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

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ABSTRACT

Technology Transfer Offices (TTOs) are the main institutions responsible for the establishment of university–industry partnerships. R&D contracts exemplify the indirect mechanisms through which enterprises and universities collaborate on a win–win basis. This study addresses organizational and institutional aspects that act as drivers for the establishment of successful university–industry partnerships. First, a series of regression models explain the determinants of R&D contracts. These models include two main dimensions: the university and the technology transfer office. Second, further analysis empirically explores whether universities in regions with a favorable environment enjoy greater active involvement in this particular knowledge transfer mechanism. The empirical study analyzes 2010 data for Spanish public universities. Results indicate that successful R&D contracts depend on university and TTO characteristics, and the university's location. The paper also presents a set of managerial implications for improving the establishment of university–industry partnerships.

1. Introduction

In a dynamic, globalized economy, firms must engage in a constant adaptation and evolution to survive. Despite this ongoing change, firms drive markets by leveraging and strategically managing knowledge. Growing awareness of knowledge as a potential source of competitive advantage means that universities are key within the science and technology ecosystem, as an inexhaustible source of knowledge and technology capabilities.

Universities are essential in human capital development and in new knowledge provision (D'Este & Patel, 2007). Apart from nurturing highly qualified graduates and researchers, universities must foster links with business through knowledge transfer mechanisms. Therefore, universities are expanding their traditional functions of teaching and research through the third mission (Goddard, 2005), thus re-establishing their role in society and re-evaluating their relationships with communities and stakeholders.

The third mission encompasses several activities (Tuunainen, 2005) like creating, using, applying, and exploiting knowledge in non-academic environments. The third mission transforms basic research outcomes into applications with economic and social repercussions besides production (i.e., academic research) and transmission (i.e., teaching and publication).

Universities must not only develop new technologies and deliver them to the business sector. Academic research is now central to the economic cycle of innovation and growth. Universities and firms must foster together knowledge or technology's full potential (Lee & Win, 2004). Successful exploitation of new external knowledge requires effective knowledge transfer mechanisms. Since knowledge is progressive and co-created, knowledge transfer entails active involvement from participants, who must learn together. In this scenario (i.e., within the remit of the third mission), university–industry partnerships become important mechanisms for providing R&D services.

According to Santoro and Chakrabarti (2002), collaboration in university–industry partnerships equals teamwork. Universities boast the appropriate physical facilities and staff expertise to make scientific discoveries and technological breakthroughs (Debackere & Veugelers, 2005). However, they need businesses' knowledge of the market to develop new, applicable, and successful technologies. Industry practitioners are closer to users and downstream research, and thus more aware of users' needs (Siegel, Waldman, & Link, 2003). Likewise, additional private funding support is essential to ensure the viability of future research (Lai, 2011).

Mindful of university–industry partnerships' importance in generating technology spillovers, many governments deploy initiatives to enhance such partnerships (D'Este & Patel, 2007). Spain is one of the European countries boasting programs and initiatives to encourage university–industry R&D partnerships. According to the 2010 report from the Innovation and Knowledge Transfer Survey by the Spanish Network of Technology Transfer Offices (RedOTRI) interactions

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between universities and the business sector in 2010 account for 632 million Euros.

To cope with these ongoing changes, universities are adapting their structures and infrastructures to provide better R&D services, fully exploiting their scientific research (Muscio, 2010). Such changes include establishing technology transfer offices (TTOs), service businesses bridging the gap between science and industry. RedOTRICRUE report results indicate that 98.3% of Spanish TTOs carry out licensing activities, 96.7% perform intellectual and industrial protection tasks, and 95% create R&D contracts and provide consulting services. These activities are the most common undertakings of Spanish TTOs, with over 90% of all TTOs performing them.

Despite the economic downturn, Spanish TTOs' annual budget is growing significantly. Whereas the 2009 budget is 24.96 million Euros, the 2010 budget is nearly 167% greater (41.63 million Euros). In aggregate terms, this figure represents just 6.5% of the total revenues from university–industry R&D contracts, but still represents a two-thirds increase from the contribution in 2009 (3.9%). These numbers signal the appeal and importance of TTOs in Spain.

Previous research on university–industry partnerships mainly focuses on patenting, licensing, or spin-offs. Several authors indicate that abundant empirical evidence suggests that university–industry partnerships embrace much more activities and act through multiple channels (Arundel & Geuna, 2004; Mowery & Sampat, 2005). Despite its importance for universities, little information on university–industry R&D contracts is available (Conti & Gaulé, 2008).

In Spain, university–industry contracts govern activity, media, or diligence. Researchers commit to allocating human resources and materials to carry out several specific tasks. Resources rather than results thus measure commitment. This consideration is important when determining rights, obligations, and responsibilities of the contracting company and the contracted research center. Article 83 of the LOU (Spanish Law on Universities) regulates these contracts.

This study focuses exclusively on R&D contracts. First, R&D contracts represent the biggest revenue-generating knowledge transfer output (on average, 44,370€ per contract). Second, in R&D contracts stakeholders must define who owns the property rights of the contract's results. Consequently, studying how regulatory frameworks affect R&D contracts is valuable.

This paper examines the extent to which TTOs' institutional and organizational characteristics, as well as those of the parent university, affect the establishment of successful university–industry partnerships regarding number of R&D contracts and the income they generate. This study focuses on the performance of Spanish TTOs from public universities in2010. To yield more comprehensive findings, a second-stage analysis examines exogenous variables' effect—relating to regional aspects—on these collaborative R&D agreements.

Section 2 summarizes literature key findings on R&D cooperation between universities and firms. Section 3 presents the conceptual model and the hypotheses using empirical data. Section 4 introduces the sample and explains the methodological approach. Section 5 presents empirical findings. Section 6 discusses conclusions and findings' policy implications.

2. R&D cooperation between firms and universities

Many empirical studies focus on quantifying different forms of academic knowledge transfer (Carlsson & Fridh, 2002; Lockett & Wright, 2005; Wright, Clarysse, Lockett, & Knockaert, 2008). This study comprises two ways of transferring academic knowledge: 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. Licensing arrangements of university inventions, incubator facilities, R&D contracts, and consulting services are indirect mechanisms through which enterprises and research institutions collaborate on a win-win basis. This study covers organizational and institutional aspects driving to 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 benefit commercially from the research center's unique capabilities (Lee & Win, 2004).

The effectiveness of this knowledge transfer process diminishes if the indirect mechanism has an inefficient design. Accordingly, identifying common interests is crucial (Veugelers & Cassiman, 2005). Businesses seek specific research applications to shorten the time between discovery and implementation. Universities respond to industry needs by providing meaningful knowledge with practical applications (Lockett & Wright, 2005).

Lee and Win (2004) list the potential benefits of cooperation agreements between universities and firms. University–industry partnerships usually seek to cut the lag between discovery and practical application. Universities give access to human capital, knowledge, and innovation networks (Lai, 2011). They also help firms to identify technological opportunities, and assist in pre-competitive stages of product development. Businesses, especially small and medium enterprises, may struggle to carry out in-house R&D because it requires complex infrastructures and advanced services for product development. Hence, firms naturally outsource research activities to universities, or use universities' infrastructures (i.e., R&D labs) to save money and exploit academics' expertise.

Academically, access to financial resources that facilitate activities in new research fields encourages universities to make such alliances. Furthermore, working with businesses may improve the state of the art, and may yield fresh ideas that lead to new basic research, improving researchers' performance (Guldbrandsen & Smeby, 2005). For universities' efficiency on this matter, the academic community needs the time, freedom, means, and motivation to engage in university–industry partnerships.

Thus, policymakers must introduce new formulas and policies (e.g., on intellectual property rights, conflict of interests, and copyright) to achieve successful university–industry partnerships since the incentives of knowledge exploitation and the prospect of extra revenues may motivate institutions and their faculty alike (Arvanitis, Kubli, & Woerter, 2008).

3. Determinants of R&D contracts

Universities face considerable constraints on resources and changes in their environment. For universities is therefore essential to know the determinants explaining why some universities are more successful than others at providing R&D services through R&D contracts are.

A resource-based approach identifies organizational capabilities, internal resources, and services that support research and knowledge transfer activities at universities. This model has two main dimensions: Universities and TTOs. Universities provide knowledge, technology, and research expertise. TTOs facilitate and accelerate the relationship between business and science, enabling the business sector to keep abreast of the latest technological trends and maintain competitiveness (Rothaermel, Agung, & Jiang, 2007). A third dimension complements the model. This dimension comprises regional factors that may shape R&D contracts' creation and success.

3.1. TTO profile

According to Gueno (1998) and Merton (1988), old universities (and thus, mature TTOs) may create both a halo and a Matthew effect because of the historical interactions of expertise and prestige. This effect may appear because mature TTOs establish a working environment and a certain modus operandi that can positively affect their activities (Caldera & Debande, 2010). Therefore, the hypotheses herein posit that more experienced TTOs generate greater, more frequent revenues from R&D contracts.

Human capital (HC) is essential for universities because these educational institutions heavily rely on individuals' capabilities. HC thus constitutes a key factor in ensuring corporate success. R&D contracts involve many parties, and not just the researchers performing the research on businesses' behalf (Caldera & Debande, 2010). R&D contracts establish guidelines for an activity that requires coaching and appropriate assessment, making technical TTO staff devoted to R&D tasks important. Results should thus reveal a positive relationship between TTO staff devoted to R&D contracts and R&D activity.

Many studies affirm that a positive relation exists between access to funding and knowledge transfer activities (De Coster & Butler, 2005; Landry, Amara, & Ouimet, 2007). This study stresses the effect of a TTO's annual budget on knowledge transfer activities (Berbegal-Mirabent, Sabaté, & Cañabate, 2012). Due to financial resources' importance for conducting R&D, the hypotheses herein posit that TTOs with larger budgets will generate more R&D contracts.

Finally, this study investigates social capital effects. The establishment of university–industry partnerships also depends on links between research and market factors (Landry, Amara, & Rherrad, 2006). Thus, social capital is important because it refers to the meaningful interactions between scientists and market agents (Aldridge & Audretsch, 2011). Specifically, this research focuses on universities' networks with foreign private firms (i.e., 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, the hypotheses herein posit that social capital positively relates to R&D contracts.

3.2. University profile

Human capital relates to the knowledge accumulation process, and symbolizes universities' background in a specific field. Previous experience gives university staff the specific knowledge and capabilities to develop more successful strategies, which may lead to more efficient resource allocation and a higher output rate. Thus, expertise in knowledge transfer activities acts as a catalyst for new R&D activities (Clarysse, Wright, Lockett, Van de Velde, & Vohora, 2005; Lockett, Wright, & Franklin, 2003). The hypotheses herein indicate a positive relationship between the number of faculty members participating in knowledge transfer activities and R&D contracts volume.

This study also covers the university's academic spread. Empirical studies (Caldera & Debande, 2010; Carlsson & Fridh, 2002) suggest that some disciplines are essential for knowledge transfer activities. Particularly, research seems to indicate that polytechnic universities usually achieve higher levels of knowledge transfer outputs (Belderbos, Carree, & Lokshin, 2006). As per this rationale, polytechnic universities should display better performance rates regarding R&D contracts.

Finally, this study explores specific infrastructures that should boost the creation of university–industry partnerships. Previous studies suggest that university science parks may affect university performance (Agrawal & Cockburn, 2003). A science park's purpose is mainly to create knowledge clusters, and to aid interaction between universities and firms in the park. In a science park, information flows from academia to business, which geographical proximity accelerates. Thus, the hypothesis herein posits that the presence of a science park positively contributes to establishing R&D contracts.

3.3. Regional factors

Universities partially reflect their regional context. Public administrations design incentives to promote and intensify university–industry partnerships. These policies reflect cultural patterns. Moreover, innovations not only receive impetus from universities' capacity to create knowledge, but also depend on local market characteristics. Some territories enjoy a greater endowment of technological conditions, and this feature may force firms to remain at the cutting-edge and offer pioneering products and services. Therefore, firms are appropriate partners for universities to meet market requirements. Nevertheless, each territory faces these challenges at different speeds.

Regional factors affect university performance and efficiency (Berbegal-Mirabent, Lafuente, & Solé, 2013; García-Aracil & Palomares-Montero, 2008). Correspondingly, this study tests the hypothesis that the wealth of the region and certain regional characteristics (i.e., innovation intensity, the access to high-technology sectors) may participate in establishing R&D contracts.

4. Data and method

4.1. Data

The data for the empirical analyses come from two main sources: Annual survey reports from the Spanish Network of Technology Transfer Offices (RedOTRI) and biannual reports from the Council of Rectors of Spanish Universities (CRUE). The data lack some observations, so additional sources like manual searches through universities' annual reports and TTOs complete these missing data. Although these sources can successfully fill most gaps in the data, some missing values remain.

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 calendar 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 calendar 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 perform 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 in foreign countries (outside Spain) that contract the university in the calendar 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 for a polytechnic university; 0 otherwise.	CRUE (2008/09)
Science park	Dummy variable. Takes the value 1 if the university is 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)

Additional information regarding specific variables comes from the IUNE Observatory of Spanish University Research Activity and the Spanish National Institute of Statistics (INE) websites.

The original database contains information from 47 Spanish public universities for the period 2008–2010. However, the final sample includes only TTOs for which a complete dataset of the variables of interest is clearly identifiable (43 universities). The STATA statistical package provides the statistical data treatment tool.

4.2. Definition of variables

Two dependent variables assess university R&D contract performance in 2010: Number of R&D contracts, measuring the quantity of R&D activity; and income from the R&D contracts, measuring the quality. Table 1 provides the definitions of the variables under study. Apart from the set of explanatory variables, university size controls for the advantages universities may gain from their scale (Belenzon & Schankerman, 2009).

Two adjustments are necessary before regressions estimation. First, to obtain normality, the natural logarithm transforms some variables: R&D income contracts, TTO budget, university size, and TTO age. Second, explanatory variables as lagged terms control for potential endogeneity problems, since the values of these variables correspond to those for 2009 (i.e., the academic year 2008/09). Table 2 shows descriptive statistics for the variables under study.

4.3. Method

Linear regression analysis assesses the determinants of R&D contract income, whereas negative binomial regression evaluates the number of R&D contracts. This study uses negative binomial regression because of the dependent variable's highly skewed distribution (Greene, 2003, 2008). For each dependent variable, two models test the hypotheses. Model 1 comprises explanatory variables relating to TTOs specific characteristics, while model 2 covers variables relating to the university's profile. A third model comprising all explanatory variables checks the robustness of the results.

Normal-probability plots of the residuals test whether disturbances in the different models assessing R&D contract income follow a normal distribution. The plots for each regression support the normality assumption of disturbance terms, validating such an approach.

Table 2
Descriptive statistics for the selected variables.

Variable	Mean	Std. Dev.	Min	Max
Dependent variables				
Number of R&D contracts	157.86	164.60	2.00	783.00
R&D contract income (thousands of Euros)	7085.04	8075.86	470	41,875.76
Explanatory variables (TTO)				
TTO age	17.86	3.98	7.00	26.00
TTO staff in R&D contracts (%)	0.12	0.08	0.00	0.38
TTO budget (thousands of Euros)	608.25	701.12	21.50	2964.00
Foreign private firms (%)	0.06	0.08	0.00	0.51
Explanatory variables (university)				
Faculty involved in KT activities (%)	0.24	0.16	0.06	1.10
Polytechnic university	0.09	0.29	0.00	1.00
Science park	0.63	0.49	0.00	1.00
University size	3149.35	2088.57	711.00	10,385.00

5. Empirical results

5.1. First-stage analysis: regression analysis

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

Findings from model 1 support the hypothesis that the TTO's experience is determinant for R&D contracts because this experience gives TTO employees the specific knowledge to help them carry out their tasks more efficiently, leading to higher performance rates.

The role of TTO staff devoted to R&D contract tasks does not explain the number of R&D contracts and the income they generate. To better understand the rationale behind these findings, additional descriptive statistics indicate a weak, non-significant, negative relationship between the proportion of faculty members assigned to knowledge transfer activities, and the number and income of R&D contracts (26.10% and 18.22%, respectively). Correlating the total number of TTO staff with the two dependent variables unveils the effect of TTO staff. Additional descriptive statistics corroborate that a positive significant correlation exists between these variables (35.43% for the number of R&D contracts, p-value < 0.05; and 47.90% for R&D contracts income, p-value < 0.01). These results indicate that TTO staff members may have to perform different tasks, and, although specialization is desirable, Spanish TTOs have a relatively low number of technical staff (15.98 on average), with approximately 42% of TTOs operating with 10 employees or fewer.

Results indicate that TTOs with bigger annual budgets achieve more R&D contracts and greater income. This finding corresponds to the hypothesis positing that a positive relationship exists 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 employing the university's services for knowledge transfer activities during the past year, results support the argument that university–industry collaboration, as a driver of knowledge spillovers, extends beyond regional collaboration (Ponds, Van Oort, & Frenken, 2010).

Model 2 examines university characteristics' effect on the dependent variables. Results indicate that faculty involvement in knowledge transfer activities does not significantly affect any dependent variable. To check this finding, the analysis examines the correlation effects between these variables, observing weak and statistically non-significant effects. This result means that the quality and capabilities of faculty members are more important than the number of faculty members participating in knowledge transfer activities. Furthermore, the lack of significance of this variable may indicate that academics perceive little or no incentive to engage in R&D contracts. Future research is necessary to confirm whether adequate regulatory frameworks motivate researchers to engage in R&D contracts. Unfortunately, the available data for Spanish universities is inadequate for this analysis: 41 of the 43 universities state that they have a specific regulatory framework, but withhold any additional information.

Two further interesting findings appear regarding the effect of the university's technical orientation 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 involving advanced technologies and knowledge. This result involves competitive R&D contracts that require significant financial investment, as the positive sign of the estimated coefficient indicates. The underlying rationale for the effect of the science park dummy variable relates to the geographical proximity between university and marketplace. Science parks are knowledge-based enclaves where firms and researchers can meet, exchange ideas, and cooperate. Results suggest that universities with a science park secure more R&D

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
TTO age	2.18***	1.61***			0.4011	0.50
	(0.71)	(0.39)			(0.39)	(0.33)
TTO staff in R&D contracts (%)	0.42	−0.98			1.42	−0.38
	(1.78)	(1.00)			(1.24)	(0.96)
TTO budget	0.42***	0.33***			0.16*	0.20***
	(0.12)	(0.07)			(0.09)	(0.06)
Foreign private firms (%)	3.99***	2.46***			3.66***	2.28***
	(1.07)	(0.76)			(0.89)	(0.78)
Faculty involved in KT activities (%)			0.23	0.16	0.40	0.73
			(0.43)	(0.46)	(0.55)	(0.62)
Polytechnic university			0.83***	0.18	0.73*	−0.16
			(0.19)	(0.23)	(0.37)	(0.23)
Science park			0.22	0.52**	0.04	0.45**
			(0.20)	(0.20)	(0.23)	(0.19)
University size			1.38***	1.13***	1.30***	0.83***
			(0.16)	(0.15)	(0.21)	(0.16)
Intercept	−0.78	−1.89	−2.83**	−4.49***	−4.65	−5.05***
	(1.94)	(1.22)	(1.24)	(1.15)	(1.39)	(1.38)
F-test	11.87***		43.27***		19.34***	
R squared	0.44		0.68		0.74	
RMSE	0.91		0.68		0.66	
Log-likelihood		−221.60		−242.61		−213.41
Pseudo R^2		0.06		0.07		0.09
Wald chi^2		97.55***		77.07***		248.19***

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

contracts relative to universities without a science park. This variable's effect on R&D contract income diminishes, indicating that, although firms in a science park may look for specialized facilities and new knowledge, the magnitude of the financial investment is not a determining factor.

Like in previous studies (Carlsson & Fridh, 2002), this study tests whether universities offering medical studies perform differently. To enable this analysis, a dummy variable takes the value 1 when university has a medical school, otherwise 0. Results confirm the initial hypothesis that, in Spain, the influence of a medical school does not affect 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 research projects and findings' dissemination.

To check results' robustness, model 3 considers the effects of characteristics of TTOs and universities. Although the model appears to fit the data well, readers should interpret results with caution. The small number of full observations (40), including 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, staff specialization—both technical TTO staff in charge of R&D contracts and the number of faculty members participating in knowledge transfer activities—has a non-significant effect. This finding reinforces that quality, rather than quantity, and an appropriate system of incentives drive faculty involvement in R&D contracts (Lach & Schankerman, 2008; Macho-Stadler, Pérez-Castrillo, & Veugelers, 2007).

Regarding established international networks' effect on R&D contracts, the third model confirms the hypothesis that social capital facilitates a more fertile setting for establishing R&D contracts. Likewise, in all specifications, large universities obtain advantages in R&D contracts.

Results show the effect of the polytechnic and science park dummy variables. Accordingly, polytechnic universities achieve larger revenues from R&D contracts, whereas science parks positively contribute to explaining the number of R&D contracts.

Experienced TTOs' effect weakens in the full model (model 3). An explanation for this finding is the correlation between the TTO's age and the dependent variables: 45.52% (p-value = 0.0022) for the number of R&D contracts and 51.64% (p-value = 0.0004) in correlation with R&D contract income. Although the TTO's age seems to be important, the non-significant effect in the full model raises questions as to whether seniority 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 < 0.1 instead of p-value < 0.01) 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 establishing R&D contracts.

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	0.04
Aragón	1	24,656.00	1.32	0.09
Illes Balears	1	24,580.00	0.15	0.02
Islas Canarias	1	19,792.00	0.39	0.02
Cantabria	1	23,111.00	0.62	0.06
Castilla y León	2	22,475.00	1.61	0.06
Castilla-La Mancha	1	17,573.00	0.63	0.04
Catalunya	7	26,863.00	1.06	0.10
Comunidad Valenciana	5	20,295.00	0.67	0.04
Extremadura	1	16,590.00	0.41	0.02
Galicia	3	20,056.00	1.06	0.05
Madrid	6	30,142.00	1.28	0.09
Murcia	2	18,731.00	0.55	0.03
Navarra	1	29,495.00	1.57	0.11
País Vasco	1	30,683.00	1.71	0.11
La Rioja	1	24,811.00	0.92	0.05

This table only includes the regions of the 43 universities included in this study.
Source: Spanish National Statistics Institute (INE).

5.2. Second-stage analysis: regional effects

According to Shattock (2009), exposure to region-specific economic variables may affect university–industry R&D activities. Spain has striking regional differences regarding economic development and public and private investment (García-Aracil & Palomares-Montero, 2008). Therefore, a second-stage analysis explores the potential effect that exogenous variables regarding universities' location may have on R&D contracts.

At the NUTS 2 level, Spain comprises 17 regions (autonomous communities). Literature reveals discrepancies on the impact of public policies and regional factors on higher education institutions' performance (García-Aracil & Palomares-Montero, 2008). Thus, three factors are important for this regional analysis: (1) The wealth of the region, taking regional GDP per capita as a proxy; (2) innovation intensity (innovation expenditure divided by total regional expenditure); and (3) employment in high-tech sectors divided by total regional employment. Data come from the Spanish National Statistics Institute for the year 2009. Table 4 summarizes descriptive statistics for these variables.

The Mann–Whitney *U* test is the main method for this stage of the analysis. This procedure tests whether observed median differences between two groups of universities do not share the same central tendency. This statistical test is appropriate for this type of analysis, permitting to assess whether the medians of the two groups are significantly different. The analysis also employs a *t*-test of mean differences to corroborate findings. Table 5 shows the results of this analysis.

Results indicate that regional economic factors consistently affect the performance of university–industry partnership regarding number of and income from R&D contracts. Particularly, universities 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. A similar pattern emerges when exploring R&D contract income, with universities in regions with high GDP per capita (above the median) signing a higher number of R&D contracts. This result's significance is only partial (*t*-test) for R&D contract income. Descriptively, universities generating greater R&D contract income are in regions with higher levels of GDP per capita. Thus, findings imply that R&D contracts accompany a region's economic prosperity.

6. Concluding remarks

Nowadays, knowledge transfer from university to industry is an important strategic consideration. In fact, academic research actually drives business by providing new scientific discoveries and advanced technologies that accelerate innovation. Many firms therefore see universities as ideal partners to outsource their R&D activities and remain competitive. 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 provide the appropriate incentives to optimize knowledge transfer mechanisms and reconcile the potentially conflicting interests of stakeholders.

Literature includes three research streams that examine enhancers of collaborative partnerships. The first approach is from the university's point of view (Di Gregorio & Shane, 2003; Friedman & Silberman, 2003); the second addresses the issue regarding the firms involved (Cohen, Nelson, & Walsh, 2002; Fontana, Geuna, & Matt, 2006); and the third takes the individual academic researcher as the unit of analysis (D'Este & Patel, 2007). Despite the existence of these three bodies of literature, empirical evidence on the determinants of R&D contracts is scarce. To bridge this theoretical research gap, this study first analyzes universities' and TTOs' internal resources and capabilities that may explain performance differences in the number of R&D contracts and R&D contract income. Second, the study empirically evaluates whether universities in regions with a favorable environment enjoy greater active involvement in this particular knowledge transfer mechanism. Finally, the study tests the research hypotheses for the Spanish public university sector.

This study provides implications and offers opportunities for future research. First, results suggest that both TTOs and universities shape university–industry relationships. This finding sheds some light on internal resources and capabilities that help explain R&D activity. Results indicate that successful TTOs have more accumulated experience and larger budgets than those of an average TTO, as well as boasting an international social network. Contrary to previous studies, this research shows that staff specialization (i.e., staff devoted to R&D contract activities) neither results in more R&D contracts nor generates greater R&D contract income. This finding indicates that individual capabilities are more important than the number of TTO technical staff.

Regarding universities' characteristics, results indicate that larger universities attain better performance rates. Conversely, the positive effect of faculty members engaging in knowledge transfer activities is statistically non-significant in all models. Literature on incentive schemes and regulatory frameworks within universities provides a potential explanation for this result. A key finding is that polytechnic universities usually achieve 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.

Second, this study shows that, apart from the characteristics of the university and the TTO, establishing R&D contracts depends on exogenous factors. The second-stage analysis yields valuable findings in this area, validating the hypothesis that universities in regions with a favorable economic context usually engage in university–industry

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	203.27	92.62	220.14	86.35	220.04
	(69.56)	(192.34)	(77.73)	(200.28)	(74.10)	(195.66)
Mann–Whitney test	−2.01**		−2.49**		−2.79***	
t-test	−2.78***		−2.78***		−3.04***	
Observations	17	26	21	22	20	23
R&D contract income	4956.85	8476.56	5148.58	8933.79	4884.17	8998.85
	(6419.00)	(8837.70)	(6365.15)	(9193.69)	(6411.09)	(8987.78)
Mann–Whitney test	−1.39		−1.75*		−2.02**	
t-test	−1.16*		−1.59*		−1.89**	
Observations	17	26	21	22	20	23

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

partnerships. Particularly, findings indicate that economic conditions and university location affect outputs. Exogenous factors outside universities' control affect how universities create and disseminate knowledge transfer activities, and consequently determine their level of interaction with firms.

Third, universities' competitive advantage hinges on their capacity to create knowledge. Due to the importance of successfully managing the complementarities between basic and applied research at universities, future studies should examine regulatory frameworks' effects on R&D contracts. Industry collaboration directly affects academic knowledge creation, which highlights a possible dilemma. From the researcher's perspective, applied collaboration with firms might distract academics from conducting research activities resulting in publishable outcomes in academic journals. Usually, secrecy considerations prevent academics from sharing research materials, resulting in publication delays that might slow down promotion processes. Nevertheless, university–industry collaborations involve high degrees of interactivity, which might generate stimulating learning opportunities and know-how about technological problems and market trends that are indispensable for an integral training of academics. Thus, university–industry partnerships constitute a two-way exchange rather than a one-way transfer of university-generated technology. Hence, university managers and governmental institutions must design appropriate policies and incentive structures that encourage academics to strike an appropriate balance between basic and applied research activities.

The size of the data sample is a limitation of this study. Despite covering almost all Spanish public universities, the sample is relatively small. Furthermore, the lack of a systematic process to collect comprehensive data for all universities in the sample over a longer time span undoubtedly conditions this study's findings.

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