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ABSTRACT: Portuguese and Spanish universities have adopted well-defined royalty sharing schedules during the last fifteen years. We investigate whether these inventor royalty shares 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 completed by inventors and Technology Transfer Offices (TTOs). Econometric evidence from the university-level dataset indicates that royalty shares have no impact on patenting or licensing income. The same result emerges from the inventors' survey, with most respondents claiming to be largely unaffected by royalty sharing. Evidence from both the TTO and inventors' surveys suggests that inventors do not react to royalty sharing because of the poor commercial prospects of their inventions, which means there is little income to be shared. These poor prospects appear to reflect the fact that the TTOs do not focus sufficiently on commercializing inventions and inventors are unable to produce potentially licensable inventions.

JEL Codes: 034, 031, I23

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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). Such knowledge transfer can be implemented via a number of routes including the hiring of students, sponsored research, licensing, the creation of university spin-off firms or simply via knowledge spillovers (Bercovitz and Feldman, 2006). In this regard, one mechanism that has become increasingly important for researchers and policymakers is patent licensing (Geuna and Rossi, 2011; Perkmann et al., 2013).[5]

A question that has aroused considerable interest of late is whether pecuniary incentives to inventors are a useful tool for improving licensing outcomes. In the US, as in most European countries, university intellectual property policies grant the university control rights over inventions (Sampat et al., 2003; Geuna and Rossi, 2011). The royalty income from inventions is then shared between the inventor and the university according to terms generally specified by the university. This naturally allows (or 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 potential royalties, then universities can conveniently set inventor royalty shares so as to incentivize their effort. Studies to date, however, present mixed results as to whether such royalty sharing arrangements are effective at incentivizing academics' efforts (Sauermann et al., 2010, Perkmann et al., 2013), suggesting that they might be persuasive in certain institutional contexts but not in others (Sauermann et al., 2010).

The purpose of our paper is to investigate the role of inventor royalty shares in incentivizing patenting and licensing in universities in Portugal and Spain, two countries with specific characteristics that make them an interesting case. First, university patenting and licensing are recent and remain at a low rate. Second, Technology Transfer Offices (TTOs) are relatively young and still in an early stage of

[5] Patenting and licensing are important components of university technology transfer and have been the focus of many studies in the last two decades. Verspagen (2006) has surveyed the literature on university patenting, while Baldini (2006) has provided a review of the literature on patenting and licensing in universities.

their learning curve.[6] Third, the quality of applied research might not be as high as that in the US.[7] Fourth, both countries have been particularly active over the last few years in developing appropriate infrastructure for improving knowledge transfer (Geuna and Rossi, 2011; Lissoni, 2013; Cartaxo and Godinho, 2014). Among the many measures taken has been the adoption of well-defined royalty sharing schedules by universities. Here, we seek to determine whether inventor royalty shares have successfully incentivized inventors' efforts in universities in Portugal and Spain, and, if not, what it is that prevents royalty shares from being effective.

We build on the framework proposed by Lach and Schankerman (2008) to analyse 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 can be expected to be non-trivial. In this regard, 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 inventor's ability to undertake applied research. Higher inventor royalty shares will serve as a greater incentive if the right interplay exists between the three moderators (i.e., inventor royalty shares are sufficiently high, TTOs are good at commercializing inventions and inventors are good at generating licensable inventions). In contrast, 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, TTOs are ineffective at commercializing inventions or inventors produce inventions with little commercial value).

Within this framework, we seek to answer two research questions. First, is the interplay between the moderators in Portugal and Spain such that inventor royalty shares are effective at stimulating inventors' efforts and improving university outcomes? Second, if not, what prevents inventor royalty shares from being effective? Or more specifically: Are inventor royalty shares poorly chosen by universities? Are TTOs ineffective at commercializing inventions? Are inventors bad at generating licensable inventions?

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

[7] 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 these research questions we employ a mix of objective evidence from university-level data and subjective evidence from new self-collected surveys addressed 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 the traditional "Mertonian" world of scientific discovery, the main goal of the majority of scientists is to establish their priority of discovery by being the first to communicate an advance in knowledge (Stephan, 1996; Lam, 2011). Accordingly, most scientists seem to be motivated by the traditional reputational and career rewards provided 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 what motivates scientists, some studies conclude that reputation lies at the heart of scientists' decision to patent.[8]

While it is widely argued in the literature that academics respond to non-pecuniary incentives, recent research has sought to determine whether academics also care about monetary incentives. This growing interest in understanding the role of monetary incentives is closely related to recent measures aimed at improving university technology transfer. Pecuniary incentives are regarded as a potentially effective means involving scientists, not just in discovery, but also in the transfer of the generated knowledge beyond the boundaries of academia (Markman, 2004).

Lach and Schankerman (2008) develop a simple model that captures the dual incentives 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

[8] See Bodas Freitas and Nuvolari (2012), Göktepe-Hulten and Mahagaonkar (2010), Baldini et al. (2007) and Owen-Smith and Powell (2003).

have an increasing amount of autonomy that allows them to devise bylaws affecting research 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 to do applied research.[9] This dimension is likely to modulate the incentive effect of royalty shares in Portugal and Spain, where the ability of academic inventors to carry out applied research might be insufficient 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 (denoted by n) and applied research devoted to improving the quality of these projects (to ensure that new projects are suitable for commercialization by the TTO). 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, a 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 to conduct 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

[9] We use "ability to do applied research" to refer to the capacity to undertake applied research that can subsequently be exploited economically by patenting and licensing. We could also have used the terms "ability to do relevant or commercially oriented applied research". We admit that scientists can conduct quality applied research that simply may not be suitable for economic exploitation through patenting and licensing.

probability. Here, we seek to consider an additional scenario in which less able scientists ($\lambda = 0$) produce inventions with no probability of being licensed by the TTO. The ability parameter λ can be accommodated within Lach and Schankerman's (2008) setting as an interaction with the gatekeeper parameter θ. This implies that the expected commercial value associated with a given level of research effort can be attenuated either because the TTO is not good at commercializing ideas or because the inventor is less capable of conducting 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 the scientists' ability to conduct applied research λ.[10] 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 $n(s,\theta,\lambda)$.[11]

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 from the utility function, thereby reducing a scientist's incentives to undertake applied research (though not completely given that she might still want to conduct applied research in order to increase utility through publications). For instance, if the inventor royalty share is very low ($s = 0$), the scientist's license revenue will be zero, regardless of the quantity or quality of the inventions, and the license revenue motive drops from the utility function. Similarly, if the TTO is not good at all at commercializing inventions ($\theta = 0$), the scientist's expected license revenue will be zero and all the scientist will care about is her publication record. Finally, scientists will not care about license revenue if their ability to conduct applied research is such that not even the maximum applied research effort can raise the quality of their inventions above the minimum standards required for commercialization by the TTO ($\lambda = 0$). Scientists

[10] These results only hold if the 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.

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

will therefore only play the licensing game if s, θ and λ all take reasonably large values and interact to create the appropriate incentives.

Interaction effects – We are interested in assessing how inventors react to one of the three moderators of an inventor's efforts: namely, royalty shares (s). Clearly, however, for these royalty shares to be effective, they need to take meaningfully large values. A second condition to ensure that the inventor royalty shares matter is that θ and λ must both be at least greater than zero. If they are not, the expected royalties shared out to scientists will always be zero, regardless of the inventor royalty share established.

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. It is this effectiveness that we seek to test empirically. Our first research question, therefore, is stated 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 studies conducted to date, that we are aware, of that have set themselves the objective of answering this question are summarized in Table 1. The literature provides mixed results that reflect the substantial heterogeneity in the methodologies adopted, datasets employed and geographical contexts analyzed (a finding in line with the literature review by Perkmann et al., 2013). The variety in the results would also seem to suggest that the conditions under which royalty shares are effective might not hold everywhere. Understanding which contextual factors make royalty shares an effective pecuniary incentive has been the goal of a small number of papers. Lach and Schankerman (2008) find the royalty shares of private universities to be more effective (arguably as they are 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 systems. 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]

In addition to knowing whether inventor royalty shares are effective, we seek to determine whether any of the "moderators" of a scientist's efforts block the licensing game. First, we need to know if the inventor royalty shares are large enough for the licensing game to make sense. If they are, we next need to determine whether the other two "moderators" prevent 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 ineffective 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 and abolished 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. Below, we describe the institutional environment in Portugal and Spain in some detail.

Institutional ownership – The Portuguese intellectual property law (*Código da Propriedade Industrial*) is devoid 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 in licensing revenues. The first explicit university-specific intellectual property rights

policy with well delimited inventor royalty shares was not adopted until 1998 in the *Instituto Superior Técnico*. Similar statues were gradually adopted over the following decade, with the vast majority of universities today operating well-defined royalty sharing schemes.[12]

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 has been 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).[13]

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 TTO 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 small, usually employing no more than two or three technicians.[14]

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 a public policy initiative aimed

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

[13] 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.

[14] 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 staff, but the figure of no more than two or three technicians engaged in technology transfer remains valid for most universities.

at promoting co-operation between university and industry.[15] 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 regulations 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 inventor's department or research group. 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 explain in more detail below, inventor royalty shares tend to concentrate around 50% 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 1990s. The first university patent was not awarded until 1998, and it was not until 2001 that the cumulative number of university patents reached double figures. This late take-up in university patenting can partially be 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. There is little to say about licensing, as data on licensing income is not available for Portuguese universities. Yet, this lack of availability suggests that licensing is not a prominent activity within Portuguese universities.

University patenting in Spain was not frequent until the 1990s. Since this date the number of university-owned patents has experienced 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

[15] 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, established the foundations for the creation of the first OTRIs.

15% of all patent grants (almost twice the share 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. 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.[16]

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 addressed to all Portuguese and Spanish university TTOs and another survey to a representative sample of inventors in Portugal and Spain. Each dataset is described below.

University-level dataset – This is an unbalanced panel spanning the years 2007 to 2011 (both inclusive) for 15 Portuguese and 39 Spanish universities.[17] The sampling criterion was to retain all university-years (for the period 2007 to 2011) for which all the following variables could be observed: inventor royalty shares, the number of patent applications made at the respective national offices, licensing income (only for Spain), size and age of the TTOs, faculty size and the volume of R&D expenditure (only for Spain).[18] Clearly, the inventor royalty share had to be accurately defined for the university to be included in the sample. Most of the instances in which we had to discard a university-year were because information on outcomes (patents or licensing)

[16] Data 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 compared to the income generated in 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 the Spanish universities together).

[17] We restrict the panel to the period post-2007 as inventor royalty share schedules had not been defined in several Portuguese universities before this date.

[18] The dataset for Portugal contains information on 15 universities and accounts 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. Here, 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.

or the explanatory variable of interest (inventor royalty share) was not available. 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 their distribution is highly skewed across universities. Licensing income in Spain (note no data are 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 at €29,600. The average number of annual 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 plots the distribution of royalty shares with average and median values standing at around 55% in both countries. Most universities opt to fix the inventor royalty share at between 50 and 60% with only a few universities opting for extremely low (around 30%) or high (above 70%) royalty shares for inventors.

[INSERT FIGURE 1]

TTO survey – The main objective of the survey addressed to the TTOs was to obtain the exact inventor royalty share at each university, the year in which royalty shares were first introduced and whether the shares have experienced significant changes over time. We were also interested in understanding the administrative process by which the royalty sharing schedules were approved at each university and the goals each university pursued with its specified royalty share.

The survey was sent to all Portuguese and Spanish TTOs during 2011. The response rate was highly satisfactory. All Portuguese TTOs (i.e., 22 TTOs) filled in the survey

between June 2011 and April 2012 and 47 Spanish TTOs did so between January 2011 and December 2012 (an 89% response rate).[19]

As it transpired most of the universities surveyed first defined their royalty sharing schedules after 2000 (95% in Portugal and 73% in Spain). Once fixed, most royalty shares have remained unaltered, with only 14% of the Portuguese TTOs and 20% of the Spanish TTOs surveyed reporting variations over time. However, all these changes took place before the sample years selected for the econometric analysis (i.e., before 2007). Royalty sharing schedules were generally the outcome of a unilateral proposal from the universities' governing councils, with researchers having almost no opportunity to influence the final decision. In most universities the primary goal pursued with the introduction of the royalty sharing schedule was to incentivize an increase in patenting, while only a few TTOs recognized the importance of maximizing licensing revenues. We provide more detailed information on the TTO survey in the following section.

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

The target of the survey was all Portuguese and Spanish inventors that had 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 approximate this target population as closely as possible, we first retained all the patent applications (to the aforementioned offices) for which the assignee was a Portuguese (555 patent applications) or Spanish (5,148 patent applications) university. We then located the email addresses 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 whom we had an email address to answer an online survey in January

[19] Red-OTRI (the network of Spanish TTOs) included 87 members in its 2010 directory. Most of these were ascribed to a university but some were universities without a TTO or TTOs ascribed to centers other than universities (such as scientific institutes and research centers). Most of the scientific research and virtually all the patents and license income are generated by 53 public universities. Therefore, we sent the survey to the TTOs of these universities that constitute our relevant population (47 of which filled it out).

(Portugal) and November (Spain) 2012. We obtained 212 complete responses for Portugal and 606 for Spain (meaning 40 and 20% response rates, respectively).

We asked inventors to supply their 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 royalty shares. Table 4 reports the descriptive statistics of the inventor characteristics. The results of the inventors' perceptions of the royalty shares are discussed in the next section.

[INSERT TABLE 4]

4. Evidence

Below we seek to provide empirical answers to the two research questions posed in Section 2. We study whether inventor royalty shares are effective at stimulating inventors' efforts and improving university patenting and licensing outcomes, and then we analyze the role played by the moderators in attenuating the incentive effects expected from inventor royalty shares. In order to tackle these two research questions we draw on information from the university-level dataset and the surveys.

Do inventor royalty shares have an incentive effect in Portugal and Spain?

We first seek to answer this question econometrically using the objective university-level dataset. University licensing revenue and the number of projects equals the scientists' expected licensing income and the 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 yield 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} represents either $\ln N_{it}$ (the log of the number of university patent applications in the corresponding national patent office) or $\ln R_{it}$ (the log of the amount of university licensing income in Spain only – note this information is not available for Portugal). The matrix of controls

x_{it} includes (the log of) faculty size, proxies for θ such as the 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 performing 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 imply that inventor royalty shares are effective at stimulating inventors' efforts.

Lach and Schankerman (2008) highlight two sources of unobserved heterogeneity that are likely to be correlated with s_{it}. First, researchers with greater commercial orientation or more valuable inventions may be able to lobby their universities for more favorable royalty shares (a reverse causality problem). This, however, does not seem to be the case at Portuguese and Spanish universities, according to the survey addressed to the TTOs.[20] Second, higher inventor royalty shares may attract more innovation-oriented faculty (a sorting problem).[21] Unlike in the US, the sorting channel is likely to play a minor role at Portuguese and Spanish universities where faculty mobility is relatively low. In any case, we 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.[22] Although most universities were observed over several years, we are unable to use within estimators because the royalty share displays little variation over time (only a few universities change royalty shares over time and none of these changes were made during the sample period). Thus, the incentive effect of the royalty share is identified from the cross-sectional variation in the

[20] The TTO survey suggests that inventors play a marginal role in the fixing of royalty shares both at 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 a third of the universities in both countries, the royalty share was discussed in the Research Commission, with researchers being given the opportunity to influence the final decision. Only in 32% of Portuguese and 2% of Spanish universities did the researchers play a more active role in the royalty share decision.

[21] 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).

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

data. We use clustered-robust standard errors to allow for heteroscedasticity 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 with 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 with the inventor's royalty share is insignificantly different from zero in all cases, except column (4) where it is only significant at the 10% level. This set of results suggests that royalty shares play a negligible role in stimulating patenting and license income at the university level in Spain and Portugal. As for the other regressors, the pre-sample average number of patent applications is significant in most of the regressions. This implies that this variable controls, at least, in part, unobserved heterogeneity. The remaining explanatory variables are mainly insignificant. The amount of experience accumulated by the TTO seems to positively affect patenting in Portugal, while faculty size is positively correlated with patenting in Spain.

[INSERT TABLE 5]

Direct feedback from the inventors' survey (reported in Table 6) concurs in the main with the econometric results. Inventors are strikingly unaware of the royalty shares in force: only 48% (Portugal) and 28% (Spain) of the respondents report knowing what the inventor royalty share is at their university. This result falls well short of the results found for the US where there seems to be full awareness of monetary incentives among faculty.[23] The degree of awareness is particularly surprising if we consider our survey was sent out to patent applicants, a subsample of faculty who should apparently be interested in the monetary incentives for commercializing their inventions. Not only is the degree of awareness low, but the majority of respondents claiming to be aware of the royalty shares reported that the share had little or no impact on their decision to

[23] More than 90% of the TTOs at US universities surveyed in Lach and Schankerman (2008) claim their faculty are aware of their monetary incentives. Importantly, here we obtain this response from the inventors themselves, rather than via the TTOs. This might explain, in part, the large difference in the respective degrees of awareness.

generate patentable inventions. Of these, only slightly more than 10% stated that the royalty share was highly influential in incentivizing their research efforts.

[INSERT TABLE 6]

Why are inventor royalty shares not effective?

Why royalty sharing policies are ineffective in incentivizing inventors' efforts is a legitimate question, because Portuguese and Spanish TTOs use royalty shares as part of their toolkit for improving technology transfer. Yet, as we have shown, they have little or no impact. As discussed in the analytical setting, several conditions have to be satisfied for royalty shares to be effective. First (and most obviously), royalty shares need to be sufficiently large (given the efficiency of the TTO and the inventors' ability to generate 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 for conducting patentable applied research to produce licensable inventions.

We have shown in Section 3 that inventor royalty shares are well above zero and, thus, cannot be said to eliminate the inventors' opportunities to earn licensing revenues. We can also confirm that inventors believe the royalty shares to be sufficiently high. Therefore, if royalty sharing schedules are not blocking the licensing game, then at least one of the other two moderators must be. Below, we discuss the extent to which the other two moderators of inventors' efforts can be held responsible for the ineffectiveness of the royalty shares.

Ineffective inventor royalty share levels – One potential explanation for the absence of any impact could be that inventor royalty shares are poorly chosen. Thus, there might be a certain threshold below which inventor royalty shares are ineffective. Does such a threshold exist and are current inventor royalty shares set below this threshold?

Table 7 reports the inventors' opinions regarding the inventor royalty shares. Most of the respondents claiming to be aware of these shares believe them to be high enough to incentivize their effort. Most of the remaining inventors (those who are either unaware of the royalties or those that are aware of them but consider them to be too low) believe

that there is a minimum royalty threshold above which it would be worthwhile to increase their effort. Surprisingly, these inventors believe the "effort" threshold to be, on average, below the actual average inventor royalty shares in force.[24]

Taken together these results suggest that current royalty shares are sufficiently high to incentivize inventors' efforts. This reinforces the perception that either the gatekeeper effect or the quality of the applied research undermines the commercial prospects of the inventions generated. In short, poor 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 inventions depending ultimately on the TTOs. This means that inventors' licensing revenues are largely dependent on the ability of TTOs to find licensees and to negotiate agreements. As discussed in the analytical setting, if the TTO is ineffective in commercializing inventions, royalty shares will have a smaller incentive effect or no effect at all. Does the TTOs' inability to successfully commercialize inventions account for the ineffectiveness of royalty shares?

An efficient way of empirically testing for the gatekeeper effect in the US has involved exploiting the fact that private universities are more aggressive than their public counterparts in their licensing strategies.[25] This strategy, however, cannot be implemented in Europe where the bulk of universities performing scientific research are public.[26] As such, we have to rely on qualitative information derived from the surveys. We explicitly asked the TTOs to identify the outcomes they pursue via their royalty

[24] This outcome is entirely driven by 'unaware' inventors who set the "effort" threshold 10 (in Portugal) and 20 (in Spain) percentage points lower than the threshold set by 'aware' (but discontent) inventors.
[25] This is the strategy adopted by Lach and Schankerman (2008), while Belenzon and Schankerman (2009) also report that private universities are more likely to adopt incentive pay. In contrast, public universities tend to care more about local development objectives and often prefer to offer licenses to local start-up companies (at the expense of foregone license income).
[26] Belenzon and Schankerman (2009) find that TTOs adopting incentive pay have between 30-40 percent more income per license. This effect is robust to differences in university ownership. We sought to implement this strategy but, unfortunately, almost none of the universities in our sample adopt incentive pay.

sharing schemes. The results to this question (reported in Table 8) reveal that TTOs are relatively uninterested in maximizing licensing income – less than a third 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 presumably reflects the poor commercialization prospects anticipated for university inventions. This perception was backed up by comments from several respondents to the inventors' survey, who accounted for the ineffectiveness of their royalty shares in terms of the limited ability of the TTOs to commercialize inventions. The general feeling is perhaps best captured in the following words of 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 its scientific production. These responses suggest that TTOs are unaware that royalty shares only incentivize enhanced research efforts if accompanied by good commercialization prospects. Indeed, the only way of boosting patenting and scientific production through royalty sharing is via a credible commitment to the maximization of 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., the size and age of the TTO) are generally found to be not significant (with only age having a positive effect on patenting in Portugal).

Inventors' ability to perform applied research – Inventors would certainly not respond to royalty incentives if their ability to perform applied research was such that their chances of producing licensable inventions were non-existent. We use the inventors' survey to determine whether inventors capable of producing high quality research are better informed about royalty shares and more sensitive to the value of these shares. We construct two dependent variables based on the results reported in Table 6: a dummy variable with a value of one if inventors are aware of the royalty share and zero otherwise; and, a dummy variable with a value of one if inventors consider the royalty share to have a high or medium influence on their efforts to be

inventive and zero otherwise. We regress these two variables on three measures of inventor quality: whether the inventor has applied for patents from international offices (as opposed to only national offices), the number of *sexenios*[27] earned by the scientists and whether the inventor holds the title of '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 a value of one if the inventor has applied for a patent from the USPTO or the EPO between 2005 and 2009 and zero if it has only applied for patents from the national office (our preferred proxy). Inventors with international patent applications have a significantly higher degree of awareness of royalty shares, but they do not seem to find them more important for incentivizing their research efforts. In the other columns we use a set of variables that proxy a more generic type of quality: a set of dummy variables representing the different number of *sexenios* earned by a scholar and a dummy variable with a value of one if the inventor holds the title of 'professor'. Neither of these variables seems to explain different attitudes towards royalty shares. If anything, inventors with four *sexenios* seem to be slightly more aware of royalty shares than inventors with no *sexenios* (but only at the 10% significance level). Interestingly, there are significant gender differences in the degree of awareness of royalty shares. Finally, the results remain stable when all the variables are included simultaneously in the regression.

The finding that inventors with international patent applications are substantially more aware of the royalties is of particular interest as it suggests that only high quality patents with a good chance of being licensed spur inventors' curiosity for learning about royalty sharing. However, as Table 4 shows, the percentage of inventors with international patent applications in our sample is extremely low (below 10%), which indicates that most inventors are producing patents with little commercial value and, hence, the

[27] *Sexenios* are a supplement to a researcher's salary awarded following evaluation by a national agency (CNEAI, National Commission for the Evaluation of Research Activity). This evaluation gives substantial weight to publications in international journals listed in the ISI's Journal Citation Reports. In the Spanish research system, *sexenios* are seen as evidence of scientific excellence and their use has had positive effects on Spain's scientific production (see Jiménez-Contreras et al., 2003).

royalty share does not matter much to them. All in all, it appears that pecuniary incentives would matter more if patents were registered in international offices.

[INSERT TABLE 9]

5. Conclusions

We have investigated whether inventor royalty shares from patented inventions serve as 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 is obtained when using a new inventors' survey, with most respondents declaring a low degree of awareness of corresponding royalty shares and only a few claiming to be influenced by the inventor royalty share.

We have relied on the responses of inventors and TTOs to the new data surveys to determine why inventor royalty shares are ineffective. These seem to indicate that the current values of the inventor royalty shares are appropriate. Indeed, most inventors claim that the royalty shares established by their university are sufficiently attractive to incentivise their research effort. Despite this, it would seem that inventors are uninfluenced by royalty sharing because of the poor commercial prospects of their inventions. Two reasons can be forwarded to account for these poor expectations.

First, TTOs are not sufficiently focused on commercializing inventions (i.e., finding licensees and negotiating agreements). It should be stressed that in Portugal as in Spain research universities are overwhelmingly public with their TTOs lacking a clear commercial orientation. Indeed, in Portugal some TTOs (see Cartaxo and Godinho, 2014) claim to be much more concerned with regional development and 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 simply to maximize the chances of university-generated knowledge being diffused among local economic agents. A further potential explanation for their lack of interest in maximizing licensing income is that TTOs can rely on other sources of financing, including university funds, revenues from training and consulting services,

and overheads charged to researchers from European projects.[28] Our surveys addressed to the TTOs reflect this lack of interest in licensing income. Surprisingly, royalty sharing schemes seek to maximize the number of patents and not the amount of licensing revenues, as one might expect. This suggests that TTOs fail to fully understand that royalty sharing can serve as an incentive by providing enhanced revenue opportunities for researchers.

Second, inventors seem to be failing to produce licensable inventions; hence, their lack of response to 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 apply for patents in international offices. While the number of patents in Portugal and Spain has grown dramatically in recent years, the quality of these patents might not yet be good enough to generate licensing income. It appears that in both countries, universities are more interested in obtaining patents to enhance their reputation and then in exploiting this reputation premium to foster technology transfer through R&D partnerships with industry. A second possibility could be that patents are being used to strengthen technology transfer through the creation of spin-off firms. In neither of these cases would patenting be related to licensing.

Clearly, a further explanation for the absence of any incentive effects attributable to royalty sharing could be that university scientists are disproportionately driven by traditional academic motivations (i.e., eponymy, prizes and publication). This argument has not been empirically tested in this paper (although it has been taken into account in the analytical model providing the predictions tested herein). Indeed, it should be stressed that in Portugal and Spain more importance has traditionally been attached to academic activities, such as publishing, for obtaining tenure and other career promotions than to patents or licensing. Thus, classic academic incentives can be said to impose a lower bound on the pay-off from commercially oriented research: scientists will only devote effort to producing commercially oriented inventions if the expected

[28] We should add that most TTOs, particularly those in Portugal, but also in Spain, are small and still at a very early stage on the learning curve. However, over the last few years, the patenting policies of some TTOs have shifted from a "quantity" to a "quality" strategy. Indeed, a number of TTOs seem now to be more commercially aware of their activities and have attained a critical scale whereby they can successfully license their universities' patents.

gains from so doing are greater than the gains from producing publications (i.e., the possibility of obtaining tenured positions, promotions and eventually wage increases).

Our findings have a number of policy implications. We have shown that inventor royalty shares in Portugal and Spain are ineffective essentially because inventions offer poor commercial prospects. For royalty shares to be an effective tool, both TTOs and inventors need to acquire greater commercial orientation. For example, TTOs would have to commit themselves to pro-active commercialization practices, including searching for licensees and not just encouraging invention disclosure and undertaking the ensuing administrative tasks (by and large their current roles). Given that most Portuguese and Spanish firms are not technology based, the demand for licenses is primarily from abroad, which means a successful licensing strategy would require the specific targeting of international licensees. Additionally, for inventor royalty shares to be an effective incentive, scientists will have to become more commercially oriented. In other words, scientists need to be able to produce inventions that can be economically exploited through patenting and licensing.

However, it is not our wish to overstate the policy implications as it might simply not be optimal from a welfare viewpoint to maximize licensing income. Indeed, universities in Spain and Portugal are public and, as such, are likely to prioritize other goals. For instance, they might prefer to maximize regional development, for which there are forms of technology transfer, such as spin-off creation and R&D cooperation agreements, that are likely to better serve this 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, on the other hand, only spurs regional development if inventions are licensed to local licensees, which might be at odds with maximizing licensing income.[29] Moreover, universities might prefer their researchers to commit to academic research (which is believed to be a greater source of spillovers than commercially oriented research).

[29] 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).

The apparent lack of interest shown by Portuguese and Spanish universities in licensing income might therefore be totally legitimate. However, TTOs in both countries do use royalty sharing schemes to improve technology transfer. It is perhaps this coexistence of royalty sharing policies and the lack of interest in licensing income that is somewhat puzzling, because royalty sharing can only be effective when combined with a credible commitment to commercialization.

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TABLES AND FIGURES

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

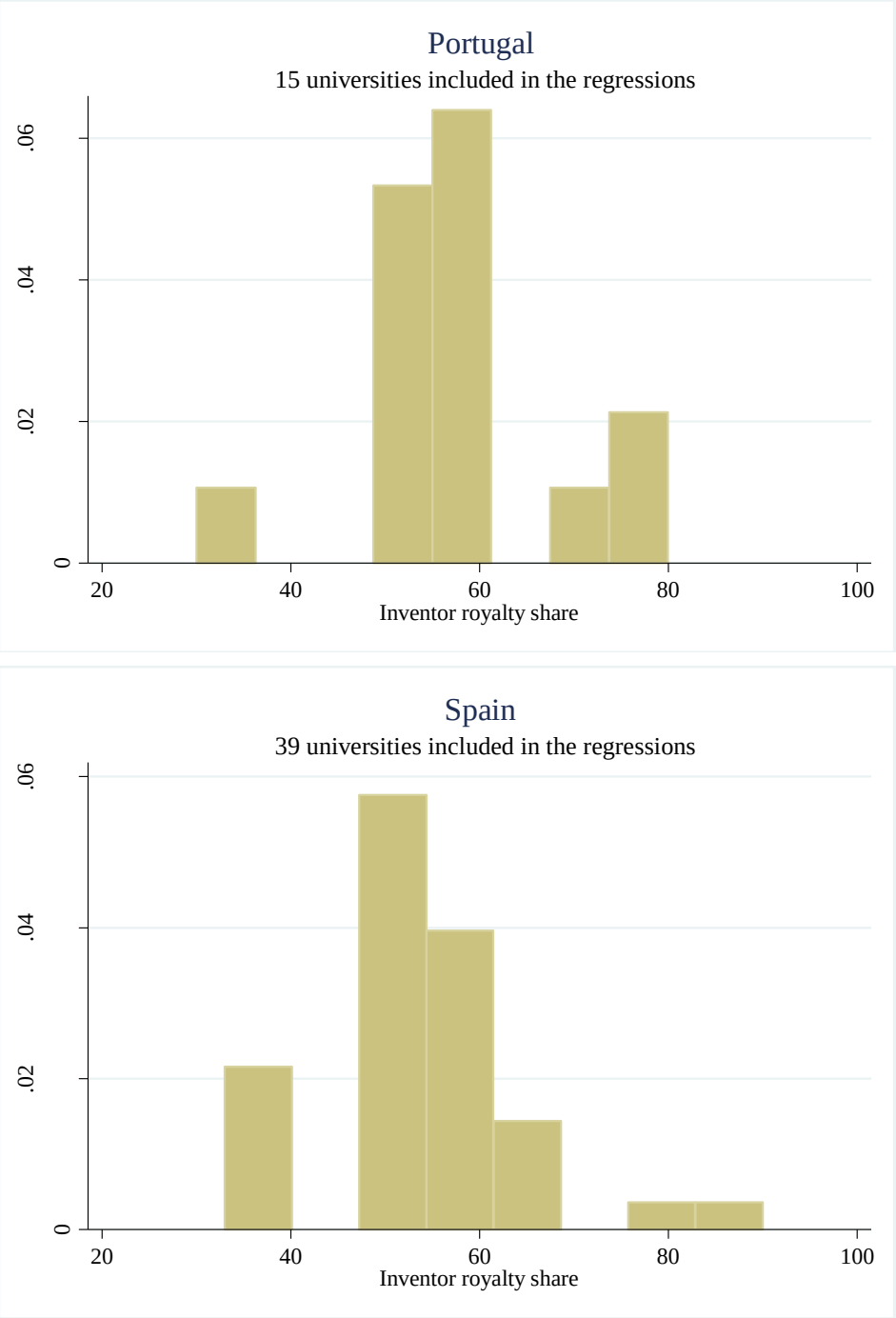

Table 1. Summary of results in the related literature

Paper	Data	Dependent variable	Explanatory variable of interest	Method-ology	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 licenses	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 panel 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 on Physical Sciences but not on 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
Göktepe and Mahagaonkar (2010)	**Germany** 2007 Max Planck Society survey on the commercial activities of 2,500 scientists affiliated to 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 TTO					17.31	15.71	3	83
Age of 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 TTO	4.47	2.80	1	9	16.35	14.96	3	83
Age of 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 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 royalty share	Share of license revenues that goes 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 TTO	Number of workers in the TTO that have a technical profile	2008 Survey to TTOs	Red OTRI Surveys[1]
Age of 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 corresponds 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 committed 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 inventors' 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. This was not obtained directly 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 footnote 23 for fuller explanation), the number of international patent applications by scientist is available for Spain but not for Portugal, the fields "Biology" and "Physics" are specific to the Spanish survey. b) The fields "Nutrition" and "Technology and Management" are specific to 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 the 1%, 5% and 10% levels, 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 inventor royalty share (from the inventors' 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) What 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 inventors' survey)

	Portugal	Spain
1) Is the inventor royalty share high enough to incentivize efforts 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 efforts to producing patentable inventions? (Addressed to researchers who either do not participate in question 1 or answer 'no' to question 1)		
Yes (%)	58	62
No (%)	42	38
# Respondents	149	500
3) What is this threshold? (Addressed to researchers who either do not participate in question 1 or answer 'no' to 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 TTO 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 (with a few even identifying three).

Table 9. Inventors' quality and effectiveness of the royalty shares. Evidence for Spain (from the inventors' 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 the 1%, 5% and 10% levels, 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 at her university (columns 1-4) and a dummy variable if the inventor claims that the inventor royalty share was of 'high' importance in 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.

2011

2011/1, Oppedisano, V; Turati, G.: "What are the causes of educational inequalities and of their evolution over time in Europe? Evidence from PISA"
2011/2, Dahlberg, M; Edmark, K; Lundqvist, H.: "Ethnic diversity and preferences for redistribution"
2011/3, Canova, L.; Vaglio, A.: "Why do educated mothers matter? A model of parental help"
2011/4, Delgado, F.J.; Lago-Peñas, S.; Mayor, M.: "On the determinants of local tax rates: new evidence from Spain"
2011/5, Piolatto, A.; Schuett, F.: "A model of music piracy with popularity-dependent copying costs"
2011/6, Duch, N.; García-Estévez, J.; Parellada, M.: "Universities and regional economic growth in Spanish regions"
2011/7, Duch, N.; García-Estévez, J.: "Do universities affect firms' location decisions? Evidence from Spain"
2011/8, Dahlberg, M.; Mörk, E.: "Is there an election cycle in public employment? Separating time effects from election year effects"
2011/9, Costas-Pérez, E.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Corruption scandals, press reporting, and accountability. Evidence from Spanish mayors"
2011/10, Choi, A.; Calero, J.; Escardíbul, J.O.: "Hell to touch the sky? Private tutoring and academic achievement in Korea"
2011/11, Mira Godinho, M.; Cartaxo, R.: "University patenting, licensing and technology transfer: how organizational context and available resources determine performance"
2011/12, Duch-Brown, N.; García-Quevedo, J.; Montolio, D.: "The link between public support and private R&D effort: What is the optimal subsidy?"
2011/13, Breuillé, M.L.; Duran-Vigneron, P.; Samson, A.L.: "To assemble to resemble? A study of tax disparities among French municipalities"
2011/14, McCann, P.; Ortega-Argilés, R.: "Smart specialisation, regional growth and applications to EU cohesion policy"
2011/15, Montolio, D.; Trillas, F.: "Regulatory federalism and industrial policy in broadband telecommunications"
2011/16, Pelegrín, A.; Bolancé, C.: "Offshoring and company characteristics: some evidence from the analysis of Spanish firm data"
2011/17, Lin, C.: "Give me your wired and your highly skilled: measuring the impact of immigration policy on employers and shareholders"
2011/18, Bianchini, L.; Revelli, F.: "Green polities: urban environmental performance and government popularity"
2011/19, López Real, J.: "Family reunification or point-based immigration system? The case of the U.S. and Mexico"
2011/20, Bogliacino, F.; Piva, M.; Vivarelli, M.: "The impact of R&D on employment in Europe: a firm-level analysis"
2011/21, Tonello, M.: "Mechanisms of peer interactions between native and non-native students: rejection or integration?"
2011/22, García-Quevedo, J.; Mas-Verdú, F.; Montolio, D.: "What type of innovative firms acquire knowledge intensive services and from which suppliers?"
2011/23, Banal-Estañol, A.; Macho-Stadler, I.; Pérez-Castrillo, D.: "Research output from university-industry collaborative projects"
2011/24, Ligthart, J.E.; Van Oudheusden, P.: "In government we trust: the role of fiscal decentralization"
2011/25, Mongrain, S.; Wilson, J.D.: "Tax competition with heterogeneous capital mobility"
2011/26, Caruso, R.; Costa, J.; Ricciuti, R.: "The probability of military rule in Africa, 1970-2007"
2011/27, Solé-Ollé, A.; Viladecans-Marsal, E.: "Local spending and the housing boom"
2011/28, Simón, H.; Ramos, R.; Sanromá, E.: "Occupational mobility of immigrants in a low skilled economy. The Spanish case"
2011/29, Piolatto, A.; Trotin, G.: "Optimal tax enforcement under prospect theory"
2011/30, Montolio, D; Piolatto, A.: "Financing public education when altruistic agents have retirement concerns"
2011/31, García-Quevedo, J.; Pellegrino, G.; Vivarelli, M.: "The determinants of YICs' R&D activity"
2011/32, Goodspeed, T.J.: "Corruption, accountability, and decentralization: theory and evidence from Mexico"
2011/33, Pedraja, F.; Cordero, J.M.: "Analysis of alternative proposals to reform the Spanish intergovernmental transfer system for municipalities"
2011/34, Jofre-Monseny, J.; Sorribas-Navarro, P.; Vázquez-Grenno, J.: "Welfare spending and ethnic heterogeneity: evidence from a massive immigration wave"
2011/35, Lyytikäinen, T.: "Tax competition among local governments: evidence from a property tax reform in Finland"
2011/36, Brülhart, M.; Schmidheiny, K.: "Estimating the Rivalness of State-Level Inward FDI"
2011/37, García-Pérez, J.I.; Hidalgo-Hidalgo, M.; Robles-Zurita, J.A.: "Does grade retention affect achievement? Some evidence from Pisa"
2011/38, Boffa, f.; Panzar. J.: "Bottleneck co-ownership as a regulatory alternative"

2011/39, González-Val, R.; Olmo, J.: "Growth in a cross-section of cities: location, increasing returns or random growth?"
2011/40, Anesi, V.; De Donder, P.: "Voting under the threat of secession: accommodation vs. repression"
2011/41, Di Pietro, G.; Mora, T.: "The effect of the l'Aquila earthquake on labour market outcomes"
2011/42, Brueckner, J.K.; Neumark, D.: "Beaches, sunshine, and public-sector pay: theory and evidence on amenities and rent extraction by government workers"
2011/43, Cortés, D.: "Decentralization of government and contracting with the private sector"
2011/44, Turati, G.; Montolio, D.; Piacenza, M.: "Fiscal decentralisation, private school funding, and students' achievements. A tale from two Roman catholic countries"

2012

2012/1, Montolio, D.; Trujillo, E.: "What drives investment in telecommunications? The role of regulation, firms' internationalization and market knowledge"
2012/2, Giesen, K.; Suedekum, J.: "The size distribution across all "cities": a unifying approach"
2012/3, Foremny, D.; Riedel, N.: "Business taxes and the electoral cycle"
2012/4, García-Estévez, J.; Duch-Brown, N.: "Student graduation: to what extent does university expenditure matter?"
2012/5, Durán-Cabré, J.M.; Esteller-Moré, A.; Salvadori, L.: "Empirical evidence on horizontal competition in tax enforcement"
2012/6, Pickering, A.C.; Rockey, J.: "Ideology and the growth of US state government"
2012/7, Vergolini, L.; Zanini, N.: "How does aid matter? The effect of financial aid on university enrolment decisions"
2012/8, Backus, P.: "Gibrat's law and legacy for non-profit organisations: a non-parametric analysis"
2012/9, Jofre-Monseny, J.; Marín-López, R.; Viladecans-Marsal, E.: "What underlies localization and urbanization economies? Evidence from the location of new firms"
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2012/11, Garcia-López, M.A.: "Urban spatial structure, suburbanization and transportation in Barcelona"
2012/12, Revelli, F.: "Business taxation and economic performance in hierarchical government structures"
2012/13, Arqué-Castells, P.; Mohnen, P.: "Sunk costs, extensive R&D subsidies and permanent inducement effects"
2012/14, Boffa, F.; Piolatto, A.; Ponzetto, G.: "Centralization and accountability: theory and evidence from the Clean Air Act"
2012/15, Cheshire, P.C.; Hilber, C.A.L.; Kaplanis, I.: "Land use regulation and productivity – land matters: evidence from a UK supermarket chain"
2012/16, Choi, A.; Calero, J.: "The contribution of the disabled to the attainment of the Europe 2020 strategy headline targets"
2012/17, Silva, J.I.; Vázquez-Grenno, J.: "The ins and outs of unemployment in a two-tier labor market"
2012/18, González-Val, R.; Lanaspa, L.; Sanz, F.: "New evidence on Gibrat's law for cities"
2012/19, Vázquez-Grenno, J.: "Job search methods in times of crisis: native and immigrant strategies in Spain"
2012/20, Lessmann, C.: "Regional inequality and decentralization – an empirical analysis"
2012/21, Nuevo-Chiquero, A.: "Trends in shotgun marriages: the pill, the will or the cost?"
2012/22, Piil Damm, A.: "Neighborhood quality and labor market outcomes: evidence from quasi-random neighborhood assignment of immigrants"
2012/23, Ploeckl, F.: "Space, settlements, towns: the influence of geography and market access on settlement distribution and urbanization"
2012/24, Algan, Y.; Hémet, C.; Laitin, D.: "Diversity and local public goods: a natural experiment with exogenous residential allocation"
2012/25, Martinez, D.; Sjögren, T.: "Vertical externalities with lump-sum taxes: how much difference does unemployment make?"
2012/26, Cubel, M.; Sanchez-Pages, S.: "The effect of within-group inequality in a conflict against a unitary threat"
2012/27, Andini, M.; De Blasio, G.; Duranton, G.; Strange, W.C.: "Marshallian labor market pooling: evidence from Italy"
2012/28, Solé-Ollé, A.; Viladecans-Marsal, E.: "Do political parties matter for local land use policies?"
2012/29, Buonanno, P.; Durante, R.; Prarolo, G.; Vanin, P.: "Poor institutions, rich mines: resource curse and the origins of the Sicilian mafia"
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2012/32, Kappeler, A.; Solé-Ollé, A.; Stephan, A.; Välilä, T.: "Does fiscal decentralization foster regional investment in productive infrastructure?"
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2013

2013/1, Sánchez-Vidal, M.; González-Val, R.; Viladecans-Marsal, E.: "Sequential city growth in the US: does age matter?"
2013/2, Hortas Rico, M.: "Sprawl, blight and the role of urban containment policies. Evidence from US cities"
2013/3, Lampón, J.F.; Cabanelas-Lorenzo, P-; Lago-Peñas, S.: "Why firms relocate their production overseas? The answer lies inside: corporate, logistic and technological determinants"
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2013/26, Lambertini, L.; Mantovani, A.: "Feedback equilibria in a dynamic renewable resource oligopoly: pre-emption, voracity and exhaustion"

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2013/30, Wang, R.; Wang, W.: "Dress-up contest: a dark side of fiscal decentralization"
2013/31, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"
2013/32, Saarimaa, T.; Tukiainen, J.: "Local representation and strategic voting: evidence from electoral boundary reforms"
2013/33, Agasisti, T.; Murtinu, S.: "Are we wasting public money? No! The effects of grants on Italian university students' performances"
2013/34, Flacher, D.; Harari-Kermadec, H.; Moulin, L.: "Financing higher education: a contributory scheme"
2013/35, Carozzi, F.; Repetto, L.: "Sending the pork home: birth town bias in transfers to Italian municipalities"
2013/36, Coad, A.; Frankish, J.S.; Roberts, R.G.; Storey, D.J.: "New venture survival and growth: Does the fog lift?"
2013/37, Giulietti, M.; Grossi, L.; Waterson, M.: "Revenues from storage in a competitive electricity market: Empirical evidence from Great Britain"

2014

2014/1, Montolio, D.; Planells-Struse, S.: "When police patrols matter. The effect of police proximity on citizens' crime risk perception"
2014/2, Garcia-López, M.A.; Solé-Ollé, A.; Viladecans-Marsal, E.: "Do land use policies follow road construction?"
2014/3, Piolatto, A.; Rablen, M.D.: "Prospect theory and tax evasion: a reconsideration of the Yitzhaki puzzle"
2014/4, Cuberes, D.; González-Val, R.: "The effect of the Spanish Reconquest on Iberian Cities"
2014/5, Durán-Cabré, J.M.; Esteller-Moré, E.: "Tax professionals' view of the Spanish tax system: efficiency, equity and tax planning"
2014/6, Cubel, M.; Sanchez-Pages, S.: "Difference-form group contests"
2014/7, Del Rey, E.; Racionero, M.: "Choosing the type of income-contingent loan: risk-sharing versus risk-pooling"
2014/8, Torregrosa Hetland, S.: "A fiscal revolution? Progressivity in the Spanish tax system, 1960-1990"
2014/9, Piolatto, A.: "Itemised deductions: a device to reduce tax evasion"
2014/10, Costa, M.T.; García-Quevedo, J.; Segarra, A.: "Energy efficiency determinants: an empirical analysis of Spanish innovative firms"
2014/11, García-Quevedo, J.; Pellegrino, G.; Savona, M.: "Reviving demand-pull perspectives: the effect of demand uncertainty and stagnancy on R&D strategy"
2014/12, Calero, J.; Escardíbul, J.O.: "Barriers to non-formal professional training in Spain in periods of economic growth and crisis. An analysis with special attention to the effect of the previous human capital of workers"
2014/13, Cubel, M.; Sanchez-Pages, S.: "Gender differences and stereotypes in the beauty"
2014/14, Piolatto, A.; Schuett, F.: "Media competition and electoral politics"
2014/15, Montolio, D.; Trillas, F.; Trujillo-Baute, E.: "Regulatory environment and firm performance in EU telecommunications services"
2014/16, Lopez-Rodriguez, J.; Martinez, D.: "Beyond the R&D effects on innovation: the contribution of non-R&D activities to TFP growth in the EU"
2014/17, González-Val, R.: "Cross-sectional growth in US cities from 1990 to 2000"
2014/18, Vona, F.; Nicolli, F.: "Energy market liberalization and renewable energy policies in OECD countries"
2014/19, Curto-Grau, M.: "Voters' responsiveness to public employment policies"
2014/20, Duro, J.A.; Teixidó-Figueras, J.; Padilla, E.: "The causal factors of international inequality in co2 emissions per capita: a regression-based inequality decomposition analysis"
2014/21, Fleten, S.E.; Huisman, R.; Kilic, M.; Pennings, E.; Westgaard, S.: "Electricity futures prices: time varying sensitivity to fundamentals"
2014/22, Afcha, S.; García-Quevedo, J,: "The impact of R&D subsidies on R&D employment composition"
2014/23, Mir-Artigues, P.; del Río, P.: "Combining tariffs, investment subsidies and soft loans in a renewable electricity deployment policy"
2014/24, Romero-Jordán, D.; del Río, P.; Peñasco, C.: "Household electricity demand in Spanish regions. Public policy implications"
2014/25, Salinas, P.: "The effect of decentralization on educational outcomes: real autonomy matters!"
2014/26, Solé-Ollé, A.; Sorribas-Navarro, P.: "Does corruption erode trust in government? Evidence from a recent surge of local scandals in Spain"
2014/27, Costas-Pérez, E.: "Political corruption and voter turnout: mobilization or disaffection?"

2014/28, Cubel, M.; Nuevo-Chiquero, A.; Sanchez-Pages, S.; Vidal-Fernandez, M.: "Do personality traits affect productivity? Evidence from the LAB"
2014/29, Teresa Costa, M.T.; Trujillo-Baute, E.: "Retail price effects of feed-in tariff regulation"
2014/30, Kilic, M.; Trujillo-Baute, E.: "The stabilizing effect of hydro reservoir levels on intraday power prices under wind forecast errors"
2014/31, Costa-Campi, M.T.; Duch-Brown, N.: "The diffusion of patented oil and gas technology with environmental uses: a forward patent citation analysis"
2014/32, Ramos, R.; Sanromá, E.; Simón, H.: "Public-private sector wage differentials by type of contract: evidence from Spain"
2014/33, Backus, P.; Esteller-Moré, A.: "Is income redistribution a form of insurance, a public good or both?"
2014/34, Huisman, R.; Trujillo-Baute, E.: "Costs of power supply flexibility: the indirect impact of a Spanish policy change"
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