of patent applications at least partly controls for unobserved heterogeneity. The remaining explanatory variables are mainly insignificant. The experience of the TTO seems to positively affect patenting in Portugal and faculty size is positively correlated with patenting in Spain.

[INSERT TABLE 5]

Direct feedback from the inventors' survey (reported in Table 6) is largely in agreement with the econometric results. Inventors have a striking unawareness of the royalty shares in force: only 48% (Portugal) and 28% (Spain) of the respondents know what the inventor royalty share is in their university. This result is far below the results found for the US where there seems to be full awareness of monetary incentives among faculty.[19] The low degree of awareness is particularly dismaying because our survey was sent to

[19] Above 90% of the TTOs from US universities surveyed in Lach and Schankerman (2008) respond that their faculty is aware of monetary incentives. Importantly, we are obtaining this response from the inventors themselves instead of through the TTOs. This might partly explain the huge differences in the degree of awareness.

patent applicants, a subsample of faculty that should be concerned about monetary incentives for commercializing inventions. Not only is the degree of awareness low. For the vast majority of aware respondents the royalty shares had little or no impact on their decision to generate patentable inventions. Only slightly more than 10% of the aware respondents believed the royalty shares to be highly influential at incentivizing their research efforts.

[INSERT TABLE 6]

Why are inventor royalty shares not effective?

We next want to understand why royalty sharing policies are ineffective at incentivizing inventor's efforts. This is a legitimate question because Portuguese and Spanish TTOs are using royalty shares as part of their toolkit for improving technology transfer. Yet, as we have shown, they are failing to achieve any outcome. As discussed in the analytical setting several conditions are needed for royalty shares to be effective. First (and most obvious one), inventor royalty shares need to be sufficiently large (given the efficiency of the TTO and the inventors' ability in applied research) for inventors to care about licensing revenues. Second, the TTOs have to be sufficiently good at commercializing inventions. Third, inventors must have a sufficiently high ability in carrying out patentable applied research to produce licensable inventions.

We have shown in Section 3 that inventor royalty shares are well above zero and far from totally eliminating inventors' opportunities to earn licensing revenues. If royalty sharing schedules are not blocking the licensing game then at least one of the other two moderators must be. We next confirm that inventors believe inventor royalty shares to be sufficiently high as they are. Next we discuss the extent to which the other two moderators of inventors' efforts are to be held responsible for the ineffectiveness of the royalty shares.

Ineffective inventor royalty share levels – One potential explanation for the absence of results could be that the inventor royalty shares are poorly chosen. There might be a certain threshold below which inventor royalty shares are ineffective. Does such a threshold exist? Are current inventor royalty shares below this threshold?

Table 7 reports inventors' opinions on the values of the inventor royalty shares. Most of the aware inventors believe the inventor royalty share to be high enough to incentivize their effort. Most of the remaining inventors (those who are either unaware of the royalties or aware but find them too low) believe there to be a minimum inventor royalty share threshold above which it would be worthwhile to increase their effort. Surprisingly, these inventors believe the "effort" threshold to be, on average, below the average inventor royalty shares in force.[20]

Taken together these results suggest that inventor royalty shares are sufficiently high as they are to incentivize inventor's efforts. This reinforces the perception that either the gatekeeper effect or the inventors' quality in applied research cause inventions to have poor commercial prospects. Bad commercialization prospects prevent royalty shares from being a useful incentive device.

[INSERT TABLE 7]

Gatekeeper effect – As in most European countries, Spanish and Portuguese universities retain ownership of intellectual property rights, with the commercialization of the inventions ultimately depending on the TTOs. This implies that inventors' license revenues largely depend on TTOs' ability of finding licensees and negotiating agreements. As discussed in the analytical section, if the TTO does a poor job at commercializing inventions the royalty shares will have a smaller incentive effect or no effect at all. Is TTOs' inability to successfully commercialize inventions behind the ineffectiveness of the royalty shares?

One clever way of empirically testing for the gatekeeper effect in the US has consisted in exploiting the fact that private universities are more aggressive in their licensing strategies than public ones.[21] This strategy can hardly be implemented in Europe where

[20] This is entirely driven by unaware inventors who set the "effort" threshold 10 (in Portugal) and 20 (in Spain) percentage points lower than aware (but discontent) inventors.
[21] This is the strategy used in Lach and Schankerman (2008). Belenzon and Schankerman (2009) report that private universities are more are more likely to adopt incentive pay. Instead public universities tend to care more about local development objectives and often prefer to license to local start-up companies (often at the expense of forgone license income).

the bulk of universities doing scientific research are public.[22] Instead, we rely on more qualitative information from the surveys. We explicitly asked the TTOs for the outcomes pursued with their royalty sharing schemes. The results to this question (reported in Table 8) reveal that TTOs are relatively uninterested about maximizing licensing income. Less than one third of TTOs mentioned being interested in maximizing total licensing revenue (27% in Portugal and 31% in Spain) or TTO revenue (9% in Portugal and 5% in Spain). This lack of interest in generating licensing income anticipates poor commercialization perspectives for inventions. This perception was reinforced by several respondents to the inventor's survey, who accompanied their questionnaire with explanations for the uselessness of the royalty shares. Many pointed directly to the inability of their TTO at commercializing inventions. The essence of most comments is captured by the following sentence by one scientist: "who cares about getting 100% of nothing?".

[INSERT TABLE 8]

Interestingly, most of the TTOs claim to use the royalty shares to incentivize university patenting and to improve the scientific production of the university. These responses suggest that TTOs do not fully understand that royalty shares only generate an incentive effect in inventors' research efforts if conveniently accompanied by good commercialization prospects. The only way of increasing patenting and scientific production through royalty sharing is through a credible commitment to maximizing licensing income.

Overall, the feedback from the surveys is consistent with the econometric results reported in Table 5 where the proxies for the quality of the TTO at commercializing inventions (i.e. size and age of the TTO) are generally found to be not significant (only age seems to have a positive effect on patenting in Portugal).

Inventor's ability in applied research – An inventor would certainly not respond to royalty incentives if her ability in applied research was so low that her chances of

[22] Belenzon and Schankerman (2009) find that TTOs adopting incentive pay have about 30–40 percent more income per license. This effect is robust to differences in university ownership. We tried to implement this strategy but, unfortunately, almost no university in our sample adopts incentive pay.

producing licensable inventions were nil. We use the inventor's survey to study if higher quality inventors are more informed about the royalty shares and more sensitive to their values. We construct two dependent variables based on the results reported in Table 6. One dependent variable is a dummy variable with value one if the inventor is aware of the royalty share and value zero otherwise. The other dependent variable is a dummy variable with value one if the inventor thinks that the royalty share had a high or medium influence at incentivizing her effort and value zero otherwise. We regress these two variables on three measures of inventors' quality: whether the inventor has applied for patents in international offices (as opposed to only national offices), the number of "sexenios" [23] earned by the scientists and whether the inventor is a professor or not. Only the last indicator of quality is available for Portugal. The results are reported in Table 9. In all cases we control for gender, age and a full set of university and field fixed effects.

In columns (1) and (5) our proxy for quality in applied research is a dummy variable with value one if the inventor has applied for a patent in the USPTO or the EPO during the years 2005-2009 and value zero if it has only applied for patents in the national office (our preferred proxy). Inventors with international patent applications have a significantly higher degree of awareness of the royalty shares but do not seem to find them more important at incentivizing their efforts. In the next columns we use a set of variables that proxy a more generic type of quality: a set of dummy variables standing for the different number of "sexenios" earned by the scholar and a dummy variable with value one if the inventor is a professor. Neither of these variables seems to explain remarkably different attitudes towards the royalty shares. If anything, inventors with four "sexenios" seem to be slightly more likely to be aware of the royalty shares than inventors with no "sexenios" (but only at a 10% significance level). As a curiosity, there are significant gender differences in the degree of awareness of the royalty shares. Finally, the results remain stable when we simultaneously include all the variables in the regression.

[23] "Sexenios" are a complement of the researchers' salary given after an evaluation by a national Agency (CNEAI, National Commission of Evaluation of the Research Activities). This evaluation gives substantial weight to publications in international journals listend in the ISI's Journal Citation Reports. "Sexenios" are seen in the Spanish resesarch system as a proof of scientific excellence and its implementation has had positive effects on Spanish scientific production (see Jiménez-Contreras et al., 2003).

The finding that inventors with international patent applications are substantially more aware of the royalties is very suggestive. It seems that only higher quality patents with higher chances of being licensed spur inventors' curiosity for learning about royalty sharing. As shown in Table 4, the percentage of inventors with international patent applications in our sample is extremely low (below 10%). This suggests that most inventors are producing patents with little commercial value for which the royalty share does not matter much. It looks like pecuniary incentives would matter more if the vast majority of patents were publishable in international offices.

[INSERT TABLE 9]

5. Conclusions

We have investigated whether inventor royalty shares on patented inventions are an effective pecuniary incentive in Portuguese and Spanish universities. Plain regressions on university level datasets indicate that royalty shares have no impact on patenting or licensing income. The same result emerges from a new inventors' survey with most respondents declaring to have a low degree of awareness of the royalty shares and only a few aware respondents claiming to react to the inventor royalty share.

We have used the newly collected surveys to inventors and TTOs to understand why inventor royalty shares are ineffective. Nothing seems to be wrong with the current values of the inventor royalty shares. Most inventors find the royalty shares in force in their university to be sufficiently high to potentially incentivise their effort. It rather seems that inventors do not react to royalty sharing because inventions have poor commercial prospects. The explanation for these poor commercial prospects seems to be twofold:

First, TTOs are not sufficiently focused on commercializing inventions (i.e., finding licensees and negotiating agreements). It is important to note that both in Portugal and Spain research universities are overwhelmingly public with their TTOs lacking a clear commercial orientation. Indeed, there are TTOs in Portugal (see Cartaxo and Godinho, 2014) that claim to be much more focused on issues such as regional development or the boosting of local entrepreneurship through university spin-offs than in licensing

revenue. In some cases, (non-exclusive) licenses are even offered to local firms without any sort of payment just to maximize the chances that university generated knowledge is diffused within local economy agents. Another potential explanation for their lack of interest in maximizing licensing income is that TTOs can rely on other sources of financing stemming from university funds, revenues from training and consulting services, or overheads charged to researchers from European projects.[24] Our surveys to the TTOs mirror this lack of interest in licensing income. Quite surprisingly, royalty sharing schemes are aimed at maximizing the number of patents and not licensing revenues, as one would expect. This suggests that TTOs fail to fully understand that royalty sharing incentives operate through enhanced revenue opportunities for researchers.

Second, inventors seem to be failing to produce licensable inventions for which it would make sense to react to the royalty shares. Inventors applying for patents in international offices (arguably higher quality patents) seem to care more about royalty sharing. However, only a few university inventors in Portugal and Spain patent in international offices. While the number of patents in Portugal and Spain has grown dramatically over the last years the quality of these patents might still not be good enough to generate licensing income. A rationale for what is happening in both countries is that universities might be interested in obtaining patents mainly to enhance their reputation and use the reputation premium to foster technology transfer through R&D partnerships with the industry. A second possibility would be that patents are used to strengthen technology transfer through the creation of spin-off firms. In neither of these cases would patenting be related to licensing.

Another possibility for the absence of incentive effects could be that university scientists are disproportionately driven by the traditional academic motivations (i.e., eponymy, prizes and publication). This potential explanation has not been empirically tested in this paper (even though it has been taken into account in the analytical model that has produced the predictions tested in our paper). However, it is important to

[24] We shall add that most TTOs, particularly in Portugal, but also in Spain, lack scale and are still very early on their learning curve. Yet, in more recent years, some TTOs are moving from a "quantity" strategy to a "quality strategy" in patenting. Some TTOs seem to be more commercially aware of their activities and are reaching the critical scale to successfully license the patents of their universities.

acknowledge that traditional academic activities such as publishing have been much more important for obtaining tenure and other career promotions in Portugal and Spain than patents or licensing. Classic academic incentives impose a lower bound on the pay-off to commercially oriented research: scientists will only devote effort to producing commercially oriented inventions if the expected gains from doing so are greater than the gains from producing publications (i.e., the possibility to obtain tenured positions, promotions and eventually wage increases).

Our findings have policy implications. We have shown that inventor royalty shares in Portugal and Spain are ineffective essentially because inventions offer poor commercial prospects. For inventor royalty shares to be an effective tool both TTOs and inventors should be more commercially oriented. TTOs would have to commit to pro-active commercialization practices. This would involve searching for licensees and not just encouraging invention disclosure and the ensuing administrative tasks (by and large their current roles). Notice that most Portuguese and Spanish firms are not technology based, which means that the demand for licenses is probably abroad and that a successful licensing strategy would require further targeting international licensees. Additionally, for inventor royalty shares to be an effective incentive, scientists should be more commercially orientated. In other words, scientists should be able to produce inventions suitable for economic exploitation through patenting and licensing.

However, we do not want to push the policy implications too far as it might simply not be optimal from a welfare viewpoint to maximize licensing income. Universities in Spain and Portugal are public and as such are likely to prioritize goals other than maximizing licensing income. For instance, they might prefer to maximize regional development. There are forms of technology transfer such as spin-off creation or R&D cooperation agreements that are likely to better serve these purpose. Spin-offs, for example, tend to locate in the same region as the university from which they emerge thereby guaranteeing regional development (Zhang 2009; Zucker et al. 1998). Licensing, instead, only spurs regional development if inventions are licensed to local licensees. This might be at odds with maximizing licensing income.[25] Moreover,

[25] Belenzon and Schankerman (2009) find that public universities with strong local development objectives see their licensing income reduced because they prefer to license to local firms (even if it is at a discount).

universities might prefer their researchers to commit to academic research (which is believed to be a greater source of spillovers than commercially oriented research).

The apparent lack of interest in licensing income by Portuguese and Spanish universities might therefore be totally legitimate. Yet, TTOs in both countries are using royalty sharing schemes to improve technology transfer. It is perhaps this coexistence of a royalty sharing policy and an apparent lack of interest in licensing income that is somewhat puzzling for royalty sharing is effective only if combined with a credible commitment to commercialization.

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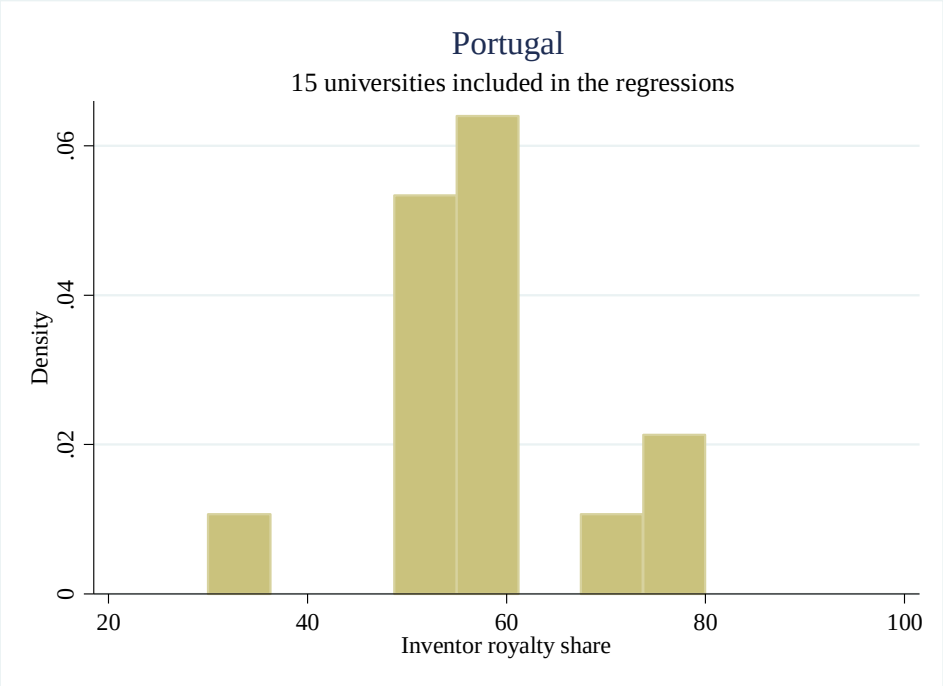
TABLES AND FIGURES

Figure 1. Distribution of the inventor royalty shares in Portugal and Spain



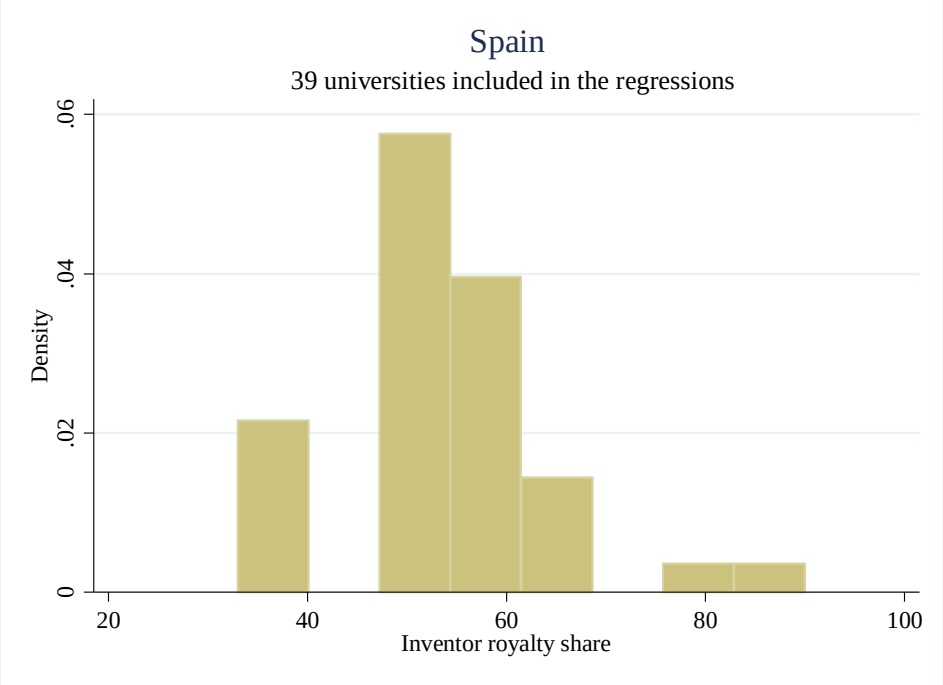


Table 1. Summary of results of the related literature

Paper	Data	Dependent variable	Explanatory variable of interest	Methodology	Effect
Friedman and Silberman (2003)	**U.S.** AUTM Annual Licensing Survey 1997-1999; "Research Doctorate Programs in the United States: Continuity and Change," National Research Council, 1995	Number of licenses and licensing Income	Royalty Share	Regression	No effect on number of licenses, positive on licensing income
Markman et al. (2004)	**U.S**. AUTM Licensing Surveys (1999, 2000); phone interviews with 128 UTTO directors; web-based searches of each UTTO's institution; the United States Patent and Trademark Office	Number of equity licensing	Royalty Share	Regression	Negative
Link and Siegel (2005)	**U.S.** AUTM Survey, 113 academic institutions, 1991-1998; field interviews at five research universities in two regions of the USA	Number of licenses and licensing income	Royalty share	SFE estimation	Positive
Lach and Schankerman (2008)	**U.S.** AUTM Annual Licensing Survey 1997-1999 (unbalanced pane of 102 universities);	Licensing Income	Royalty Share	Regression	Positive
Belenzon and Schankerman (2009)	**U.S.** 2003 survey 102 TLOs in public and private universities; AUTM annual surveys 1995-2001; patent data from U.S. Patent and Trademark Office (USPTO)	Income per license	Performance pay in TTO	Regression	Positive

Sauermann et al. (2010)	**U.S.** Survey of Doctorate Recipients (NSF, 2001, 2003); AUTM surveys; measures of PhD program quality National Research Council (1995)	Patenting	Royalty Share and salary	Regression	Royalty shares have no effect. Salary has a positive effect in Physical Sciences but not in Life Sciences and Engineering.
Baldini et al. (2007)	**Italy** survey of 208 Italian faculty inventors of university-owned 1990- 2002 patents	Patenting	Personal earnings	Survey (inventors)	Very weak
Baldini (2010)	**Italy** dataset of Italian universities' patents 1988-2002	Patents filed	Royalty Share	Regression	Positive
Caldera and Debande (2010)	**Spain** annual 2001-2005 surveys of the Spanish TTO network (RedOTRI)	Number of licenses and licensing income	Royalty Share	Regression	Positive effect on licensing income but not on the number of licenses
Goktepe and Mahagaonkar (2010)	**Germany** 2007 Max Planck Society survey on the commercial activities among 2,500 scientists affiliated within 67 institutes	Patenting	Monetary expectations	Regression	No

Table 2. Descriptive statistics

	Portugal				Spain			
	Mean	S.d.	Min	Max	Mean	S.d.	Min	Max
				License revenue regression				
		(N=0)			(N=39, N*T=155)			
License income (in thousands of Euros)					66.32	99.59	0	600
Royalty share					53.87	10.71	33	90
Pre-sample patent applications					8.20	8.06	1	36
Size of the TTO					17.31	15.71	3	83
Age TTO in 2007					15.95	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=15, N*T=56)			(N=39, N*T=188)			
Patent applications	9.52	10.06	0	54	11.95	11.47	0	72
Royalty share	54.82	8.89	30	80	53.67	11.43	33	90
Pre-sample patent applications	9.24	13.22	0	49	7.74	7.66	1	36
Size of the TTO	4.47	2.80	1	9	16.35	14.96	3	83
Age TTO in 2007	5.20	4.77	0	17	15.74	3.65	4	20
Faculty size	961	417	424	1924	2,617	4,192	546	40,879
R&D (in thousands of Euros)	na	na	na	na	31,225	24,627	2,575	119,000

Table 3. Variable definitions and sources

Variable	Definition	Source Portugal	Source Spain
Licensing income (in thousands of Euros)	Total licensing income of the university in thousands of Euros. It includes income not only from patents but also from other sources such as software, databases or know-how. Licensing income from patents is only observed from 2009 onwards and it accounted, on average, for 37%, 63% and 58% of total licensing income in the years 2009, 2010 and 2011 respectively.	na	Red OTRI Surveys[1]
Patent applications	Number of patent applications in the national offices	Portuguese patent office	Spanish patent and trademark office
Inventor's royalty share	Share of license revenues that go to the inventor as established in the royalty sharing scheme of the university	Survey to TTOs	Survey to TTOs and tables in González-Albo-Manglano and Zulueta-García (2007)[2]
Pre-sample patent applications	Average number of patent applications in the national office in the years 2005 and 2006	Portuguese patent office	Spanish patent and trademark office
Size of the TTO	Number of workers in the TTO that have a technical profile	2008 Survey to TTOs	Red OTRI Surveys[1]
Age TTO in 2007	Age of the TTO in 2007	2008 Survey to TTOs	Red OTRI Surveys[1]
Faculty size	Number of researchers in the university (in Spain this amounts to the PDI categories described in the LOMLOU)	http://w3.dgeec.mec.pt/rebides/20XX/	Red OTRI Surveys[1]
R&D (in thousands of Euros)	Total amount of research support commited to the university through programs for financing public research	na	Red OTRI Surveys[1]

Notes: 1. http://www.crue.org/Publicaciones/Paginas/Informe-RedOTRI.aspx?Mobile=0; 2. The tables with the royalty shares can be found in http://www.scielo.br/pdf/ci/v36n1/a05v36n1.pdf.

Table 4. Inventors' characteristics (from the inventor's survey)

	Portugal		Spain	
	Mean	S.d.	Mean	S.d.
Age	46.89	8.52	46.39	9.27
Male	0.71		0.77	
Permanent contract	0.54		0.82	
Position				
PhD student	0.00		0.04	
Postdoc	0.02		0.08	
Assistant professor	0.43		0.09	
Associate professor	0.37		0.51	
Professor	0.17		0.29	
Number of "sexenios"[a]	na		2.15	1.69
International patent applications[a]	na		0.09	
Field				
Architecture	0.01		0.02	
Biology[a]	na		0.06	
Chemistry	0.05		0.14	
Engineering	0.47		0.37	
Medicine	0.03		0.05	
Nutrition[b]	0.27		na	
Pharmacy[b]	0.05		0.04	
Physics[a]	na		0.06	
Technology and Management	0.04		na	
Telecomunications	na		0.06	
Other	0.19		0.17	

Notes: The statistics for Portugal are based on the 212 responses for which we have full information. The statistics for Spain are based on the 606 responses for which we have full information except for the variable "International patent applications" for which we only have information for 573 researchers. The variable "International patent applications" is a dummy variable with value one if the inventor has international patent applications (in the USPTO and EPO offices) and zero otherwise. It was not directly obtained from the survey but from matching the survey with the original database on patents retrieved from the patent offices. All the variables are dummy variables except for "Age" and "Number of sexenios" and we only report standard deviations for these last two variables. a) The number of "Sexenios" is a recognition awarded to Spanish scholars that does not exist in Portugal (see more in footnote 23), the number of international patent applications by scientist is available for Spain but not for Porttugal, fields "Biology" and "Physics" are specific of the Spanish survey. b) Fields "Nutrition" and "Technology and Management" are specific of the Portuguese survey.

Table 5. 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(Pre-sample patent applications)	0.53***	0.28	0.78***	0.57***	0.88***	0.29
	(0.14)	(0.19)	(0.07)	(0.10)	(0.25)	(0.35)
log(TTO/Faculty)		-0.31		0.11		0.17
		(0.20)		(0.08)		(0.35)
Age TTO		0.22**		0.04		-0.04
		(0.09)		(0.06)		(0.27)
Age TTO squared		-0.01*		-0.00		0.00
		(0.00)		(0.00)		(0.01)
log(Faculty)		-0.23		0.42**		0.63
		(0.21)		(0.16)		(0.41)
log(R&D/Faculty)				0.24*		0.51
				(0.14)		(0.40)
Constant	0.72	0.79	0.12	-6.24**	1.15	-10.52
	(1.07)	(1.53)	(0.28)	(3.04)	(0.92)	(9.24)
Observations	56	56	188	188	155	155
Universities	15	15	39	39	39	39
R-squared	0.34	0.43	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 6. Awareness and importance of the inventor royalty share (from the inventor's survey)

	Portugal	Spain
1) Do you know what the inventor royalty share is in your university?		
Yes (%)	48	28
No (%)	52	72
# Respondents	212	606
2) Which is the influence of the inventor royalty share on your decision to generate patentable inventions?		
High (%)	14	11
Medium (%)	28	23
Low (%)	27	34
None (%)	30	33
# Respondents	102	168

Table 7. Optimal royalty shares (from the inventor's survey)

	Portugal	Spain
1) Is the inventor royalty share high enough to incentivize the effort aimed at producing patentable inventions? (Addressed to respondents who are aware of the royalty share)		
Yes (%)	62	63
No (%)	38	37
# Respondents	102	168
2) Is there a minimum threshold above which you would find it worthwhile to devote effort to produce patentable inventions? (Addressed to researchers who either do not participate in question 1 or answer no in question 1)		
Yes (%)	58	62
No (%)	42	38
# Respondents	149	500
3) Which is this threshold? (Addressed to researchers who either do not participate in question 1 or answer no in question 1)		
3.1) All researchers		
Mean	45.6	29.9
S.d.	20.7	19.8
# Respondents	86	249
3.2) Researchers who know the current royalty shares		
Mean	53.8	47.2
S.d.	17.3	23.1
# Respondents	19	35
3.3) Researchers who do not know the current royalty shares		
Mean	43.3	27.1
S.d.	21.1	17.8
# Respondents	67	214
Difference 3.2)-3.3)		
Mean	10.6	20.3
S.d.	5.3	3.4
p-value	0.025	0.000

Table 8. Goals pursued with the established royalty share (from the TTOs' survey)

	Portugal	Spain
a. Incentivize an increase in university patenting (%)	50	93
b. Maximize total income from patents (%)	27	31
c. Maximize university (TTO) revenues (%)	9	5
d. Favor the development of "spin-off" (%)	23	10
e. Improve the scientific production of the university (%)	36	40
f. Attract high quality researchers (%)	9	2
Total number of respondents	22	45

Notes: the responses are not mutually exclusive. Most TTOs generally selected one or two goals (and a few even three).

Table 9. Inventors' quality and effectiveness of the royalty shares. Evidence for Spain (from the inventor's survey)

	Awareness				High or medium importance			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Spain				
USPTO - EPO	0.63***			0.64***	-0.08			-0.00
	(0.21)			(0.21)	(0.45)			(0.45)
1 sexenio		0.16		0.17		0.13		0.13
		(0.26)		(0.26)		(0.77)		(0.77)
2 sexenios		0.21		0.23		-0.40		-0.43
		(0.20)		(0.20)		(0.63)		(0.61)
3 sexenios		0.35		0.39		0.08		0.03
		(0.25)		(0.24)		(0.48)		(0.48)
4 sexenios		0.58*		0.60*		-0.58		-0.80
		(0.31)		(0.32)		(0.83)		(0.74)
5 sexenios		0.42		0.38		-0.21		-0.40
		(0.37)		(0.37)		(0.82)		(0.85)
6 sexenios		0.31		0.43		-0.62		-0.85
		(0.46)		(0.47)		(1.15)		(1.11)
Professor			0.13	-0.03			0.04	0.30
			(0.20)	(0.23)			(0.42)	(0.43)
Male	0.60***	0.63***	0.60***	0.63***	0.43	0.50	0.44	0.39
	(0.21)	(0.21)	(0.22)	(0.21)	(0.67)	(0.74)	(0.73)	(0.70)
Age	0.01	0.00	0.01	0.00	0.01	0.02	0.01	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.03)
Constant	-2.32***	-2.01**	-2.18***	-2.07**	-4.55***	-5.17***	-4.59***	-5.20***
	(0.70)	(0.91)	(0.78)	(0.91)	(0.94)	(1.84)	(1.26)	(1.60)
Observations	536	534	536	534	119	118	119	118
				Portugal				
Professor			0.13				-0.54	
			(0.67)				(0.68)	
Male			0.52*				0.63	
			(0.29)				(0.77)	
Age			0.01				0.04	
			(0.02)				(0.03)	
Constant			0.58				-3.43**	
			(0.82)				(1.38)	
Observations			181				84	

Notes: ***, ** and * indicate significance at a 1%, 5% and 10% level respectively. Clustered (at the university level) robust standard errors in parentheses. The dependent variables are a dummy variable with value one if the inventor is aware of the inventor royalty share in her university (columns 1-4) and a dummy variable if the inventor claims that the inventor royalty share was of high importance at stimulating her effort (columns 5-8). All the regressions include a full set of university and field dummies. In the regressions we use all the available observations from the surveys for which all the variables needed in the regressions have non-missing values.