

# **CAPABILITIES, UNCERTAINTY, AND THE DECISION TO OUTSOURCE R&D TO DEVELOPED AND DEVELOPING COUNTRIES**

Andrea Martínez-Noya  
Universidad de Oviedo

Esteban García-Canal  
Universidad de Oviedo

Mauro F. Guillén  
The Wharton School  
University of Pennsylvania

## **Abstract**

We examine the choice of a foreign supplier instead of a domestic one when outsourcing R&D services. We argue that the determinant factors to choose a foreign supplier are different for suppliers from developed countries than for suppliers located in emerging countries. While firms with strong R&D capabilities have a higher propensity to outsource to suppliers from both types of countries rather than to domestic suppliers, a preference for suppliers from developed countries is only observed for firms seeking to acquire new capabilities. On the contrary, R&D suppliers located in emerging countries are preferred to domestic suppliers only for firms seeking lower labor costs. We find support for our hypotheses using original survey data on R&D outsourcing agreements by European and U.S. firms operating in technology-intensive industries.

## **Key words:**

R&D services; outsourcing location; offshoring; capability-seeking; low labor cost-seeking

# **CAPABILITIES, UNCERTAINTY, AND THE DECISION TO OUTSOURCE R&D TO DEVELOPED AND DEVELOPING COUNTRIES**

## **1. INTRODUCTION**

In today's globalized world, firms need to be more flexible, leaner and more focused on their core competencies in order to maintain their competitiveness and be responsive (Kedia and Mukherjee, 2008). Due to these competitive pressures, firms disintegrate their business functions and increase outsourcing to take advantage of external resources, because no single firm can possess world-class capabilities in all business areas, (Domberger, 1998; McLaren, 2000). Firms are changing their sourcing strategies in several ways. First, they are increasing outsourcing through the fragmentation of their value chains (Adler, 2003; Gilley and Rasheed, 2000; Hitt et al., 1998; Jacobides, 2005; Jacobides and Winter, 2005; Kotabe, 1998; Kotabe and Murray, 2004; Quinn and Hilmer, 2004; Schilling and Steensma, 2001). Second, outsourcing practices are being progressively extended to areas that were traditionally vertically integrated, such as those related to the innovation process (Granstrand et al., 1997; Leiblein et al., 2002; Lieberman, 2004; Manning et al., 2007, 2008; Narula, 2001; Quinn, 2000; Subramanian and Venkatraman, 2001; UNCTAD, 2005; Veugelers, 1997; Veugelers and Cassiman, 1999). And third, firms are increasingly dispersing these outsourcing agreements to international providers located in developed and developing countries (Bunyaratavej et al., 2007, 2008; Doh, 2005; Hirshfield and Schmid, 2005; Kedia and Mukherjee, 2008; Kotabe and Mudambi, 2009; Levy, 2005; Lewin and Peeters, 2006; Mol et al., 2005; Swamidass and Kotabe, 1993).

In effect, due to the uneven distribution of resources around the world, the external resources needed by the firm may not be available at home, and such cross-country differences in resource endowment may drive the firm to seek for foreign suppliers (Dunning, 1993, 1995; 1998). This fact has facilitated the relocation of outsourcing agreements around the world, and, coupled with globalization and improvements in information and communication technologies (ICT), has made the sourcing of human capital possible 'anywhere and anytime' (Lewin, 2005). A new stream of research has emerged, largely among International Business scholars keen to gain a better understanding of this international outsourcing phenomenon, and comprises the literature on *offshoring* or global sourcing (Bunyaratavej et al., 2007; Doh, 2005; Graf and Mudambi, 2005; Hätonen, 2009; Kedia and Mukherjee, 2008; Kotabe and Mudambi, 2009; Kotabe and Murray, 2004; Lewin et al., 2008; Manning et al., 2008; Mol et al., 2005; Mudambi, 2008; Lewin and Peeters, 2006). However, as stated in the work by Doh et al. (2008), despite the important contributions of previous literature regarding these practices, past research focused largely on offshoring in the aggregate — the works by Graf and Mudambi (2005) and

Hätönen (2009) being remarkable exceptions— sometimes overlooking the diversity and complexity of offshore services activities and related location decisions geared toward specific offshoring functions. So in response to this tendency, the present work aims to develop this line of research by analyzing international outsourcing decisions in the specific context of R&D services. We think this is an interesting context for the study of this phenomenon for two reasons. First, due to the undoubtedly important strategic implications of R&D within every firm's strategy. Second, because, although international outsourcing of R&D is still in an early stage (Disher and Lewin, 2007), globalization of dynamic markets and the growing complexity and multidisciplinary nature of the innovation process implies a greater need for firms to be open to external partners in order to access complementary resources, achieve lower costs, or reduce time-to-market.

Specifically, we analyze key factors which determine the decision to outsource R&D services from abroad (*offshore outsourcing*), explaining why firms outsource either to suppliers located in emerging or in developed countries instead of relying on domestic suppliers for these services. To do so, in this paper we take into account three sets of explanatory variables: firms' characteristics, firms' motives for outsourcing, and attributes of the R&D service outsourced. We test these hypotheses empirically using original survey data on 99 R&D service outsourcing agreements carried out by high-tech firms from the U.S. and the European Union.

We present the remainder of the paper as follows. In the next section, we review recent research on international outsourcing, especially those works which analyze the main motivations driving firms to outsource. Taking these motivations into account, we develop a theoretical framework in order to explain the location of R&D outsourcing agreements, and propose hypotheses to predict which factors will influence the probability of outsourcing R&D services either to offshore providers in developed or in emerging countries rather than to domestic providers. We then describe our data and methodology, and present our results. Finally, we discuss the main implications of our study for IB literature and practitioners.

## **2. THEORETICAL BACKGROUND AND HYPOTHESES**

According to the resource-based view of the firm, firms establish outsourcing agreements searching for complementary resources and/or capabilities which they are themselves unable to provide (Barney, 1991, 1999). Regardless of the specific objective for outsourcing, whenever firms need to access external resources they will most usually prefer to search for them in their home countries because information asymmetry will thus be lower and besides, coordination between firm and provider will be easier (Mol et al., 2005; Rangan, 2000). However, due to heterogeneity of resources located around

the world, external resources needed by a firm may not be available within its home country, and these cross-country differences in resource endowment may drive the firm to seek such resources abroad searching for location-specific advantages. In effect, research has found a global tendency for knowledge-intensive firms from both advanced and emerging countries to disperse their value chains in order to control costs and apply leverage to their capabilities (Mudambi, 2008). Following previous research (Lewin and Peeters, 2006; Kakabadse and Kakabadse, 2002; Manning et al., 2008; Hätönen, 2009), we will consider the following motivations to outsource offshore: (1) capability-seeking in the form of a supply agreement with a highly specialized world-class supplier; or (2) efficiency-seeking in the form of a supplier having lower labor costs. In effect, on the one hand, some inputs and technical knowledge may be available only in limited locations, so firms may decide to outsource some of their activities from these regions in order to access available technological expertise. On the other hand, firms located in advanced economies may find that labor costs are high, compared to the value added to their products (Kotabe, 1998; Trent and Monczka, 2003) and, may thus decide to outsource some of these activities to low-cost countries in order to reduce costs. In this regard, and following the lead of previous literature, we expect that the international outsourcing decision will be mainly driven by either the objective of reducing labor costs or that of accessing technological expertise. In fact, previous research into offshoring has shown rather conclusively that the primary motives for outsourcing activities from abroad are related to cutting costs, and accessing resources or capabilities not available within the firm found that the main motives behind offshore outsourcing were primarily saving costs and acquiring resources not available within the firm.

Drawing largely upon resource-based theory and taking these motivations into account, in this paper we will attempt to move beyond the aggregate analyses, and explore the factors determining firms' decisions to outsource offshore R&D services to either providers located within developed countries or in emerging countries, instead of relying on domestic suppliers. In this regard, we will propose a framework, which argues that the location of R&D outsourcing agreements is dependent upon three sets of explanatory variables: firms' characteristics, firms' motivations to outsource offshore, and the efficiency of specialized providers.

## **2.1. Firms' characteristics: technological resources and capabilities, and international experience**

We expect that a firm's possession of valuable technological resources and capabilities will influence its need to tap external global resources—in order both to access specialized providers and to reduce costs—and thus the probability of outsourcing R&D services to a specific region.

The innovation process, like many other business functions (Gottfredson et al., 2005), is composed of different and technologically separable stages or services ranging from the initial idea to the final product. Due to the complexity of the innovation process, firms cannot achieve the same level of efficiency across all the activities within the process (Fosfuri and Roca, 2002; Pavitt, 1999), so we expect that those firms possessing valuable technological capabilities will feel more pressured to concentrate their efforts on those core R&D services fundamental to their competitive strategy in order to maintain their competitive advantage and outsource those services capable of being performed more efficiently by world-class providers: either because they are more specialized or because they can perform the task at a lower cost. Due to the heterogeneity of technological resources across countries, we expect these firms to be more likely to outsource offshore R&D services as they will need to search either for state of the art or low cost providers. In effect, these are the kind of providers which allow them to leverage their technological resources whilst maintaining a competitive advantage over their rivals.

Therefore, we argue that in the context of R&D services, those firms possessing valuable technological capabilities will not only be under more pressure to search for world-class suppliers, but also better prepared than the rest of the firms to establish outsourcing agreements with foreign providers (Mayer and Salomon, 2006). As a result of these capabilities within a technological domain, firms develop governance capabilities so as to better select, negotiate and monitor the behavior of external suppliers (Mayer and Salomon, 2006). So, although firms lacking these capabilities would also benefit from global outsourcing, whatever the motive for doing so, they may not have the capability to manage such agreements. Firms lacking valuable technological resources will be less prepared to select an appropriate partner, leading them facing adverse selection problems, and besides they will be worse prepared to monitor their performance.

As a consequence, we expect that the technological resources and capabilities possessed by a firm will increase its propensity to establish R&D outsourcing agreements with offshore providers. On the one hand, because such firms will feel under more pressure to tap external resources located worldwide so as to remain competitive—in order to tap centers of excellence, access skilled labor, reduce time-to-market, increase flexibility, concentrate efforts on its core R&D activities or reduce cost. And, on the other hand, because they will thus be better prepared to identify the best suppliers worldwide and monitor their behaviour. This leads us to our first hypothesis:

*H1. The more technological resources and capabilities the firm has, the more likely it will be to outsource R&D services to offshore providers.*

Previous research has found that offshore outsourcing is a result of firms' ability to search for and evaluate foreign providers (Mol et al., 2005; Rangan, 2000). In this regard, Rangan's study argues that a lack of knowledge leads to the screening out of foreign sources, whilst a lack of previous interaction increase uncertainty regarding partners' reliability and fear of opportunistic behaviour. For this reason, it can be expected that the likelihood of a firm choosing to locate R&D offshore will depend not only on its technological capabilities but also on its previous international experience in that particular region. So, as it happens in relation to firm's technological capabilities, firms lacking international experience in a particular region may face severe problems arising from their unawareness of how to operate in those offshore locations. Firms' international experience has been considered in the literature as one of the most important sources of organizational learning (Belderbos, 2003; Barkema and Vermeulen, 1999; Kogut and Zander, 1993). As, in fact, it has been shown that firms' foreign subsidiaries may act as a mechanism to access local knowledge and source technology (Veugelers, 1997; Frost, 2001). Therefore, in the context of R&D services outsourcing, we expect firms' previous international experience to be especially determinant if deciding to offshore outsource to developing countries because of the uncertainty and risk associated with emerging markets. This is due to the fact that the policy instability that usually exists in these countries may provide a loophole for the local service provider to behave opportunistically due to the restricted capacity of the foreign firm to enforce their rights (Henisz, 2000). As a result, we expect that the fact of having previous experience operating in foreign countries will increase the likelihood of the firm offshore outsourcing R&D to these locations. In particular, we hypothesize that:

*H2. Firms with international experience will be more likely to outsource R&D services to offshore providers.*

*H3. Firms with international experience in developing countries will be more likely to outsource R&D services to offshore providers in emerging countries.*

## **2.2. Firms' motives for offshore outsourcing: capability-seeking versus the search for lower costs**

As we argued before, there exist two main motivations behind R&D offshore outsourcing: (1) capability-seeking in the form of a supply agreement with a highly specialized world-class supplier; or (2) efficiency-seeking in the form of lower labor costs overseas (Lewin and Peeters, 2006; Kakabadse and Kakabadse, 2002; Manning et al., 2008; Hästönen, 2009)). Therefore, we expect that the preferred location, i.e. domestic as opposed to offshore providers in developed countries or in emerging countries, will vary depending on the firm's motivation for outsourcing a particular R&D service.

### Capability-seeking

Because R&D services are knowledge-based activities, and knowledge tends to be location-specific, some regions may offer specialized know-how or capabilities within a specific technological domain. In relation to this, research has found that the dispersion of R&D activities is largely a result of the emergence of increasingly specialized-niche business activities, many of which are strongly tied to a particular geographic space (Calderini and Scellato, 2005). As a result, in order to tap these resources and access this technological expertise, firms may need to establish outsourcing agreements with providers located within such regions so as to benefit from these specialized providers and take advantage of their experience within the field. In fact, prior research has found that main locational drivers for services offshoring are the abundance and quality of human capital, cultural similarity and telecommunication infrastructure (Bunyaratavej, et al., 2007, 2008; Graf and Mudambi, 2005). In effect, recent work has shown that the majority of high-end product development and engineering activities are still being carried out in advanced Western economies (Disher and Lewin, 2007; Mudambi, 2008). As a consequence, we expect that because world leaders in knowledge and technology are typically located within developed regions, when a firm wishes to outsource a particular R&D service so as to access specialized know-how or technological capabilities, it will be more likely to outsource offshore to a provider located in a developed country, as such countries are usually more technologically developed, boasting access to better technological infrastructure or centers of excellence. Thus, we argue that:

*H4. The more important capability-seeking as a motive for outsourcing, the more likely the R&D service will be outsourced to an offshore provider located in a developed country.*

### The search for lower labor costs

As R&D activities are knowledge based and, as a consequence, rather labor intensive, cost remains an important driver behind offshore outsourcing, given that some firms within developed countries may find their labor costs high compared to those of developing countries (Kotabe, 1998; Swamidass and Kotabe, 1993). The development of a low-cost market of qualified providers located in emerging countries, not only for standardized non-core activities but also for those which add more value to the firm, such as R&D, has driven some firms to outsource some of these activities to these regions (Engardio and Einhorn, 2005; Liebaerman, 2004; Maskell et al., 2006; Patel and Vega, 1999; Subramaniam and Venkatraman, 2001; UNCTAD, 2004, 2005), as this implies the possibility of significant savings on production costs being achieved due to labor cost differentials. As a consequence, we expect that when the reason for outsourcing is the search for a provider able to perform the R&D service more efficiently than the firm due to lower labor cost, firms will prefer to

outsource R&D services to providers located in emerging countries as is the case with other activities, such as manufacturing. We are thus led to the following hypothesis:

*H5. The more important cutting labor costs as a motive for outsourcing, the more likely the R&D service will be outsourced to an offshore provider located in an emerging country.*

### **2.3. R&D service attributes: The extent of tacit knowledge and technological uncertainty**

In this paper, and in the context of R&D services, we will take two service attributes into account which are especially relevant when deciding either to outsource innovation activities or where to locate them: (i) the extent to which tacit knowledge is required to perform the service; and (ii) the degree of technological uncertainty surrounding the activity.

#### The extent of tacit knowledge

On the one hand, we expect the degree of tacit knowledge implicit in the service being outsourced to influence the efficiency of specialized providers worldwide, especially when firms' motivation for outsourcing is the need to access specialized know-how or technological expertise.

Once the firm decides to outsource to an external provider an activity characterized by a high component of tacit knowledge, the odds of finding a specialized provider will be reduced due to the impossibility of an external supplier benefiting from scale or scope economies when performing such idiosyncratic services (Williamson, 1985). For this reason, we argue that the propensity of the firm to outsource offshore will be lower in this case. When a firm outsources a service requiring tacit knowledge, the supplier will find difficulties in exploiting the capabilities related to this service to other firms. Thus, the efficiency gap between a domestic supplier and the best state of the art supplier overseas will narrow according to the extent to which tacit knowledge is necessary. For this reason, the higher the tacit component of the technological knowledge required to performing the service, the less likely the firm will be to outsource it to a provider located in a developed country, given that the main motivation to outsource there is to benefit from the supplier's expertise. In addition, outsourcing offshore will entail higher coordination costs than when outsourcing domestically. This is so because tacit knowledge is difficult to articulate, codify and transfer (Kogut and Zander, 1993), and when outsourcing abroad the transfer of this knowledge is more difficult due to different cultures of the nations of the client and the supplier (Madhok, 1997). Specifically, we expect these difficulties to be even more critical if outsourcing to offshore providers in developing countries, as the capability of the provider to outperform domestic providers will be reduced due to institutional differences, cultural distance, and communication costs (Teece, 1986). Thus, we hypothesize that:

*H6. The more tacit the R&D service, the less likely the firm will be to outsource it to an offshore provider.*

### Technological uncertainty

Technological change may have an important effect on the decision to internalize or outsource a particular activity, and thus on the probability of outsourcing it to a particular location. Internalizing activities under conditions of rapid technological change imposes inflexibility precisely when flexibility is most needed (Poppo and Zenger, 1998). In this regard, previous research has shown that, on the one hand, greater use of outsourcing may deliver more flexibility, which may help firms to respond quickly to unanticipated threats and market opportunities (Hitt et al., 1998). On the other hand, due to the fact that investments in technology are commonly quite specialized, rapid technological change may increase the likelihood of technological investments in knowledge and routines being rendered obsolete (Balakrishnan and Wernerfelt, 1986). As a result, when an activity is characterized by a high degree of technological uncertainty, the capabilities required to perform it may be subject to frequent changes, and firms are thus expected to outsource it to the provider with the most suitable resources and capabilities to effectively perform it wherever the said provider is located. In effect, as stated by Kogut and Kulatilaka, (1994) in presence of uncertainty firms can gain flexibility through international outsourcing as it allows for greater adaptability by enabling firms to switch location in the face of changing circumstances. In this regard, outsourced activities can be rapidly transferred to competing providers in alternative locations (Mudambi, 2008). Thus, taking all the above into account together with the main motivations driving firms to outsource R&D services abroad, it can be expected that, for services characterized by a high level of technological uncertainty, outsourcing decision will be largely driven by the need to access specialized providers with the resources and capabilities required to perform them at a particular moment in time, and not so much by the need to reduce costs. For this reason, we expect the level of technological uncertainty surrounding the R&D service to have a positive effect on the probability of a firm outsourcing it to offshore providers in developed countries, but we do not expect a significant effect on the probability of outsourcing to offshore providers in developing countries. This leads to our final hypothesis:

*H7. The more technological uncertainty surrounding the R&D service, the more likely the firm will be to outsource it to an offshore provider located in an OECD country.*

Therefore, the hypotheses proposed in relation to firms' R&D offshore outsourcing location decisions can be summarize in Table 1.

**Table 1. Factors driving the probability of outsourcing R&D services to offshore providers in developed countries or in emerging countries instead of relying on domestic providers**

<b>Factors influencing the R&amp;D outsourcing location</b>	<b>Probability of offshore outsourcing to developed countries</b>	<b>Probability of offshore outsourcing to emerging countries</b>
<i>Firms' characteristics</i>		
• Technological resources and capabilities (H1)	(+)	(+)
• International experience of the firm (H2)	(+)	(+)
• International experience in emerging countries (H3)	n.s	(+)
<i>Firms' motives for offshore outsourcing R&amp;D</i>		
• Capability-seeking (H4)	(+)	n.s.
• Lower labor costs (H5)	n.s.	(+)
<i>R&amp;D service attributes</i>		
• The extent of tacit knowledge (H6)	(-)	(-)
• Technological uncertainty (H7)	(+)	n.s.

### 3. DATA AND METHODS

#### 3.1. Research Setting and Data

We obtained data on R&D outsourcing agreements through a mail survey conducted on a sample of firms competing in R&D-intensive industries. The targeted population was companies with headquarters in the U.S. and the European Union (EU), with more than 100 employees, and whose 2-digit SIC code was one of the five defined in the OECD (OECD, 1997) classification as technology-intensive industries: (28) chemicals and allied products, (35) transportation equipment, (36) computers and electronics, (37) industrial machinery, and (38) analysis and measurement equipment. We stratified the sample according to industry and firm size to ensure external validity, using both domestic and international versions of the *Dun & Bradstreet Million Dollar Database*, which spans all industries providing information on companies with \$1 million or more in sales, or 20 or more employees. Using these criteria, we obtained a list of 3,529 U.S. firms and 3,375 EU firms. From these lists, we randomly selected stratified samples of 2,000 firms from the U.S. and 2,000 from the EU. As mentioned above, efficiently managing R&D plays a crucial role in the competitive strategy of these industries, so we expect these firms to undertake efforts in order to achieve superior performance in their R&D outsourcing agreements worldwide.

In order to better understand the R&D outsourcing phenomenon and to develop a more comprehensive questionnaire, we conducted interviews with the heads of Technology and Innovation of a large US-based multinational company. Furthermore, the questionnaire was pre-tested on seven R&D managers located in different countries. Due to the international nature of the targeted population the questionnaire was translated into five languages: English, French, Italian, Spanish, and German. Given the different sizes of the firms and industries included in our targeted population, the questionnaire was mailed to the firms' CEOs along with a request to pass it on to the head of R&D or technology if necessary. We also made all versions of the questionnaire available on the Internet. The returned questionnaires were filled out by senior managers, namely, CEOs, VPs, heads of R&D or heads of technology or engineering departments.

We followed the principles of the Total Design Method (Dillman, 1978). A total of 105 completed questionnaires were received from the first mailing in July 2006. A second mailing was sent three months later and an additional 33 questionnaires were received. 303 mailings were returned as undeliverable (197 for the U.S. and 106 for the EU). After a telephone follow-up process, 44 extra questionnaire replies were collected. We thus obtained a final sample of 182 usable responses (81 for the U.S. and 101 for the EU). After excluding the undeliverable addresses, our response rates were 4.5 % for the U.S. and 5.3% for the EU. It must be noted that cross-national mail surveys aiming at an industrial population generate very low response rates, normally similar to the ones obtained in this study (see for instance, Yip and Dempster, 2005). In addition, in an international context there are virtually no alternatives to mail surveys if more than a couple of countries are included (Harzing, 2000). The 182 responses obtained are representative of the spectrum of firms in terms of industry, country of origin, and firm size (see table A1 in the Appendix for the distribution by firm, country of origin, and industry). Besides this, we compared the responses from first mailing and those from the second but we found no significant differences at the 95% confidence level between early and late respondents in terms of firm size or the decision to outsource R&D. We thus conclude that a significant non-respondent bias is unlikely.

We asked firms to indicate which R&D service activities they were outsourcing from a comprehensive list of twelve, and where. The R&D services included on the list are basic or fundamental research, applied or experimental research, development of new products or new or improved processes, product design, design of technology processes and engineering systems, architectural services, software development, scientific and technical support consulting services, software implementation services, and testing and analysis services. Given this list, 108 of the 182 firms outsource at least one of the R&D services listed (60% of our sample). Due to the fact that 96 of the 108 firms outsourcing R&D indicated that they were outsourcing more than one type of R&D service, and in order to be able

to focus our study on a specific outsourcing relationship for each of the firms in our sample, we asked these firms to identify a type of R&D service that the company was outsourcing regularly, representative of the R&D activities carried out by the company (in terms of resources compromised and volume being contracted) from the range of different R&D services outsourced. By focusing on these agreements we were able to analyze the most representative R&D agreement within the firm strategy more precisely. Missing data on some of the variables reduced the sample to 99 usable questionnaires. Of the 99 outsourcing agreements in the sample, 62 are with domestic providers, 20 with offshore providers in developed countries, and 17 with offshore providers in emerging countries (see figure A1 in the Appendix for an illustration of the offshore outsourcing destinations).

Because our dependent and some independent variables were obtained using the same survey instrument, our results may be affected by common-method bias. In order to deal with this issue, we used the procedural remedies related to questionnaire design suggested by Podsakoff, MacKenzie and Podsakoff (2003). First, we guaranteed response-anonymity and we did not reveal to respondents the exact goal of the survey. Second, the questionnaire items related to the dependent variable followed the independent variables rather than preceding them. Third, the data used for some independent variables do not come from the survey. Lastly, in order to address the issue of common-method bias statistically, we performed Harman's single-factor test (Harman, 1967). This technique consists of loading all of the variables in the study into an exploratory factor analysis, and examining the unrotated factor solution in order to determine the number of factors necessary to account for variance in the data. Consequently, if there is a significant amount of common-method bias in the data, a single factor will emerge from the factor analysis, or one general factor will account for the majority of the co-variance among the measures. Unrotated factor analysis using eigenvalue-greater-than-one criterion revealed seven factors accounting for 69.6% of the variance, with the first factor accounting for only 21.2% of the variance, thus suggesting the absence of common-method bias.

### **3.2. Method of Analysis**

In order to estimate a model with multiple discrete outcomes—i.e. outsourcing R&D services to domestic providers, outsourcing R&D services to offshore providers in developed countries, or outsourcing R&D services to offshore providers in emerging countries—we use a multinomial probit model. This model is becoming more common as an alternative to the more widely-established multinomial logit model (Albert et al., 2008). As in multinomial logit models, in multinomial probit, the estimates of coefficients for independent variables measure the effect of the variation of the independent variable on the relative probability of the dependent variable taking a particular value in relation to the probability of it taking another value which is used as reference (domestic suppliers in this case). For this reason,  $n-1$  coefficients are estimated for each independent variable, being  $n$  the

number of categories of the dependent variable. The main advantage of using the multinomial probit instead of the logit is that this model allows error terms to be correlated across alternatives, thereby permitting it to circumvent the dilemma of the independence of irrelevant alternatives present in the multinomial logit model (Kennedy, 1998).

### 3.3. Measures

Our dependent variable 'LOCATION' equals 1 if the R&D service is outsourced to a provider in the home country, 2 if the provider is located abroad but in a developed country, and 3 if the provider is located offshore in an emerging country. As a confirmation that international R&D outsourcing is probably in its early stage (Disher and Lewin, 2007; Hirshfeld and Schmid, 2005; Manning et al., 2008) our data shows that R&D outsourcing takes place basically at the domestic level, while outsourcing to emerging countries is the exception rather than the rule. Of the 99 outsourcing agreements in the sample, 62 are domestic, 20 are outsourced to foreign providers located in developed countries, and 17 are located in emerging countries. Domestic providers (LOCATION= 1) act as the reference category, as we expect it to be the default option (Rangan, 2000).

We included several independent variables. First, as an indicator of the firm's technological resources and capabilities we introduced two different measures. One input variable (*R&D INTENSITY*) as an indicative of the firm's effort on R&D. In order to do so, we asked the firm to estimate its percentage of R&D investment over sales. Second, as an output measure of the firm's valuable technological capabilities (*PATENTS*), we use the number of patents assigned to the firm before the end of 2006, as recorded by the United States Patent and Trademark Office, UPSTO). To assess for the firm's overall international experience we introduced the variable (*MULTINATIONALITY*) that counts the number of international wholly-owned subsidiaries possessed by the firm. On the other hand, in order to assess for the firm's international experience in emerging markets (*EXPERIENCE IN EMERGING COUNTRIES*) we introduced a dummy variables that takes value 1 if the firm owns subsidiaries either in East Europe, Asia, Africa, LatinAmerica or East Europe, and 0 otherwise. To account for the motivation for outsourcing an R&D service we used two different items within the questionnaire. On the one hand we measured the need to access specialized providers (*CAPABILITY-SEEKING*), asking the firm to evaluate the importance of 'Lack of skilled personnel within the company' as a reason for outsourcing the R&D service from 1 (very low) to 5 (very high) on a Likert scale. On the other hand, to measure the need to reduce costs (*LOW LABOR COST-SEEKING*), we asked the firm to evaluate the importance of 'Cutting labor costs' as a reason for outsourcing the R&D service on a Likert scale from 1 (very low) to 5 (very high). In relation to the attributes of the R&D service, we proxied the efficiency of specialized providers with the extent to which tacit knowledge is implicit in the service being outsourced (*TACITNESS*). Consequently, we expect that the more tacit the service, the lower the

efficiency gap between offshore specialized providers and domestic providers. We used three items adapted from Kogut and Zander's (1993) work, and asked the firm to indicate their level of agreement with three statements related to the attributes of the R&D service they were outsourcing. Our interitem reliability was also very high (Cronbach's  $\alpha = 0.823$ ) so we combined these three items to represent our construct: (1) It is difficult for third parties to understand the company know-how related to this service; (2) It is difficult for third parties to copy or imitate the abilities or technological knowledge required to perform the service; (3) Effective transfer of company know-how to perform this service requires a high level of frequent interaction with company personnel. Finally, we created a variable (*UNCERTAINTY*) in order to assess the level of technological uncertainty surrounding the service. We asked the firm to indicate their level of agreement from 1 to 5 with two statements adopted from Poppo and Zenger (1998) in relation to the attributes of the R&D service they were outsourcing: (1) The skills required to perform the service are subject to frequent change; (2) The optimal configuration of hardware and software required to perform this service is subject to frequent change (Cronbach's  $\alpha = 0.79$ ).

We also included the following control variables: First, as previous literature also signaled process improvement as one of the main motives for outsourcing (Graf and Mudambi, 2005), we introduced a variable in order to control for this third motive for outsourcing (*PROCESS IMPROVEMENT*). In order to develop this measure, we asked the firms to rank the level of importance of the following factors in the decision to outsource the R&D service on a Likert scale from 1 to 5: (1) Reduction of time taken from product development to sales ('time-to-market'); (2) Cost reduction achieved through the consolidation of certain activities at specialized centers; (3) Increase of operational flexibility; (4) Reorientation company efforts and resources to core activities. As the interitem reliability was high (Cronbach's  $\alpha = 0.754$ ) we combined these four items to represent our construct. Second, in relation to the R&D service being outsourced we controlled for the level of difficulty in measuring worker performance (*MEASUREMENT*) as it may have an effect on the outsourcing location decision. In order to do so, we asked the firm to indicate its level of agreement with the following statement on a Likert scale from 1 to 5: 'It is difficult to measure the collective performance of those individuals who perform this service'. This one single-item measure was adapted from Poppo and Zenger (1998) and it is consistent with previous work (Anderson and Schmittlein, 1984). Besides, we also introduced some variables to control for heterogeneity of firms. We created a dummy variable (*FIRM ORIGIN*) coded as one for firms founded in the European Union and zero for the U.S. We introduced the following industry dummies: SIC 28 (Chemicals); SIC 35 (Transportation Equipment); SIC 36 (Electronics); SIC 37 (Machinery); SIC 38 (Measurement Equipment). Due to our low number of observations, in our regression model both SIC 37 (Machinery) and SIC 38 (Measurement Eq.) act as reference categories, given that they were the ones with the lowest number of observations.

## 4. RESULTS

Table 2 shows correlations and descriptive statistics for all independent and control variables used in our model. No high correlations were observed. Table 3 reports the results from our multinomial probit regressions using two different specifications: control variables only (model I), and the full model (model II). Specifically, the table shows the value of the estimated coefficients, their robust standard errors and an indication of their significance level for each model. The models run present significance levels below 0.001, as shown by the chi-squared values. Thus, the null hypothesis after which all the estimated coefficients are equal to zero may be rejected in all cases.

As can be seen in Table 3, the overall results support our hypotheses. To test Hypotheses 1, relative to the influence of a firm's technological resources and capabilities in its outsourcing location decision, we introduced two different variables: R&D INTENSITY and PATENTS. Table 3 shows that, according to our first hypothesis, PATENTS is positive and statistically significant, so the fact of having valuable technological resources and capabilities increases the probability of offshore outsourcing as compared to the probability of outsourcing to a domestic provider. Thus, this result supports the proposed hypothesis that those firms having more technological resources and capabilities are more likely to outsource offshore R&D services, either to developed or to emerging locations. On the one hand, through international outsourcing, those firms possessing sound technological resources and capabilities can enjoy access to either state of the art providers in developed countries or low-cost providers in emerging countries, which may help them to sustain their competitive advantage within an increasingly competitive and globalized world. And, on the other hand, the possession of valuable technological capabilities may allow these firms to develop governance capabilities, so they will be better prepared to identify world-class providers and to monitor their behaviour. However, it should be noted that when we analyze the variable R&D INTENSITY aimed at measuring the technological resources a firm may have due to its R&D efforts, although we observe the expected positive sign, it is only statistically significant for those firms offshore outsourcing their R&D services to providers in developed countries. Thus, this result may suggest that, everything else being constant, firms which are more R&D intensive may feel less pressure to search for low-cost providers. The fact of having large technological resources allows these firms to avoid a significant need to outsource to low-cost providers, tending instead to prompt a search for those offering complementary state of the art technological resources and capabilities. So, when we measure firms' technological resources and capabilities through their efforts in R&D, the more R&D intensive the firm, the more likely it will be to outsource R&D services to providers located abroad, instead of to domestic ones, but only within developed countries.

**Table 2. Descriptive statistics and correlation matrix**

	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. TACITNESS	2.99	1.01															
2. R&D INTENSITY	5.82	5.65	0.05														
3. PATENTS (mean centered)	0	296.46	-0.05	-0.09													
4. EXPERIENCE IN EMERGING COUNTRIES	0.18	0.39	0.07	-0.07	0.34*												
5. LOW LABOR COST-SEEKING	2.23	1.52	-0.00	0.02	-0.02	-0.02											
6. CAPABILITY-SEEKING	3.02	1.40	0.02	-0.28*	0.05	0.10	-0.15										
7. PROCESS IMPROVEMENT	3.23	1.05	0.25*	0.15	-0.18	-0.01	-0.01	0.07									
8. MEASUREMENT	2.62	1.18	0.23*	-0.05	-0.11	-0.15	-0.01	0.20*	0.31*								
9. UNCERTAINTY	2.44	1.16	0.03	0.11	-0.11	-0.13	-0.02	0.01	0.29*	0.41*							
10. MULTINATIONALITY	8.96	24.59	0.18	0.09	0.13	0.22	-0.15	-0.08	0.03	-0.09	0.11						
11. FIRM ORIGIN	0.50	0.50	0.03	0.11	-0.2*	-0.15	0.11	-0.05	-0.10	0.03	0.23*	-0.06					
12. SIC28	0.25	0.43	0.03	-0.11	0.11	0.11	-0.16	0.00	-0.13	0.03	-0.04	0.21*	0.18				
13. SIC35	0.27	0.44	-0.20*	-0.10	0.00	0.02	0.25*	0.08	-0.26*	-0.08	-0.05	-0.13	-0.09	-0.35*			
14. SIC36	0.22	0.41	0.18	-0.05	-0.01	-0.08	-0.10	0.12	0.39*	0.23*	0.06	-0.15	-0.14	-0.30*	-0.33*		
15. SIC37	0.10	0.30	-0.07	0.05	-0.07	-0.00	-0.01	-0.00	0.01	-0.02	-0.02	-0.04	0.02	-0.19*	-0.20*	-0.18	
16. SIC38	0.14	0.35	0.04	0.28*	-0.06	-0.06	0.00	-0.2*	0.00	-0.20*	0.05	0.12	0.04	-0.24*	-0.25*	-0.22*	-0.14

Note: (\*) significant at the 5% level

**Table 3. Multinomial probit regressions results. Probability of offshore outsourcing R&D to either a provider from an OECD country or from a non-OECD country (Baseline category: outsource R&D to a domestic provider)**

Independent variables	Model I		Model II	
	Developed countries	Emerging countries	Developed countries	Emerging countries
<b>R&amp;D INTENSITY</b>			0.142 (2.89)***	-0.033 (0.47)
<b>PATENTS</b>			0.002 (3.10)***	0.002 (3.23)***
<b>CAPABILITY-SEEKING</b>			0.418 (2.34)**	-0.176 (0.54)
<b>LOW LABOR COST-SEEKING</b>			0.187 (2.34)	2.291 (5.33)***
<b>MULTINATIONALITY</b>			-0.010 (1.19)	-0.026 (0.82)
<b>EXPERIENCE IN EMERGING COUNTRIES</b>			0.165 (0.23)	3.03 (1.95)*
<b>TACITNESS</b>			-0.527 (2.00)**	-1.49 (2.36)**
<b>UNCERTAINTY</b>			0.625 (2.44)**	-0.092 (0.20)
<b>PROCESS IMPROVEMENT</b>	0.027 (0.12)	-0.071 (0.32)	-0.155 (0.57)	-0.174 (0.40)
<b>MEASUREMENT</b>	-0.313 (1.56)	-0.126 (0.63)	-0.58 (2.27)**	0.363 (0.99)
<b>FIRM ORIGIN</b>	-0.749 (1.75)	-0.826 (1.83)	-1.304 (2.20)**	-2.033 (1.74)*
<b>SIC28 (CHEMICALS &amp; PHARMACEUTICALS)</b>	0.798 (1.35)	0.798 (1.35)	1.788 (2.79)***	-2.473 (1.63)
<b>SIC35 (TRANSPORTATION EQUIPMENT)</b>	-0.292 (0.47)	0.133 (0.24)	-0.533 (0.70)	-4.384 (2.83)***
<b>SIC36 (ELECTRONICS)</b>	0.150 (0.23)	-1.247 (1.58)	0.733 (1.04)	-3.669 (2.80)***
<b>Constant</b>	-0.008 (0.01)	0.197 (0.21)	-1.543 (1.19)	-0.865 (0.49)
<i>Log pseudolikelihood</i>		-77.176		-42.593
<i>Wald chi2</i>		23.67*		183.03***

Robust z statistics in parentheses

\* significant at p<0.05; \*\* significant at p<0.01 ; \*\*\* significant at p<0.001

As regards the tests of Hypotheses 2 to 7, all variables involved present the expected sign and are statistically significant, except from Hypothesis 2. The variable measuring the overall firm's international experience (MULTINATIONALITY) is not statistically significant. So, we found no support for our hypothesis that the overall previous international experience possessed by the firm will increase the likelihood of that firm outsourcing offshore R&D services. However, in relation to Hypothesis 3, it may be observed that the variable EXPERIENCE IN EMERGING COUNTRIES shows a positive and significant effect ( $p < 0.10$ ) when explaining the likelihood of offshore outsourcing the R&D service to providers in non-OECD countries, as compared to the likelihood of outsourcing to domestic providers. This suggests that, in this case, according to what we expected, those firms owning subsidiaries in emerging countries are more likely to offshore outsource R&D services to these regions as they may be more able than the others to better select available suppliers and manage outsourcing agreements in those institutional environments. In relation to Hypothesis 4, it is observed that the variable CAPABILITY-SEEKING has a positive and significant effect ( $p < 0.05$ ) on the probability of firms outsourcing R&D services to offshore providers located in developed countries as opposed to outsourcing to domestic providers. While, on the other hand, the LOW LABOR COST-SEEKING variable is positive and highly significant ( $p < 0.001$ ) when explaining the probability of outsourcing R&D services to emerging countries, as compared to the probability of outsourcing them within the firm's home country. Thus, this result supports Hypothesis 5. In this regard, recent evidence has shown that accessing highly qualified workforce has emerged as a new strategic driver behind offshoring activities not only to developed countries but also to emerging countries (Bunyaratavej et al., 2007; Lewin and Peeters, 2006). Thus, our findings contribute to IB literature by showing that despite this tendency, at least in the specific context of R&D services, the firm's main motive for offshore outsourcing to emerging providers still seems to be lower labor costs, while they are still more likely to rely on providers within developed countries when searching for specialized know-how or capabilities for these services. We should note, however, that because R&D offshore outsourcing is a rather novel business practice, this may not be the case for other services. So, one limitation of this study is that our findings may be context-specific. However, this is rather inevitable when trying to disentangle this phenomenon and move beyond the aggregate analysis within this topic.

In order to test Hypothesis 6, we proxied the efficiency of specialized providers through the degree of tacit knowledge implicit to the R&D service being outsourced. In this regard, we expected that the more tacit the service, the lower the efficiency gap between domestic and specialized offshore providers, so the less likely the firm will be to decide to outsource offshore, specially to emerging countries. The results showed in table 3 support our hypothesis. The variable TACITNESS displays a negative and statistically significant coefficient in relation to the firm's probability of offshore

outsourcing R&D services to developed and emerging locations compared to the probability of outsourcing them to domestic providers. Besides, as we expected, TACITNESS shows a larger negative impact on the probability to outsource offshore R&D to emerging countries than on the probability to outsource offshore to providers in developed countries. Consequently, it seems that for services requiring the transference of a high component of tacit knowledge, firms show a preference for providers in their domestic countries.

Finally, according Hypothesis 7, the more technological uncertainty the more likely the firm will be to outsource R&D services to offshore providers located in developed countries, as is shown by the positive and significant coefficient of the UNCERTAINTY variable. This result supports previous studies which argue that in the presence of uncertainty, international outsourcing may allow firms to increase flexibility, as it provides the firm with the capability to switch between providers located in different countries. In this regard, it is important to note that, as we expected, the UNCERTAINTY variable is non-significant in terms of explaining the probability of outsourcing to emerging countries as opposed to outsourcing to domestic providers. Consequently, this finding supports our proposed argument, that for services characterized by a high level of technological uncertainty, the outsourcing decision would be primarily driven not so much by the need to reduce costs as by the need to access providers with the required technological resources and capabilities, in order to effectively perform the R&D service at a particular moment.

With respect to the control variables, some results deserve special emphasis. On the one hand, the variable MEASUREMENT has a significant negative effect on the likelihood of outsourcing R&D services to offshore providers located in developed countries, but not to providers in emerging countries. This result suggests that, because outsourcing to developed countries has been found to be mainly driven by the need to take advantage of more developed capabilities, higher difficulty in measuring provider performance may aggravate the information asymmetry faced by firms when contracting foreign suppliers. On the other hand, our results suggest that U.S. firms are more likely to outsource offshore R&D services as compared to those from the European Union, according to the negative and significant effect of the variable FIRM ORIGIN both when explaining the probability both to offshore to OECD countries and to non-OECD countries as opposed to outsourcing to domestic providers.

#### **4. DISCUSSION AND CONCLUSION**

The main objective of this paper has been to improve understanding of the location determinants of R&D offshore outsourcing agreements. In particular, to analyze the factors driving firms to outsource

offshore R&D services either to providers located within developed countries or in emerging countries, instead of relying on domestic suppliers to perform them. We think this research question of interest to the IB community, as the rise of R&D service outsourcing has coincided with a trend on the part of multinational enterprises towards reallocating some of their R&D activities to emerging countries (Bunyaratavej et al, 2007; Kotabe and Murray, 2004; Lewin and Peeters, 2006). However, due to the fact that this R&D offshore outsourcing phenomenon is still at an early stage, there remains a lack of empirical studies able to shed light on its determining factors.

To address this research question, we took into account three set of explanatory variables, i.e., firms' characteristics, firms' motives for outsourcing, and R&D service attributes. Thus, the integration of these factors allowed us to develop a more fine-grained analysis of the R&D offshore outsourcing phenomenon, as previous research on IB has stated the difficulty in exploring the distinctive features of these business practices. Our findings suggest that, overall, firms' technological resources and capabilities, firms' international experience, their motives for outsourcing R&D services, i.e. capability versus efficiency-seeking, and R&D service attributes, such as the degree of tacit knowledge required to perform the service and the level of technological uncertainty surrounding it, are important factors in order to explain why firms choose a particular offshore location instead of relying on domestic providers to perform these services. We think this paper is an important contribution to IB literature as, to the best of our knowledge, it constitutes the first attempt to explore this research question in this particular setting.

In relation to firms' characteristics, and in consonance with the resource-based view, we expected those firms possessing more valuable technological resources and capabilities to be more likely to outsource R&D services to offshore providers, as opposed to domestic providers. On the one hand, through international outsourcing, those firms having sound technological resources and capabilities can enjoy access to either state of the art providers in developed countries or low-cost providers in emerging countries, which may help them to sustain their competitive advantage within an increasingly competitive and globalized world. And, on the other hand, the possession of valuable technological capabilities may allow these firms to develop governance capabilities, so they will be better prepared to identify world-class providers and to monitor their behavior (Mayer and Salomon, 2003). In order to assess the technological resources and capabilities possessed by firms, we included two different variables in our study. One input variable to measure the R&D efforts made by the firm, i.e. its R&D intensity, and one output variable to measure the technological resources and capabilities obtained as a result of these R&D efforts, i.e. the number of patents assigned to the firm. In this regard, we found full support for our hypothesis in relation to the output variable (PATENTS) but only partial support when considering the R&D efforts made by the firm (R&D INTENSITY). We found that those firms having more technological resources and capabilities as a result of their R&D efforts,

are more likely to outsource R&D services to providers located abroad, but only within developed countries (not to developing ones), as opposed to outsourcing them within their home countries. Thus, it seems that the more R&D-intensive firms may feel less pressure to outsource to low-cost locations compared to those firms with less abundant technological resources. Our result complements Berry's (2006) finding that it is the leading technological firms that are investing in foreign R&D because a firm's prior possession of relevant knowledge and skill is crucial for a knowledge-seeking strategy to work. In effect, our study shows that in order to a firm to decide to offshore outsource to developing countries, previous international experience in those regions is important. Consequently, this indicates the important role that foreign subsidiaries in emerging countries may have as a way to reduce uncertainty and the risk inherent to these regions, and thus allow the firm to better select available providers and manage these agreements. So, according to this, overall it seems that because firms have different abilities to absorb and transfer foreign knowledge, this will influence which firms will be able to use foreign R&D as part of a strategy to augment their technological capabilities (Berry, 2006).

In relation to motives for offshore outsourcing R&D, we are able to distinguish two main motives for outsourcing R&D abroad: cost reduction or access specialized knowledge or capabilities; A similar tendency to that identified as the primary motive for internationalization in FDI literature (Dunning, 1993)—capability-seeking in the form of a cooperative relation with a highly specialized best-in-world supplier; and efficiency seeking in the form of lower labor and production costs overseas. In fact, previous studies of offshoring have shown rather conclusively that the primary motives for outsourcing activities from abroad are related to cutting costs, accessing resources or capabilities unavailable within the firm, and, to a lesser extend, process improvement (Lewin and Peeters, 2006; Kakabadse and Kakabadse, 2002; Manning et al., 2008). Thus, in relation to these motives, we argue that world leaders both in terms of knowledge and technology being typically located within developed regions, when a firm's motive for outsourcing a particular R&D service is the need to access specialized know-how or technological capabilities, the firm will be more likely to offshore it to a provider located in developed country. However, when the outsourcing decision is driven by the desire to cut labor costs, the firm will be more likely to outsource the R&D service to an offshore provider located in an emerging country where wages are lower.

Finally, when considering the attributes of the outsourced R&D service we found that, on the one hand, the more tacit the knowledge required to perform the service, the less likely the firm will be to outsource it to an offshore provider as compared to outsourcing it domestically, as the need for transferring tacit knowledge will lower the efficiency gap between a specialized offshore provider and a domestic provider. This is justified because the more tacit the service, the more specific to the firm, so the firm will have more difficulties in taking the most of the specialization advantages offered by a provider in terms of economies of scale, scope, and learning effects. As a consequence, our results

showed that level of tacitness of the R&D service has a larger negative impact on the probability to offshore outsource to emerging countries, as the difficulties associated to transferring this knowledge would be increased the higher the institutional and cultural distance between the firm's home country and that of the provider. On the other hand, we found that the more technological uncertainty surrounding the R&D service, the more likely the firm will be to outsource it to an offshore provider in developed countries as opposed to relying on a domestic provider (to perform it). As a consequence, this shows that under these circumstances, offshore outsourcing adds flexibility to the firm as it offers the possibility of switching (production) locations between countries offering providers with different technological resources and capabilities as the need arises.

However, this paper is not devoid of limitations. A more fine-grained study could be developed were we able to know the percentage of the volume being outsourced over the total budget designated to the R&D service, and over the firm's total R&D outsourcing budget. Although our respondent firms are representative of the population of firms in the selected industries, we obtained a low response rate. Besides, this study could be further developed by analyzing the type of outsourcing relationship—i.e. long-term versus short-term agreement—chosen by the firm depending on the R&D outsourcing location. In effect, further research overcoming these limitations could facilitate a better understanding of the R&D offshore outsourcing phenomenon. Given the actual business environment, from a managerial point of view the further analysis of these outsourcing practices is very relevant, as managers must search for the best way to effectively organize their firm's innovation activities worldwide in order to benefit from the comparative advantages offered by both developed and developing countries in terms of specialized technological knowledge, or lower labor costs. In this regard, global outsourcing of R&D activities offers several managerial challenges which deserve further attention, and thus with this study we hope to encourage future theoretical and empirical investigation within this field.

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## APPENDIX

Table A1. Distribution of survey responses by country of origin and industry.

COUNTRY		Mailed		Received	
		Number	%	Number	%
COUNTRY	US	2000	50%	81	4.05%
	European Union	2000	50%	101	5.05%
	Austria	56	2.80%	2	1.98%
	Belgium	25	1.25%	2	1.98%
	Czech Republic	20	1%	1	0.99%
	Denmark	23	1.15%	0	0%
	Finland	32	1.60%	0	0%
	France	221	11.05%	9	8.91%
	Germany	617	30.85%	24	23.76%
	Greece	2	0.10%	2	1.98%
	Ireland	17	0.85%	0	0%
	Italy	507	25.35%	32	31.68%
	Luxembourg	1	0.05%	0	0%
	Poland	37	1.85%	3	2.97%
	Portugal	13	0.65%	1	0.99%
	Spain	93	4.65%	9	8.91%
	Sweden	42	2.10%	3	2.97%
	The Netherlands	21	1.05%	1	0.99%
	UK	249	12.45%	12	11.88%
	East Europe	24	1.2%	0	0%
INDUSTRY	SIC 28 (Chemicals)	760	19%	45	24.7%
	SIC 35 (Transportation Eq.)	1357	33.93%	58	31.9%
	SIC 36 (Electronics)	947	23.68%	40	22%
	SIC 37 (Machinery)	487	12.18%	16	8.8%
	SIC 38 (Measurement Eq.)	449	11.23%	23	12.6%

Figure A1. Location of offshore R&D outsourcing agreements

