Location, location…Do universities matter for foreign R&D?

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Preliminary (please do not cite)

Abstract

This paper explores the extent to which the scientific quality of the Universities in a region determines the location of foreign R&D establishments in Spain. In doing so, we exploit a rich panel dataset providing information on the location of foreign R&D labs in specific Spanish regions over the period 2005-2013, together with novel measures of the presence and quality of university research. Our findings suggest that the probability of a foreign R&D establishment being located in a region depends on the region's academic strength after controlling for market potential, the technological strength of the region and other regional characteristics.

Key words: foreign R&D establishments, universities, location choice, Spanish regions.
JEL classification: F21, F23, O32.

1 Introduction

This study aims at providing comprehensive evidence on the extent to which the scientific quality of the Universities in a region determines the location of foreign R&D. In doing so, we exploit a rich panel dataset providing information on the location of foreign R&D establishments in specific Spanish regions over the period 2005-2013, together with novel measures of the presence and quality of academic research. In particular, the resulting dataset draws from two different sources: *The Technological Innovation Panel* (PITEC), the panel on innovation activities of Spanish firms[1], and the *IUNe* observatory, which publishes data on the quality of private and state-owned universities.

In the light of the importance of R&D as a driver of economic growth, it comes as no surprise that the analysis of the driving factors of R&D still remains a subject of concern to researchers. Government policies increasingly recognise the benefits of supporting and attracting R&D investment, not just national but also international. In parallel, it is widely acknowledged in the international business (IB) literature that the internationalisation of R&D has reached high levels over the past decades (Dunning and Lundan, 2009; Narula and Zanfei, 2005). Dunning (1998) argues that firms' location strategies are becoming more complex and "*have shifted from traditional requirements*". But what are the factors driving multinational enterprises (MNEs) to locate their R&D labs abroad? To what extent the quality of the University system in the host economy determines this location?

In addition to the traditional role of R&D foreign investment in the diffusion of technology aiming at adapting products and services to local market conditions or supporting MNCs local manufacturing operations, R&D foreign investment is being increasingly motivated by tapping into worldwide centres of knowledge as part of firms strategies to source innovation globally (OECD, 2008). In particular,

[1] PITEC is sponsored by *Fundación Española para la Ciencia y la Tecnología* (FECYT) and the *Foundation for Technical Innovation* (COTEC). Details on the survey as well as the database can be found at http://icono.fecyt.es/PITEC.

several recent studies have found that the aim to collaborate with universities abroad constitutes one of the main drivers of the internationalization of business R&D (Abramowsky et al., 2007; OECD, 2011; Thursby and Thursby, 2006). Enhancing these global-local, university-industry knowledge links is not only of relevance for the innovation strategies of MNCs, but also for national/regional policymakers who aim at maximizing knowledge spillovers from foreign investment (D'Este et al., 2013).

Recently, a renewed interest has emerged on the empirical analysis of the location choice of foreign affiliates. This is linked to recent studies in international trade, new economic geography and international business (Belderbos and Caree, 2002; Barry et al., 2003; Crozet et al., 2004; Disdier and Mayer, 2004; Head and Mayer, 2004; Basile et al., 2008). However, the literature focusing specifically on the case of the location choice of R&D foreign investment is scarce. Though many factors driving the location choice of foreign affiliates are also relevant in the case of foreign affiliates in R&D, factors specific to the R&D sector, in particular in relation to the knowledge sourcing aspect of the foreign direct investment in R&D become increasingly important (Belderbos et al. 2008).

In this paper we contribute to the literature by examining the locational drivers of R&D investments by multinational firms in specific regions of Spain, with a focus on these regions as innovation hubs and in particular on the quality of their University systems. We follow previous literature and control also for other factors that previously have been shown to affect affiliates location, such as market potential of the region, or labour costs. Furthermore, we consider a number of salient characteristics of the regional innovation systems.

The remainder of the paper is structured as follows. Section 2 provides a review of related literature. Section 3 presents the data and describes the empirical methodology. The results of the econometric analysis are presented in Section 4. Finally Section 5 summarises the main results and concludes.

2. Related Literature

There is a large empirical literature focusing on the regional location of foreign multinational affiliates (Basile et al., 2008; Crozet et al., 2004; Villaverde and Maza, 2015). Along with the increasing internationalization of R&D in the EU, and particularly in Spain (Dunning and Lundan, 2009; Siedschlag et al. 2013), an expanding body of the literature has specifically focused on the determinants of foreign R&D location (Belderbos et al., 2008; 2014; Shimizutani and Todo, 2007). These studies conclude that the motives to locate R&D activities abroad differ from those related to other downstream activities of the firm (Crescenzi et al. 2014).

The international business literature has traditionally proposed two main drivers for conducting R&D investment overseas (Dunning and Narula, 1995). On the one hand, there are "*home-based exploiting*" motives, by which multinational firms invested R&D abroad in order to support overseas production and to adapt products and services to local market conditions. On the other hand, nowadays companies appear to be delocalizing their R&D abroad more for "*home-based augmenting*" motives (Ambos, 2005; Cantwell et al., 2004). Here the motivation that attracts foreign firms to locate their R&D overseas is to have access to a locally available knowledge from which to tap into and source foreign technology (Almeida, 1996; Belderbos et al., 2008; Siedschlag et al., 2013).

Existing empirical evidence on the determinants of the location choice of international investment in R&D has identified both "*home-based exploiting*" and "*home-based augmenting*" motives. For instance, previous studies have shown that R&D is attracted to large and important markets, which helps companies to be at the forefront of consumer's demands (Kumar, 2001). Further, the location choices for foreign R&D have been shown to be influenced also by the availability of a pool of qualified scientists and the wage cost levels of these scientist and engineers (Kumar, 2001).

On the other hand, the literature on innovation and economic geography has emphasized the role of proximity to academic centres for firms to benefit from knowledge spillovers (Anselin et al. 1997). However there is little research on how the potential spillovers from academia may drive the location of foreign R&D investments (being exceptions Abramovsky et al. 2007; Cantwell and Piscitello, 2005; Belderbos et al. 2014).

3. Data and Model

3.1. Data and measures

The data used in this paper are drawn from a yearly survey called *The Technological Innovation Panel* (PITEC)[2], a by-product of the European Community Innovation Survey. The survey is conducted by the Spanish National Institute of Statistics (INE), and contains questions characterizing the innovative activities of a panel of more than 12,000 Spanish firms since 2003 in all sectors of the economy[3]. Since 2005, the response rate to the survey is above 95. While the sample is representative of the population of firms with 200 or more employees, the representativeness of firms with less than 200 employees is biased towards firms having internal and/or external R&D[4]. Besides, Hall and Rama (2016) show that the PITEC database is representative concerning the geographic distribution of foreign subsidiaries within Spain.

The PITEC survey, which follows the Oslo Manual (OECD, 2005), provides detailed information on firms' innovation strategies. In particular, the

[2] We use the anonymized data set (López, 2011).

[3] In 2003 the sample contained only two sub-samples: a sample of firms with 200 or more employees (with an estimated representation of 73), and a representative sample of firms undertaking intramural R&D. In 2004 the sample was enlarged to include, on the one hand, firms with less than 200 employees, external R&D and no intramural R&D; and on the other, a representative sample of small non-innovative firms (with less than 200 employees).

[4] This is so because all firms that have received any form of public support for R&D or those that have reported R&D expenses are surveyed every year. The remaining surveyed firms come from a random sample stratified by size and sector among non-R&D performing firms.

questionnaire asks firms to state the percentage of R&D spending and the number of R&D personnel in each of the 17 NUTS2 regions in Spain[5]. This information allows us to identify the regional location of each R&D unit, independently of the main location of the firm.

The analysis is conducted for firms in the manufacturing sector and we use information from the PITEC survey for the period 2005 to 2013[6]. We exclude from the sample public firms and research associations as well as merged or acquired firms. We also eliminate data with missing values in variables of interest.

The data regarding the regional University system were collected from those contained in the observatory IUNE, showing the scientific activity of the Spanish Universities. This Observatory is supported by the Ministry of Education and since 2004 provides information on annual basis on the scientific and innovation activity conducted in Spanish public and private universities.

a) Dependent Variable

The dependent variable is a binary variable indicating in which Spanish region a foreign firm locates a new R&D establishment over the period 2005-2013. This variable takes the value of one if a foreign firm has a new R&D establishment in a particular host region h and zero otherwise.

Table 1 shows the concentration of foreign R&D establishments and university activities in the top two regions. We observe that more than 58% of the number of foreign establishments and more than 60% of the R&D investment by foreign firms is located in two regions, Madrid and Cataluña. Similarly, more that 41% of citations and publications in the first quartile are from universities located in those two regions. However, in terms of the number of applied patents, these are

[5] NUTS2 is the *Nomenclature of Territorial Units for Statistics*, which at level 2 and in the case of Spain corresponds to autonomous communities and cities. We exclude from the analysis Ceuta and Melilla.

[6] Due to the enlargement of the survey suffered in 2004, we start the analysis in 2005, although we may use data from previous years as some variables are defined as lags.

concentrated in Cataluña, and depending of the year Sevilla and Comunidad Valenciana.

Table 1: Concentration rates in the Top 2 regions

	Foreign R&D		***Regional University Research Performance***		
Year	Number of foreign R&D plants	R&D spending by foreign plants	Citations	Number of publication in 1Q	Number of applied patents
2005	61.6	76.8	42.9	42.4	42.4
2006	59.9	79.6	41.9	41.8	39.1
2007	63.8	79.5	44.2	42.8	42.2
2008	62.6	81.0	42.2	42.0	48.5
2009	61.4	74.9	43.8	42.8	40.0
2010	62.1	66.6	42.3	41.6	38.4
2011	58.8	74.6	43.6	42.5	40.3
2012	59.0	66.4	44.9	42.7	45.6
2013	59.3	60.6	44.7	42.8	45.8

Source: PITEC and IUNe dataset.

b) Regional University System

To assess the role of the scientific strength of a particular region and how this may be able to attract foreign R&D investment we use data from the *IUNe* observatory. To construct the indicators of research quality and scientific strength of regions, we identify the universities, public and private, which are then allocated to NUTS2 regions based on their address. This allows us to calculate the different indicators at the regional level. We focus on indicators that reflect the quality of the university system in terms of research and innovation. Therefore, we use the number of citations that publications from universities in that region receive in a particular year (*citations*)[7]; the total number of publications (*publications*); the number of publications in the first quartile of the Journal Citation Report[8] (*1Q-publications*).

[7] This indicator measures the average number of citations per document received by the annual publications of each university. The original data comes form the Web of Science.

[8] It measures the annual number of articles for each university published in journals of the first quartile of the subject category of the Journal Citation Reports, being ordered by Impact Factor. Since a journal can be subscribed to more than one subject category, and be positioned, therefore, in different quartiles,

We also use the number of the number of patents granted to each Spanish university in a particular region by the Spanish Patent and Trademark Office (*upatents*). This provides a measure of the degree of innovativeness and technological strength of the university system.

In addition, we also use a measure of the overall prestige of the regional university system. This is obtained considering the number of universities that each region has in the ARWU (Academic Ranking of World Universities). This is a worldwide ranking of universities published annually by the Jiao Tong University in Shangahi since 2003 (Saisana et al. 2011).

c) Other explanatory variables

The literature on the internationalization of R&D argues that the access to a strong knowledge base is an important factor driving foreign R&D investment (Almeida 1996; Le Bas and Sierra, 2002). Therefore, besides examining the overall attractiveness of regional academic research for foreign R&D, we analyse also the extent to which the supply of *graduates* in a region attracts foreign R&D. The supply of graduates in a region can determine the types of firms operating in the area and also contribute to the innovation process and to knowledge spillovers. The analysis also controls for the relevant technological strength of the region. We use the *patent intensity* of a region, calculated as the number of patent applications to EPO by a particular region per GDP, as a measure of technological strength. In addition, we use R&D expenditure intensity at regional level, which has been used also to proxy innovation activity and the level of technological development of the region (Kumar, 2001; Siedsschlag *et al.* 2013).

Another important variable in the analysis is the market potential of a region. Following Siedsschlag *et al.* (2013) we measure *market potential* of each host region by the GDP in constant prices in that region and a distance-weighted sum of GDP in all other regions.

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each title has been considered only once (regardless of the number of subject categoriess to which has been assigned) and in the most favorable quartile.

There are also other variables that control for the cost of production such as labour costs or unemployment rates (a proxy for labour market flexibility). We control for *labour cost* using compensation per employee in each region. The effect of this variable may be ambiguous, as high labour costs may also point at the presence of highly skilled workers. The effect of *unemployment* on the attractiveness of a region may also be ambiguous. High unemployment may foster the attractiveness of regions to foreign R&D as can indicate a pool of available workers (Chung and Alcacer 2002); but on the other hand, may also be related to labour market rigidities in a region.

Table 2. Definition and summary statistics of explanatory variables

Variable	Description	Mean	Standard deviation
1Q-publications	Log of publication in 1st quartile of JCR	6.567	1.104
Citations	Log of citations of university publications in a region	9.570	1.231
Upatents	Log of patents registered by universities in a region	2.407	1.270
Shanghai-rank	Number of universities in a region in the ranking of Shanghai.	0.580	0.896
Market Potential	The log of real GDP of the host region plus the sum of distance-weighted real GDP of other regions.	10.638	1.020
R&D share	Share of R&D over GDP by region	1.131	0.894
Patent intensity	Share of registered patents over GDP by region	1.016	0.501
Labour Cost	Total labour cost per hour worked by region	15.496	7.859
Unemployment	Regional unemployment rate	17.532	2.388
Graduates	Percentage of population with tertiary education by region	29.786	6.561
Infrastructure	Log of motorway & railway km. per thousand square km.	4.117	0.516

The quality of infrastructure in a region may also affect the costs of and productivity of operations in a location. In fact, it is widely reported in the literature that regions with superior transportation facilities are more appealing to FIEs. We test this effect by using the number of air traffic passengers in a region.

All explanatory variables are lagged one period with respect to the dependent variable and all specification include time dummies. A one-period lag is commonly used in investment-based models to account for the fact that investment decisions are lagged in time and to avoid possible endogeneity problems (Belderbos *et al*. 2014). In the estimated models we cluster standard errors at investing firm level. Definition of the variables and summary statistics are displayed in Table 2.

3.2. Empirical Model

The determinants of regional location choice of foreign R&D establishments are estimated in this study through a conditional logit model, as developed by McFadden (1974). This model has been used extensively in the literature to estimate location choices in situations in which agents have to choose one alternative among *n* known mutually exclusive possibilities (Carlton, 1983; Luger and Shetty, 1985).

Consistent with the *Random Utility Maximization* (RUM) framework, this model assigns a utility level U_{ij} to each alternative for each decision maker $i=1, \ldots, I$ for vectors of observed attributes. For each establishment *i* the utility from locating in a given region j depends on a deterministic component X, which is a function of the observed attributes of each location choice and some unobservable factors which are captured by a stochastic term ε_{ij}.

$$U_{ij} = X_{ij}^{'}\beta + \varepsilon_{ij}$$

The probability that a foreign firm *i* chooses to locate an R&D establishment in a region *h* as opposed to any other region *k* is then equal to the probability of U_{ij} being the largest of all $U_{i1}, \ldots, U_{iJ}$ (Heiss, 2002). Given that ε_{ij} is unknown, to solve the above equation, one must impose a probability density function on ε_{ij}. The traditional conditional logit model assumes that is independently and identically distributed (*iid*), with type I extreme value distribution (McFadden, 1974). Under these assumptions, the probability of choosing region *h* can be obtained as a closed-form expression of:

$$P(y = h \mid 1, \ldots, J) = \frac{e^{\beta X_{ih}}}{\sum_{j=1}^{J} e^{\beta X_{ij}}}$$

where the coefficient of vector β are then estimated through maximum likelihood procedures. The conditional logit is not devoid of problems though, as it relies on the assumption of *Independence Irrelevant Alternatives* (IIA), implying that choosing region h over alternative k only depends on the characteristics of those two regions and not on any third alternative.

4. Econometric Results

Table 3 shows the estimates of the conditional logit models for all foreign R&D establishments over all regions. The table contains three models; which differ depending on the variable use to proxy the scientific strength of the regional university system. It appears that on average, other things equal, the probability to locate R&D activities of foreign affiliates across regions in Spain is associated positively with the scientific quality of the regional University system. This is independently of the measure that we use. In all cases, using the number of publication in the first quantile, the number of citations or the number of universities in the Shanghai ranking, we find a positive and significant effect.

Most of the control variables have the expected signs and are significant. Positive and significant effects are found for the R&D share and patent intensity of the region, both proxies of the technological and innovation strength of the region. Therefore, regions with more innovative and technologically advanced attract foreign R&D establishments. Market potential of a regions appears also positive and significantly related to the probability of foreign R&D location choice.

With respect to the role of institution in the labour market, we find that the effect of the regional unemployment rate is negative, indicating that the availability of labour or the presence of labour market rigidities affects the attractiveness of regions to R&D foreign affiliates. Similarly, higher regional labor costs per hour worked reduce the attractiveness of a region as host of foreign R&D. In addition, those regions with better infrastructures are also more attractive to foreign R&D. The striking result is with regards to the percentage of the population with tertiary education (graduates) that appears with a negative sign and statisticslly significant.

Table 3: Conditional logit analysis of Spanish location choices for foreign R&D investment, 2005-2013.

	Model 1		**Model 2**		**Model 3**	
	b	s.e.	b	s.e.	b	s.e.
1Q-publications	0.800***	(0.040)				
Citations			0.750***	(0.038)		
Shanghai rank					0.706***	(0.037)
Market potential	1.384***	(0.092)	1.393***	(0.092)	1.433***	(0.096)
Patent intensity	0.886***	(0.068)	0.877***	(0.067)	0.906***	(0.069)
R&D share	2.096***	(0.343)	2.112***	(0.344)	2.123***	(0.348)
Unemployment	-0.438***	(0.027)	-0.438***	(0.027)	-0.441***	(0.027)
Labor cost	-0.832***	(0.071)	-0.836***	(0.071)	-0.862***	(0.074)
Graduates	-0.112***	(0.022)	-0.109***	(0.022)	-0.102***	(0.021)
Infrastructure	0.395**	(0.201)	0.384*	(0.200)	0.368*	(0.207)
Observations	53909		53909		53909	
R&D establishments	663		663		663	
Pseudo-R^2	0.491		0.489		0.476	

Note: Standard errors shown in parentheses are clustered at firm level. Explanatory variables are lagged with respect to the dependent variable by one period.

5. Conclusions

In this paper we have analyzed to what extent the scientific quality of the Universities in a region determines the location of foreign R&D establishments in Spain. In doing so, we have used a rich panel dataset providing information on the location of foreign R&D establishment in specific Spanish regions over the period 2005-2013, together with novel measures of the presence and quality of university research. Our findings suggest that the probability of a foreign R&D establishment being located in a host region is positively affected by the region's academic strength after controlling for market potential, the technological strength of the region and other regional characteristics.

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