This is a pre-print of an article published in the Journal of Business Research. The final authenticated version is available online at:

Berbegal-Mirabent, J.; Sánchez García, J.L.; Ribeiro-Soriano, D.E. (2015). University–industry partnerships for the provision of R&D services. *Journal of Business Research*, 68(7): 1407-1413. https://doi.org/10.1016/j.jbusres.2015.01.023

University–industry partnerships for the provision of R&D services

Abstract

Technology Transfer Offices (TTOs) are the main institutions responsible for the establishment of university–industry partnerships. In this paper, we explore the internal resources and capabilities of TTOs and universities that best explain R&D contracts. To do so, we analyze a sample of Spanish public universities for the year 2010. First, we run a series of regression models to explain the determinants of R&D contracts. Second, we explore the effect of specific regional variables on this knowledge transfer mechanism. Our results indicate that, in addition to the characteristics of the university and the TTO, successful R&D contracts also depend on the geographical location of the university.

Keywords: technology transfer office (TTO); university–industry partnerships; R&D contracts

1. INTRODUCTION

In a dynamic, globalized economy, firms need to engage in a process of constant adaptation and evolution if they wish to survive. In spite of this ongoing change, however, firms in fact drive markets by leveraging knowledge and then managing this knowledge strategically. Growing awareness of knowledge as a potential source of competitive advantage means that universities are now thought of as holding a key position within the science and technology ecosystem, representing an inexhaustible source of knowledge and technology capabilities.

Universities play a key role in human capital development, as well as in the provision of new knowledge (D'Este and Patel, 2007). This means that, in addition to providing highly qualified graduates and researchers, universities also have to offer innovative solutions through knowledge transfer mechanisms that foster links with the business sector. As a result, universities have expanded their traditional functions of teaching and research, and have enlarged their service portfolio through the so-called third mission (Goddard, 2005), reconsidering their role in society and re-evaluating their relationships with communities and stakeholders.

According to Tuunainen (2005), the third mission encompasses a wide array of activities including the creation, use, application, and exploitation of knowledge in non-academic environments. The aim of the third mission is to convert basic research outcomes into applications with economic and social repercussions that go beyond production (i.e., academic research) and transmission (i.e., teaching and publication).

Yet universities must do more than just develop new technologies and hand them over to the business sector. Academic research is now profoundly integrated into the economic cycle of innovation and growth. Both universities and firms need to collaborate to harness the full potential of knowledge or technology (Lee and Win, 2004). Indeed, successful exploitation of new external knowledge requires effective knowledge transfer mechanisms, and, because knowledge is progressive and co-created, knowledge transfer entails an active involvement from participants, who must learn from and with others. In this scenario—within the remit of the third mission—, the establishment of university–industry partnerships prevails as an important mechanism for the provision of R&D services.

According to Santoro and Chakrabarti (2002), collaboration in university–industry partnerships is analogous to teamwork. On the one hand, universities have the appropriate physical facilities and staff expertise to make scientific discoveries and technological breakthroughs (Debackere and Veugelers, 2005). On the other hand, they need the industry's knowledge of the market to come up with new, applicable, successful technology developments, as industry practitioners are much more in tune with user needs, due to their proximity to users and downstream research (Siegel et al., 2003). Likewise, additional private funding support is essential to ensure the viability of future research (Lai, 2011).

Mindful of the importance of university–industry partnerships for the generation of technological spillovers, many governments have introduced initiatives to enhance such partnerships (D'Este and Patel, 2007). At the same time, universities are adapting their structures and infrastructures to improve their provision of R&D services, and thus exploit their scientific research as fully as possible (Muscio, 2010). Whereas initiatives to foster university–industry partnerships may include the establishment of regulatory frameworks that facilitate the payment of rewards to holders of intellectual property rights, making changes to infrastructure means setting up technology transfer offices (TTO), which are service businesses aimed at bridging the gap between science and industry.

Previous research on university–industry partnerships mainly concentrates on the issues of patenting, licensing, or the creation of spin-offs, but, as several authors point out, abundant empirical evidence suggests that university–industry partnerships embrace a much broader spectrum of activities and act through multiple channels (Arundel and Geuna, 2004; Mowery and Sampat, 2005). Nevertheless, there is little available information on university–industry R&D contracts (Conti and Gaulé, 2008) despite the importance of this source of revenue for universities.

Hence, within this context, we scrutinize the extent to which TTOs' institutional and organizational characteristics, as well as those of the parent university itself, condition the establishment of successful university–industry partnerships, measured via the volume and monetary value of signed R&D contracts. We focus our study on the performance of Spanish TTOs from public universities for the year 2010. In order to achieve a more comprehensive picture of the situation, in a second-stage analysis, we also examine the effect of exogenous variables—related to regional aspects—on these collaborative R&D agreements.

The following section summarizes the key findings in the extant literature on R&D cooperation between universities and firms, while Section 3 presents the conceptual model and the hypotheses to be tested using empirical data. Section 4 then offers an overview of the Spanish university–industry R&D landscape, with Section 5 introducing the sample and setting out the methodological approach. Section 6 contains the empirical findings from the study, and, lastly, Section 7 covers a discussion of conclusions and policy implications from these findings.

2. R&D COOPERATION BETWEEN FIRMS AND UNIVERSITIES

Many empirical studies focus on quantifying different forms of academic knowledge transfer (e.g., Carlsson and Fridh, 2002; Lockett and Wright, 2005; Wright et al., 2008). Two main ways of transferring academic knowledge fall within the scope of this research: direct and indirect placement of products and services in the marketplace. Academic spin-offs constitute the direct mechanism, representing the entrepreneurial route to commercializing public research. Contrarily, licensing arrangements of university inventions, incubator facilities, R&D contracts, and consulting services are examples of indirect mechanisms through which enterprises and research institutions collaborate on a win-win basis. This study covers organizational and institutional aspects that act as drivers for the establishment of successful indirect mechanisms, particularly in R&D contracts. An R&D contract is an agreement whereby a firm contracts R&D services from a research center—usually a university—so that the firm can pursue commercial benefit by harnessing the research center's unique capabilities (Lee and Win, 2004).

The effectiveness of this knowledge transfer process diminishes if the indirect mechanism has an inefficient design. Accordingly, a first step where common interests are identified is crucial (Veugelers and Cassiman, 2005). Businesses seek specific research applications to shorten the time span between discoveries and their implementation. Universities, aiming at obtaining social and economic gains from research, respond to industry needs by providing meaningful knowledge with practical applications (Lockett and Wright, 2005).

Lee and Win (2004) provide a comprehensive list of the potential benefits arising from cooperation agreements between universities and firms. From the business perspective, university–industry partnerships usually seek to cut the time lag between discoveries and their practical application. Universities provide access to a wide array of human capital, knowledge, and innovation networks (Lai, 2011). They also help firms identify technological opportunities, and give assistance in pre-competitive stages of product development. Moreover, businesses, in particular small and medium enterprises, may have problems with carrying out in-house R&D, as such activities usually require complex infrastructures and advanced services for product development. The above arguments therefore explain a firm's natural tendency to outsource their research activities to universities, or to use universities' infrastructures (i.e., R&D labs) as a way of saving money and taking advantage of academics' expertise.

From an academic point of view, access to financial resources that facilitate activities in hitherto untapped research fields represents a university's incentive to enter into such alliances. Furthermore, working side by side with industry can help improve the state of the art, and may yield fresh ideas that form the basis for new basic research, thereby improving researchers' performance (Guldbrandsen and Smeby, 2005). For this role to take place effectively, however, the academic community must have the time, the freedom, the means, and the motivation to engage in university–industry partnerships.

In light of the above, policymakers must introduce new formulas and policies (e.g., on intellectual property rights, conflict of interests, and copyright) to achieve successful university–industry partnerships, as the incentives of knowledge exploitation and the chance of accessing extra revenues may represent an important motivation for institutions and its faculty alike (Arvanitis et al., 2008).

DETERMINANTS OF R&D CONTRACTS

Universities face considerable constraints on resources, and are vulnerable to changes in their environment. A better understanding of the determinants that help explain why some universities are more successful than others in the provision of R&D services through R&D contracts therefore becomes a central concern.

In an attempt to understand the underlying rationale behind this issue, we identify the organizational capabilities, internal resources, and services that support research and knowledge transfer activities at universities. The theoretical model, and its corresponding hypotheses, appears below. This model has two main dimensions: the university and the TTO. While the former provides the knowledge, technology and research expertise, the latter is in charge of facilitating and accelerating the relationship between business and science, enabling the business sector to keep up to date with the latest technologies and maintain a competitive edge (Rothaermel et al., 2007).

TTO profile

According to Gueno (1998) and Merton (1988) long-standing universities (and, by extension, mature TTOs) may create both a halo and a Matthew effect, based on historical interactions of expertise and prestige. This may be because old TTOs have established a working environment and a certain *modus operandi* that can have a positive influence on their activities (Caldera and Debande, 2010). We therefore hypothesize that experienced TTOs will generate greater, more frequent revenues from R&D contracts.

Human capital (HC) is especially relevant in the case of universities, as these educational institutions rely heavily on individuals' capabilities. HC thus constitutes a key factor in ensuring corporate success. R&D contracts entail involvement from more parties than just the researchers who perform the research demanded by the industry (Caldera and Debande, 2010). R&D contracts set out guidelines for an activity that requires coaching and appropriate assessment, which highlights the need to consider the

TTO’s technical staff devoted to R&D tasks. We thus expect to observe a positive relationship between TTO staff devoted to R&D contracts and R&D activity.

Many studies emphasize the existence of a positive relation between access to funding and knowledge transfer activities (De Coster and Butler, 2005; Landry et al., 2007). In this paper, we stress the impact that a TTO’s annual budget has on knowledge transfer activities (Polo-Otero, 2009). Given that financial resources are critical for conducting R&D, we hypothesize that TTOs with larger budgets will generate more R&D contracts.

Finally, we study the effect of social capital. The establishment of university–industry partnerships also depends on the links between research and market factors (Landry et al., 2006). Here, the concept of social capital is significant, in that it refers to the meaningful interactions between scientists and market agents (Aldridge and Audretsch, 2011). Specifically, we focus on universities’ established networks with foreign private firms—companies operating in different countries—to examine whether universities with an international network of contacts are more likely to engage in R&D contracts than universities primarily operating regionally. Consequently, we posit that social capital is positively related to R&D contracts.

University profile

Human capital relates to the knowledge accumulation process, and symbolizes a university’s background in a specific field. Previous experience gives university staff the specific knowledge and capabilities to help them develop strategies that are more successful, which may lead to more efficient resource allocation and a higher output rate. Thus, expertise in knowledge transfer activities can be considered a catalyst for new R&D activities (Lockett et al., 2003; Clarysse et al., 2005). Accordingly, we hypothesize a positive relationship between the number of faculty members involved in knowledge transfer activities and the volume of R&D contracts.

We also consider the university's academic spread. Empirical studies (Carlsson and Fridh, 2002; Caldera and Debande, 2010) suggest that some disciplines play a key role in knowledge transfer activities. In particular, research seems to indicate that polytechnic universities are associated with higher levels of knowledge transfer outputs (Belderbos et al., 2006). Based on this rationale, we expect that polytechnic universities are linked to better performance rates in terms of R&D contracts.

Lastly, we also account for specific infrastructures that are expected to boost the creation of university–industry partnerships. Previous studies suggest that university science parks may affect university performance (Agrawal and Cockburn, 2003). Essentially, a science park's purpose is to create knowledge clusters, and to facilitate the interaction between universities and firms located in the park. In a science park, information flows from academia to business, accelerated by geographical proximity. Thus, we posit that the presence of a science park positively contributes to the establishment of R&D contracts.

AN OVERVIEW OF THE SPANISH R&D LANDSCAPE

In recent years, Spanish policymakers—mainly public administrations—have implemented a series of programs and initiatives to encourage university–industry R&D partnerships. According to the 2010 report from the Encuesta I+TC (RedOTRICRUE, 2011) interactions between universities and the business sector accounted for 632 million Euros in 2010. The report also cites examples of numerous technology transfer initiatives that have flourished within Spanish universities.

The results of the RedOTRI survey from 2006 to 2010 (Figure 1), indicate that 98.3% of Spanish TTOs carry out licensing activities, 96.7% tasks related with intellectual and industrial protection, and 95% R&D contracts and the provision of consulting services. In fact, these three activities are the most common undertakings of Spanish TTOs, with over 90% of all TTOs performing them. At the bottom of this list of the most habitual activities lies the management of science parks—falling from 16.10% of TTOs in 2006 to 10.0% in 2010—, followed by the management of seed capital (16.60%). According to RedOTRICRUE (2011), an external unit generally performs these functions.

Figure 1 here.

Levels of recruitment of new personnel for R&D activities have clearly suffered from the downturn in the country's economy. In 2010, Spanish TTOs had, on average, 12.2 full time equivalent (FTE) employees, 13.48% fewer than in 2009. Nevertheless, an increase in public calls for the establishment of university–industry R&D collaborations boosted the number of faculty members involved in knowledge transfer activities in 2010 by 5%. The activities that demand most technical staff are those related to R&D programs in collaboration with firms (3.8 FTE employees, on average), followed by the licensing of patents, know-how and software (1.8 FTE employees, on average), and the formalization and management of R&D contracts (1.4 FTE employees, on average).

The annual budget of Spanish TTOs has undergone significant growth. Whereas in 2009 the budget stood at 24.96 million Euros, 2010 saw a massive increase of nearly 167%, lifting this figure to 41.63 million Euros. Although, in aggregate terms, this amount represents just 6.5% of the total revenues from university–industry R&D contracts, it represents a two-thirds increase from the contribution in 2009 (3.9%).These numbers signal the appeal and importance of TTOs within the Spanish context.

Between 2009 and 2010, financing of the TTOs from the general budget of their parent institutions followed a downward trend, dropping from 48.6% to 36.5% (Encuesta I+TC, 2010). These figures suggest that Spanish universities are committed to diversifying the sources of funding for their associated TTOs. An in-depth analysis of the sector's financial statements corroborates the assertion that Spanish TTOs are promoting the participation of their researchers in R&D activities, particularly through two main instruments: competitive and collaborative R&D projects and research contracts with firms.

In Spain, research contracts are conceived as contracts of activity, media, or diligence. The researcher (or its organization) assumes the commitment to allocate human resources and materials to carry out a series of specific tasks. Their commitment is thus measured in terms of resources rather than results. This consideration is of great importance when determining the rights, obligations, and responsibilities of the contracting company and the contracted research center. These contracts are regulated by article 83 of the LOU (Organic Law of Universities).

While different types of contracts exist under this legislation, the following three are the most prevalent.

- R&D contracts. Under these contracts, the university carries out an R&D project as a response to a specific company or agency request. This research activity leads to new knowledge, subject to uncertainty. Careful regulation of the ownership and exploitation of the results is therefore paramount.

- Technical services. This type of contract covers services that, owing to the purpose of the contract and its small financial value (e.g., performing laboratory tests or using scientific equipment), are exempt from requirements to sign a legal document that regulates aspects of execution rights.
- Consulting services. This contract governs the provision of advisory services, opinion, or diagnosis on a particular issue brought up by a company. This service rarely results in knowledge creation, but rather entails the exploitation of extant knowledge available at the university.

For the purposes of this study, we focus exclusively on R&D contracts. The reason for doing so is twofold. First, R&D contracts represent the biggest revenue-generating knowledge transfer output from those shown in Figure 1 (on average, 44,370 Euros per contract). Second, in this type of contract, stakeholders must define who owns the property rights of the results of the research contract. Consequently, the study of how regulatory frameworks influence R&D contracts becomes a supplementary matter of interest that is worthy of consideration.

DATA AND METHOD

Data

The data to carry out the empirical analysis come from two main sources: the annual survey reports of the Spanish Network of Technology Transfer Offices (Red de Oficinas de Transferencia de Resultados de Investigación, RedOTRI) and the biannual reports produced by the Council of Rectors of Spanish Universities (Conferencia de Rectores de Universidades Españolas, CRUE). The data are nonetheless missing some observations, so to mitigate for these missing data, the use of additional sources was necessary, with manual searches through the annual reports of each university and its TTO yielding this additional information. Although we successfully filled in the majority of the gaps in the data, some missing values remain.

We obtained additional information regarding specific variables through the IUNE Observatory of Spanish University Research Activity (Observatorio IUNE de la Actividad Investigadora en la Universidad Española) and the Spanish National Institute of Statistics (Instituto Nacional de Estadística, INE) websites.

The original database comprises information for all 47 Spanish public universities for the period 2008–2010. In the interests of methodological rigor, however, the final sample only includes TTOs for which a complete dataset of the variables of interest is clearly identifiable. The STATA statistical package provides the statistical data treatment tool.

Definition of variables

We use two dependent variables to assess university performance in R&D contracts in 2010: the number of R&D contracts, as a proxy of the quantity of R&D activity; and income from the R&D contracts, as a measure of quality. Table 1 provides the definitions of all the variables under study. As Table 1 shows, in addition to the set of explanatory variables, we also include university size to control for the advantages universities may gain due to their scale (Belenzon and Schankerman, 2009).

Table 1 here.

Prior to estimating the regressions, two considerations are necessary. First, to obtain normality, we transformed some variables using the natural logarithm (R&D

income contracts, TTO budget, university size, and TTO age). Second, to control for potential endogeneity problems, explanatory variables were introduced as lagged terms, whereby the values of these variables correspond to those reported for the year 2009 (or the academic year 2008/09). Descriptive statistics for the selected variables are depicted in Table 2.

Table 2 here.

Method

To assess the determinants of R&D contract income, we opted for linear regression analysis, whereas, for the number of R&D contracts, we adopted a negative binomial regression technique, due to the highly skewed distribution of the dependent variable (Greene, 2003, 2008). We tested two models for each dependent variable. Model 1 includes explanatory variables related to the specific characteristics of the TTO, while Model 2 covers variables related to the university's profile. A third model including all explanatory variables allowed us to check the robustness of the significance of the results.

Before proceeding to a discussion of our results, it is important to note that we also tested whether disturbances emerging from the different model specifications assessing the incomes from R&D contracts follow a normal distribution. To do so, we used normal probability plots of the residuals. The plots for each of the regressions support the normality assumption of disturbance terms, validating our approach.

EMPIRICAL RESULTS

First-stage analysis: Regression analysis

Table 3 reports the parameter estimates for the two models tested with two alternative dependent variables: number of R&D contracts and R&D contract income for 2010.

Table 3 here.

Considering the effect of TTO characteristics on the dependent variables (Model 1), our findings support the hypothesis that the experience of the TTO is a determinant factor for R&D contracts, as it gives people working at the TTO the specific knowledge to help them carry out their tasks more efficiently, leading to higher performance rates.

One interesting result is that the role of TTO staff devoted to R&D contract tasks is unhelpful in explaining the number of R&D contracts and the income they generate. Additional descriptive statistics indicate a weak, non-significant, negative relationship between the proportion of faculty members assigned to knowledge transfer activities, and the number of R&D contracts and the income they generate (26.10% and 18.22%, respectively). In order to extend the examination of the effect of TTO staff, we correlated the number of total staff in TTOs with the two dependent variables. Additional descriptive statistics corroborate the existence of a positive, statistically significant correlation between these variables (35.43% for the number of R&D contracts, p-value < 5%; and 47.90% for R&D contracts income, p-value < 1%). These results indicate that TTO staff members may have to perform different tasks, and, although specialization is desirable, Spanish TTOs are characterized by a relatively low number of technical staff on their payroll (15.98 on average), with approximately 42% of TTOs operating with 10 employees or fewer.

Our results indicate that TTOs with bigger annual budgets enter into more R&D contracts and achieve larger incomes. This is consistent with our hypothesis about the presence of a positive relationship between access to financial resources and the TTO's capability to foster a greater number of more lucrative R&D contracts.

As for the proportion of foreign private firms that have employed the university's services for knowledge transfer activities during the past year, results support the argument that university–industry collaboration, as one of the drivers of knowledge spillovers, goes beyond regional collaboration (Ponds et al., 2010).

Model 2 allows us to examine the effect of university characteristics on the dependent variables. The results indicate that, in keeping with the behavior observed in Model 1, faculty involvement in knowledge transfer activities has no significant impact on any of the dependent variables. To corroborate this finding further, we analyse the correlation effects between these variables, observing weak and statistically non-significant effects. A natural interpretation of this result is that the quality and capabilities of the faculty members are more important than the number of faculty members involved in knowledge transfer activities. Furthermore, the lack of significance of this variable may indicate that academics perceive an absence of, or, at most, little incentive to engage in R&D contracts. Future research is necessary to be sure of whether adequate regulatory frameworks motivate researchers to engage in R&D contracts. Unfortunately, the available data for Spanish universities is inadequate for this sort of analysis (41 of the 43 universities state that they have a specific regulatory framework, but withhold any additional information).

Two further interesting findings emerge regarding the effect of the technical orientation of the university and the presence of specific infrastructures. Results indicate that, whereas the dummy variable polytechnic/non-polytechnic university helps explain R&D contract income, the science park variable does so for the number of R&D contracts. The first result suggests that polytechnic universities engage in university–industry partnerships associated with advanced technologies and knowledge. This translates as competitive R&D contracts that require significant financial investment, as indicated by the positive sign of the estimated coefficient. The underlying rationale for the effect of the science park dummy variable relates to the geographical proximity of the university and the marketplace. Science parks are knowledge-based enclaves where firms and researchers can meet, exchange ideas, and cooperate in close proximity. Our results suggest that universities with a science park secure a higher number of R&D contracts relative to universities without a science park. The effect of this variable on R&D contract income, however, diminishes, indicating that firms located in a science park may look for specialized facilities and new knowledge, but that the magnitude of the financial investment is not a determining factor.

Based on previous studies (Carlsson and Fridh 2002), we also test whether universities with medical studies perform differently. To do so, we include a dummy variable that takes the value 1 if the university has a medical school, and 0 otherwise. Results confirm our initial hypothesis that, in Spain, the influence of a medical school is not a determinant factor in the number and value of R&D contracts.

University size is statistically significant. This result is unsurprising because small universities have more difficulties in accessing research resources, and in creating economies of scale in the execution of research projects and the subsequent dissemination of findings.

In order to check the robustness of the results, **Model 3** simultaneously considers the effects of the TTO's and university's characteristics. Although the model appears to fit the data well, results should be interpreted with caution. Because of the low number of full observations (40), the inclusion of a large number of variables consumes too many degrees of freedom, which may lead to an incidental parameters problem with inconsistent maximum likelihood estimators.

Nevertheless, results for the full model indicate that Models 1 and 2 are consistent. Particularly, the non-significant effect of staff specialization—both in terms of the technical TTO staff devoted to R&D contracts and the number of faculty members involved in knowledge transfer activities—reinforces the argument that quality, rather than quantity, as well as an appropriate system of incentives, are the drivers for faculty involvement in R&D contracts (Macho-Stadler et al., 2007; Lach and Schankerman, 2008).

Regarding the effect that established international networks have on R&D contracts, the third model also corroborates the hypothesis that social capital helps in creating a more fertile setting for establishing R&D contracts. Likewise, in all the specifications tested, large universities obtain advantages in R&D contracts.

From the results, we also confirm the effect of the polytechnic and science park dummy variables. This is in accordance with the idea that polytechnic universities achieve larger revenues from R&D contracts, whereas a science park positively contributes to explaining the number of R&D contracts.

The effect of experienced TTOs weakens in the full model (Model 3), however. An explanation for this finding is the correlation between the age of the TTO and the dependent variables: 45.52% (p-value = 0.0022) for the number of R&D contracts and 51.64% (p-value = 0.0004) when correlated with R&D contract income. We thus conclude that, although the age of the TTO seems to be important, the non-significant effect found in the full model raises questions as to whether seniority on its own is insufficient and is less important than experience of involvement in R&D contracts.

The explanatory power of the financial resources variable (TTO budget) also decreases in the full model (p-value < 10% instead of p-value < 1%) when income from these agreements acts as a proxy for R&D contracts. Nevertheless, this variable is still significant, implying that financial resources are critical for the establishment of R&D contracts.

Second-stage analysis: regional effects

According to Shattock (2009), exposure to region-specific economic variables may influence university–industry R&D activities. On the basis that Spain is a country with striking regional differences in terms of economic development and public and private investment (Buesa et al., 2002), in a second-stage analysis, we analyze the potential effect that exogenous variables related to the geographical location of universities may have on R&D contracts.

At the NUTS 2 level, Spain is divided into 17 regions called autonomous communities. Based on this approach, and given that the literature reveals discrepancies in opinion as to the impact of public policies and regional factors on HEI performance (García-Aracil and Palomares-Montero, 2008), we introduced three factors: (1) the wealth of the region, taking regional Gross Domestic Product per capita (GDP divided by total population) as a proxy; (2) the innovation intensity, calculated as innovation expenditure as a proportion of total expenditure in the region; and (3) the employment in high-tech sectors as a proportion of total employment in the region. The data for these variables come from the Spanish National Statistics Institute for the year 2009, with Table 4 providing a summary of descriptive statistics for these variables.

Table 4 here.

We used the Mann–Whitney U test as our principal method. This procedure allowed us to test whether the observed median differences between two groups of universities have divergent central tendencies. This statistical test is appropriate for this type of analysis, as it permits the assessment of whether the medians of the two groups are significantly different. The analysis also relied on a t-test of mean differences to corroborate our findings further. Table 5 shows the results of this analysis.

Table 5 here.

Results indicate that regional economic factors consistently affect the performance of university–industry partnership in terms of both number of and income from R&D contracts. In particular, universities located in regions with above-the-median innovation intensity and proportion of employment in high-tech sectors engage in a significantly higher number of R&D contracts. Likewise, a similar pattern emerges when exploring R&D contract income, with universities located in regions with high GDP per capita (above the median) signing a higher number of R&D contracts. The significance of this result, however, is only partially supported (t-test) for R&D contract income. Here, a noteworthy observation is that, from a descriptive perspective, universities that receive greater R&D contract income are located in territories with higher levels of GDP per capita. Thus, these findings support the notion that the establishment of R&D contracts goes hand in hand with the region's economic prosperity.

CONCLUDING REMARKS

Today, knowledge transfer from university to industry is an important strategic consideration, so much so in fact that academic research is an important driver for businesses, as it greatly contributes to providing new scientific discoveries and advanced technologies that accelerate innovation. To remain competitive, many firms therefore see universities as ideal partners for the outsourcing of their R&D activities. In return, university–industry R&D partnerships represent a valuable source of additional funding for university research.

TTOs are the main institutions responsible for the establishment of university–industry partnerships. These entities aim at providing the appropriate incentives to optimize knowledge transfer mechanisms and reconcile the potentially conflicting interests of stakeholders.

The extant literature contains examples of three research streams examining the factors that enhance collaborative partnerships. The first approach is the study from the viewpoint of the university (Di Gregorio and Shane 2003; Friedman and Silberman 2003); the second, with respect to the firms involved (Cohen et al. 2002; Fontana et al. 2006); and the third, taking the individual academic researcher as the unit of analysis (D'Este and Patel, 2007). Despite the existence of these three bodies of literature, empirical evidence on the determinants of R&D contracts is nonetheless scarce. To bridge this theoretical research gap, we first embarked on the analysis of universities' and TTOs' internal resources and capabilities that may help explain performance differences in the number of R&D contracts and R&D contract income. Second, we empirically evaluated whether universities located in regions with a favorable environment are more actively involved in this particular knowledge transfer mechanism. We then tested our hypotheses for the Spanish public university sector.

Results indicate that successful TTOs have more accumulated experience and larger budgets than that of an average TTO, as well as boasting an international social network. Contrary to previous studies, we find that specialization in terms of staff devoted to R&D contract activities neither results in more R&D contracts nor generates greater R&D contract income, which indicates that individual capabilities are more important than the number of technical staff on the TTO's payroll.

As for the university's characteristics, results indicate that larger universities attain better performance rates. Conversely, the positive effect of faculty members involved in knowledge transfer activities is statistically non-significant in all of the models tested. A potential explanation for this result follows the lines of the literature on incentive schemes and regulatory frameworks within universities.

A key finding is that polytechnic universities tend to bring in greater R&D contract income, whereas the presence of a science park positively contributes to increasing the number of R&D contracts. This result suggests that the quantity (number) of R&D contracts may relate to proximity and infrastructures (the existence of a science park), and that R&D quality (taking R&D contract income as a proxy) is equivalent to having partnerships with a stronger focus on radical breakthroughs and technological developments. Consequently, polytechnic universities are more attractive to firms seeking a partner in fields where the rate of innovation and technological change is high.

The second-stage analysis also yields valuable findings, notably validating the hypothesis that universities located in regions with a favorable economic context are more prone to engaging in university–industry partnerships.

This paper paves the way for future research, as it shows that, in addition to the characteristics of the university and the TTO, establishing R&D contracts also depends on exogenous factors. Universities' competitive advantage hinges on their capacity to create knowledge. Given the importance of successfully managing the complementarities between basic and applied research at universities, future research should also examine the effects of regulatory frameworks on R&D contracts.

We are aware that the data sample is relatively small, although it comprises almost all (43 from 47) Spanish public universities. Nevertheless, the lack of a systematic process to collect comprehensive data for all the universities in the sample over a longer time span has undoubtedly conditioned the findings of our study.

References

Agrawal A, Cockburn I. The anchor tenant hypothesis: Exploring the role of large, local, R&D intensive firms in regional innovation systems. International Journal of Industrial Organization 2003; 21(9):1227–1253.

Aldridge TT, Audretsch D. The Bayh-Dole Act and scientist entrepreneurship. Research Policy 2011; 40(8):1058–1067.

Arundel A, Geuna A (2004) Proximity and the use of public science by innovative European firms. Economics of Innovation and new Technology 2004; 13(6):559–580.

Arvanitis S, Kubli U, Woerter M. University–industry knowledge and technology transfer in Switzerland: What university scientists think about co-operation with private enterprises. Research Policy 2008; 37(10):1865–1883.

Belderbos R, Carree M, Lokshin B. Complementarity in R&D cooperation strategies. Review of Industrial Organization 2006; 28(4):401–426.

Belenzon S, Schankerman M. University knowledge transfer: Private ownership, incentives, and local development objectives. Journal of Law and Econmics 2009; 52(1):111–144.

Buesa M, Martínez M, Heijs J, Baumert T. Los sistemas regionales de innovación en España. Una tipología basada en indicadores económicos e institucionales. Economía Industrial 2002; 347:15–32.

Caldera A, Debande O. Performance of Spanish universities in technology transfer: An empirical analysis. Research Policy 2010; 39(9):1160–1173.

Carlsson B, Fridh AC. Technology transfer in United States universities. A survey and statistical analysis. Journal of Evolutionary Economics 2002; 12(1/2):199–232.

Clarysse B, Wright M, Lockett A, Van de Velde E, Vohora A. Spinning out new ventures: A typology of incubation strategies from European research institutions. Journal of Business Venturing 2005; 20(2):183–216.

Cohen WM, Nelson RR, Walsh JP. Links and impacts: The influence of public research on industrial R&D. Management Science 2002; 48(1):1–23.

Conti A, Gaulé P. The CEMI Survey of Technology Transfer Offices. École Polytechnique Fédérale de Laussane; 2008.

CRUE-RedOTRI (2010) La I+D bajo contrato: Aspectos jurídicos y técnicos. Madrid: Cuadernos de RedOTRI 3; 2010.

D'Este P, Patel P. University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? Research Policy 2007; 36(9):1295–1313.

De Coster R, Butler C. Assessment of proposals for new technology ventures in the UK: Characteristics of university spin-off companies, Technovation 2005; 25(5):535–543.

Debackere K, Veugelers R. The role of academic technology transfer organizations in improving industry science links. Research Policy 2005; 34(3):321–342.

Di Gregorio D, Shane S. Why do some universities generate more start-ups than others? Research Policy 2003; 32(2): 209–227.

Fontana R, Geuna A, Matt M. Factors affecting university–industry R&D projects: The importance of searching, screening and signalling. Research Policy 2006; 35(2):309–323.

Friedman J, Silberman J. University technology transfer: Do incentives, management, and location matter? Journal of Technology Transfer 2003; 28(1):17–30.

García-Aracil A, Palomares-Montero D. Methodological problems to measure university efficiency in relation with its geographic localization. 2nd International Technology, Education and Development Conference, València (Spain), March; 2008.

Goddard J. Supporting the contribution of HEIs to regional developments project overview. Paper presented to OECD/IMHE Conference, Paris, January; 2005.

Greene W. Functional forms for the negative binomial model for count data. Economics Letters 2008; 99(3):585–590.

Greene W. Econometric Analysis (5th Ed.). Upper Sadler River, New Jersey: Prentice Hall; 2003.

Gueno A. The internationalisation of European universities: A return to medieval root. Minerva 1998; 36(3):253–270.

Guldbrandsen M, Smeby JC. Industry funding and university professors' research performance. Research Policy 2005; 34(6):932–950.

Lach S, Schankerman M. Incentives and inventions in universities. The RAND Journal of Economics 2008; 39(2):403–433.

Lai WH. Willingness-to-engage in technology transfer in industry–university collaborations. Journal of Business Research 2011; 64(11):1218–1223.

Landry R, Amara N, Ouimet M. Determinants of knowledge transfer: Evidence from Canadian university researchers in natural sciences and engineering. Journal of Technology Transfer 2007; 32(6):561–592.

Landry R, Amara N, Rherrad I. Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. Research Policy 2006; 35(10):1599–1615.

Lee J, Win HN. Technology transfer between university research centers and industry in Singapore. Technovation 2004; 24(5):433–442.

Lockett A, Wright M. Resources, capabilities, risk capital and the creation of university spin-out companies. Research Policy 2005; 34(7):1043–1057.

Lockett A, Wright M, Franklin S. Technology transfer and universities' spin-out strategies. Small Business Economics 2003; 20(2):185–200.

Macho-Stadler I, Pérez-Castrillo D, Veugelers R. Licensing of university innovations: The case of a technology transfer office. International Journal of Industrial Organization 2007; 25:483–510.

Merton RK. The Matthew effect in science, II: Cumulative advantage and the symbolism of intellectual property. Isis 1988; 79(4):606–623.

Mowery DC, Sampat BN. The Bayh–Dole Act of 1980 and university–industry technology transfer: A model for other OECD governments? Journal of Technology Transfer 2005; 30(1/2):115–127.

Muscio A. What drives the university use of technology transfer offices? Evidence from Italy. Journal of Technology Transfer 2010; 35(2):181–202.

Ponds R, Van Oort F, Frenken K. Innovation, spillovers and university–industry collaboration: an extended knowledge production function approach. Journal of Economic Geography 2010; 10(2):231–255.

Polo-Otero J. Determinantes de la transferencia de tecnología. In: Fundación CYD (eds), Informe CyD 2009 (pp. 215–217). Barcelona: Fundación Conocimiento y Desarrollo; 2009.

RedOTRI-CRUE. Informe de la Encuesta de Investigación y Transferencia de Conocimiento 2010 de las Universidades Españolas. Madrid: RedOTRI - Universidades (CRUE); 2011.

Rothaermel FT, Agung S, Jiang L. University entrepreneurship: A taxonomy of the literature. Industrial and Corporate Change 2007; 16(4):691–791.

Santoro MD, Chakrabarti AK. Firm size and technology centrality in industry–university interaction. Research Policy 2002; 31(7):1163–1180.

Shattock M. Research, technology, and knowledge transfer. In: Shattock M (ed) Entrepreneurialism in universities and the knowledge economy (pp 33–48). Maidenhead: Society for Research into Higher Education and Open University Press; 2009.

Siegel DS, Waldman D, Link AN. Assessing the impact of organizational practices on the productivity of university technology transfer offices: An exploratory research. Research Policy 2003; 32(1):27–48.

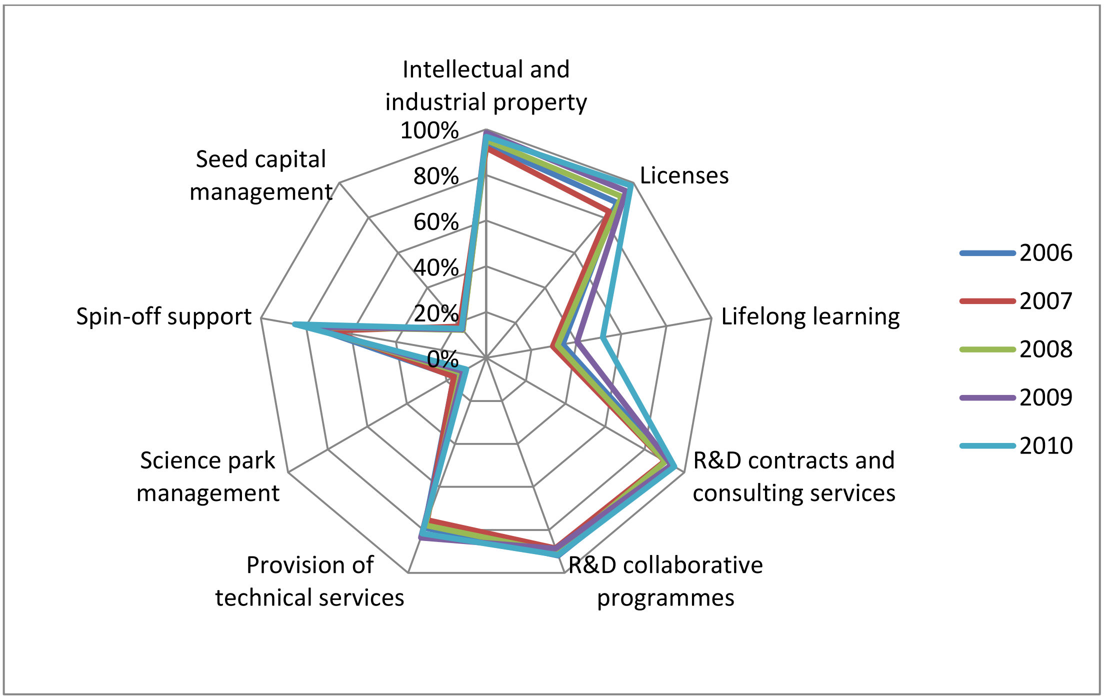
Tuunainen J. Hybrid practices? Contributions to the debate on the mutation of science and university. High Education 2005; 50(2): 275–298.

Veugelers R, Cassiman B. R&D cooperation between firms and universities. Some empirical evidence from Belgian manufacturing. International Journal of Industrial Organization 2005; 23(5/6):355–379.

Wright M, Clarysse B, Lockett A, Knockaert M. Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. Research Policy 2008; 37(8):1205–1223.

List of figures

Figure 1. Functions performed by Spanish TTOs (both public and private), expressed as the percentage of total TTOs each year



Source: Results from the Encuesta RedOTRI (2006–2009) and Encuesta I+TC (2010)

List of tables

Table 1. Variables under study

Variable	Definition	Source (year)
Dependent variables		
Number of R&D contracts	Total number of R&D contracts signed in the year (according to the Art. 83 in the Spanish LOU).	RedOTRI (2010)
R&D contract income	Income generated from R&D contracts signed in the year (in thousands of Euros).	RedOTRI (2010)
Explanatory variables		
1. TTO profile		
TTO age	TTO's age (expressed in years).	CRUE (2008/09)
TTO staff in R&D contracts (%)	Number of TTO employees appointed to manage, support and develop tasks related to R&D contracts, as a proportion of total staff employed at the TTO.	RedOTRI (2009)
TTO budget	TTOs' annual budget (in thousands of Euros).	RedOTRI (2009)
Foreign private firms (%)	Number of companies and other private entities located in foreign countries (outside Spain) that have contracted the university over the year for knowledge transfer activities, as a proportion of the total number of contracting private firms.	RedOTRI (2009)
2. University profile		
Faculty involved in KT activities (%)	Faculty involved in knowledge transfer (KT) activities as a proportion of total faculty working at the university.	RedOTRI (2009) CRUE (2008/09)
Polytechnic university	Dummy variable. Takes the value 1 if it is a polytechnic university; 0 otherwise.	CRUE (2008/09)
Science park	Dummy variable. Takes the value 1 if the university is located in a science park; 0 otherwise.	RedOTRI (2009)
University size	Total number of employees working at the university (including faculty and technical and administrative staff).	CRUE (2008/09)

Table 2. Descriptive statistics for the selected variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Dependent variables					
Number of R&D contracts	43	157.86	164.60	2.00	783.00
R&D contract income (thousands of Euros)	43	7,085.04	8,075.86	470	41,875.76
Explanatory variables (TTO)					
TTO age	43	17.86	3.98	7.00	26.00
TTO staff in R&D contracts (%)	43	0.12	0.08	0.00	0.38
TTO budget (thousands of Euros)	40	608.25	701.12	21.50	2,964.00
Foreign private firms (%)	43	0.06	0.08	0.00	0.51
Explanatory variables (university)					
Faculty involved in KT activities (%)	43	0.24	0.16	0.06	1.10
Polytechnic university	43	0.09	0.29	0.00	1.00
Science park	43	0.63	0.49	0.00	1.00
University size	43	3,149.35	2,088.57	711.00	10,385.00

Table 3. Determinants of R&D contracts: Regression results.

	Model 1		Model 2		Model 3	
	R&D contract income	R&D contracts	R&D contract income	R&D contracts	R&D contract income	R&D contracts
Age TTO	2.1811*** (0.7071)	1.6094*** (0.3875)			0.4011 (0.3939)	0.4989 (0.3349)
TTO staff in R&D contracts (%)	0.4235 (1.7770)	–0.9821 (0.9968)			1.4223 (1.2439)	-0.3763 (0.9615)
Budget TTO	0.4235*** (0.1207)	0.3340*** (0.0654)			0.1558* (0.0928)	0.2048*** (0.0635)
Foreign private firms (%)	3.9886*** (1.0656)	2.4613*** (0.7637)			3.6561*** (0.8928)	2.2801*** (0.7844)
Faculty involved in KT activities (%)			0.2345 (0.4298)	0.1621 (0.4600)	0.4005 (0.5452)	0.7300 (0.6222)
Polytechnic university			0.8324*** (0.1873)	0.1812 (0.2339)	0.7281* (0.3683)	-0.1642 (0.2314)
Science park			0.2175 (0.2044)	0.5237** (0.2048)	0.0425 (0.2261)	0.4534** (0.1928)
University size			1.3805*** (0.1570)	1.1321*** (0.1477)	1.3044*** (0.2128)	0.8267*** (0.1621)
Intercept	–0.7830 (1.9404)	–1.8916 (1.2153)	–2.8285** (1.2383)	–4.4850*** (1.1495)	–4.6532 (1.3902)	–5.0455*** (1.3814)
F – test	11.87***		43.27***		19.34***	
R squared	0.4380		0.6807		0.7392	
RMSE	0.9062		0.6780		0.6559	
Log likelihood		-221.5957		-242.61323		-213.4069
Pseudo R2		0.0576		0.0688		0.0924
Wald chi2		97.55***		77.07***		248.19***

Robust standard errors adjusted by heteroskedasticity are presented in brackets. *, **, *** indicate significance at the 10%, 5%, and 1%, respectively.

Table 4. Mean values for the selected variables by regions (year 2009)

Region	Number of universities	GDP per capita (Euros)	Innovation intensity	Employment in high-tech sectors (%)
Andalucía	9	17,498.00	0.69	0.035
Aragón	1	24,656.00	1.32	0.092
Illes Balears	1	24,580.00	0.15	0.018
Islas Canarias	1	19,792.00	0.39	0.02
Cantabria	1	23,111.00	0.62	0.058
Castilla y León	2	22,475.00	1.61	0.059
Castilla-La Mancha	1	17,573.00	0.63	0.04
Catalunya	7	26,863.00	1.06	0.103
Comunidad Valenciana	5	20,295.00	0.67	0.041
Extremadura	1	16,590.00	0.41	0.02
Galicia	3	20,056.00	1.06	0.049
Madrid	6	30,142.00	1.28	0.091
Murcia	2	18,731.00	0.55	0.025
Navarra	1	29,495.00	1.57	0.112
País Vasco	1	30,683.00	1.71	0.113
La Rioja	1	24,811.00	0.92	0.049

This table only includes the regions housing the 43 universities included in this study.

Source: Spanish National Institute of Statistics (INE).

Table 5. Mann–Whitney U tests and t-tests

	GDP per capita		Innovation intensity		Employment in high-tech sectors (%)	
	< Median	> Median	< Median	> Median	< Median	> Median
R&D contracts	88.41 (69.56)	203.27 (192.34)	92.62 (77.73)	220.14 (200.28)	86.35 (74.10)	220.04 (195.66)
Mann–Whitney test	-2.012**		–2.491**		–2.788***	
t-test	-2.780***		–2.775***		–3.036***	
Observations	17	26	21	22	20	23
R&D contract income	4,956.85 (6,419.00)	8,476.56 (8,837.70)	5,148.58 (6,365.15)	8,933.79 (9,193.69)	4,884.17 (6,411.09)	8,998.85 (8,987.78)
Mann–Whitney test	-1.391		–1.749*		–2.021**	
t-test	-1.155*		–1.594*		-1.893**	
Observations	17	26	21	22	20	23

Standard deviation is presented in brackets. *, **, *** indicate significance at the 10%, 5%, and 1%, respectively.