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30 October 2012

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October 2012

Abstract. Firms acquire external technological knowledge via different channels. In this paper we compare the technology sourcing via R&D outsourcing, R&D outsource offshoring, domestic cooperation for innovation and international cooperation for innovation of foreign subsidiaries and domestic firms. Because the different technology sourcing choices are potentially correlated we apply a multivariate probit specification which allows for systematic correlations among the different choices. The results show that the different technology sourcing choices are indeed interdependent and that foreign subsidiaries show a different pattern of external technology sourcing. Compared to affiliated domestic companies, foreign subsidiaries show a smaller propensity for external technology sourcing via R&D outsourcing from independent firms in the host country, for R&D outsource offshoring, and for international cooperation for innovation. In contrast, foreign subsidiaries show a greater propensity for domestic cooperation for innovation.

Keywords: Multinational enterprise, foreign subsidiaries, R&D outsourcing, cooperation for innovation, multivariate probit model.

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* We gratefully acknowledge the financial support of the Spanish Ministry of Science and Innovation (ECO2010-17485).

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1. Introduction

Today, industry growth is largely driven by innovation. However, in today's fast-paced, knowledge-intensive environment innovation is rarely the outcome of firms own internal R&D efforts. Innovation is increasingly the outcome of interactions among multiple actors and both R&D outsourcing as well as R&D cooperation have become significant features in current innovation management as ways to develop and gain access to new technologies. At the same time, the technology necessary for global competitiveness is often dispersed internationally. In this context, international R&D networks can provide firms with access to country-specific advantages and allow them to tap into the comparative advantages of foreign countries. While technology transfer is now recognized among economists and policymakers as key for economic growth, there is still relatively little knowledge at the firm level on the patterns of technology sourcing and the mechanisms underlying technology transfer. Technology sourcing from sources external to the firm and its entrepreneurial group includes a wide range of arrangements such as research contracts, acquisitions of R&D services and cooperation for innovation. These arrangements may engage partners and providers of technology located in the national and international market.

There is now a growing body of literature that focuses on the determinants of cooperation for innovation, (see, for example Veugelers and Cassiman, 2004; Knell and Shrolec, 2006; Shrolec, 2009 and 2011; and Gallié and Roux, 2010)). There is also some literature on the external sourcing of R&D services (see for example, Veugelers and Cassiman, 1999; Veugelers and Cassiman, 2004; Jabbour, 2009; Garcia-Vega and Huergo, 2011). These two bodies of literature have, however, largely developed separately. Cooperation for innovation and R&D outsourcing are both important instruments to acquire external technological knowledge and firms may simultaneously combine knowledge from these different external sources in their innovation strategy; thus there might be important complementarities.

The simultaneous decision of the firm to use different forms of technology sourcing has been rarely studied. Certain studies analyse R&D outsourcing and cooperation jointly but do not focus on the domestic versus international dimension nor on differences among domestic and multinational firms (Veuglers and Cassiman, 2004; Schmiedeberg, 2008; Vega-Jurado et al., 2009; Dhont-Peltraut and Pfister, 2011, for example). More importantly, these studies do not analyse the simultaneous decision to engage in different types of technology sourcing with partners or providers located in different geographic locations. To the best of our knowledge, there are no studies that jointly analyse the decision to cooperate for innovation and outsource R&D in the domestic and international markets.

This article analyses the simultaneous decision of the firm to engage in different types of external technology sourcing, the possible interdependence among different sourcing strategies and how some factors, notably foreign subsidiary status, may be associated to the adoption of some strategies but not to others. We analyse four technology sourcing strategies external to the firm and its entrepreneurial group: domestic cooperation for innovation, international cooperation for innovation, domestic R&D outsourcing and international R&D outsourcing (definitions below). The contribution of this paper is to jointly study the technology sourcing behaviour of domestic and multinational firms through different channels. The paper also contributes to the literature on the spatial dimensions of technology sourcing first by assessing the relative importance of domestic sourcing in host countries versus international linkages of technology sourcing both in domestic and multinational firms.

As stated, we aim especially at understanding how foreign subsidiary status may be related to different patterns of technology sourcing. Local embeddedness can have a positive influence on multinational enterprises (MNE) performance and R&D development since subsidiaries may absorb new knowledge more easily through close relationships with clients, suppliers, competitors or local institutions (Almeida, 2004; Andersson et al., 2005). MNEs source technology in the host-country for a variety of reasons, such as adapting their products to national tastes and regulations, getting access to skilled researchers or taking advantage of technology development of the national innovation system (Edler, 2008). The literature characterises as knowledge exploiting the activities of MNEs which aim at adapting products to local markets and as knowledge augmenting those which aim at acquiring new knowledge, for instance through access to the public research base of the host-country (Edler, 2008; Kuemmerle, 1999).

Conversely, MNEs play an important role in international technology transfer because of their global production networks and because they are often technologically superior to domestic firms (Veugelers and Cassiman, 2004). Consequently, many countries aim to attract foreign direct investment (FDI), expecting that multinational enterprises will provide skills and new technology that will ultimately enhance the competitiveness of domestic firms. However, as McCann and Mudambi (2004) note, many FDI schemes are unlikely to fulfil all, or even most, of policy-makers' expectations with regard to the development of national industrial capabilities. MNEs may remain as enclaves within a host-country economy, rarely establishing external ties with domestic firms or the rest of the national innovation system (Crone and Roper, 1999; Morris, 1992; UNCTAD, 2001). More precisely, they may avoid spillovers of knowledge in the host-country (Caves, 1998). Therefore, understanding their patterns of technology sourcing in the host-country is crucial. This task is particularly pressing for host-countries which are not at the forefront of sciences and techniques, and may potentially profit from the presence of subsidiaries.

We contend, however, that subsidiaries may behave differently according to the specific channel of technology sourcing; hence, the need to study simultaneously their patterns of R&D outsourcing and their patterns of cooperation for innovation. We also argue that domestic firms, and specifically, domestic affiliated firms, should be considered in the analysis since they could help us to understand the specificities of foreign subsidiary status and the possible liability of foreignness (LOF) incurred by subsidiaries in the host-country.

2. Literature review

Today, technology is becoming increasingly complex, multi-disciplinary and dynamic. This means that developing all necessary technological know-how internally is increasingly costly (Powell et al., 1996; Nilsson, 2001; Cooke, 2005). Thus, to cope with this situation and stay competitive, firms rely on necessary knowledge from other firms (Hagedoorn, 1993). Herstad et al. (2010) suggest that the importance of external knowledge sourcing may be increasing. More specifically, Hagedoorn and Narula (1996) and Hagedoorn (2002) provide evidence on the rise of technology sourcing cooperation over the past decades. Herstad et al. (2010) observe the rise of "globally distributed knowledge networks" (p. 116). Since the second half of the nineties, the growing phenomenon of globally distributed work organization has brought with it also a rise in international R&D sourcing and international collaboration for innovation (Abramovsky et al., 2008). Robles et al. (2009) provide evidence on the general rise of international partnerships during the 1990's among Spanish firms.

Innovation in multinationals has traditionally been concentrated in their core units (headquarters) but is now increasingly dispersed among the subsidiaries in different countries with the globalisation of research and development activities (R&D). In other words, knowledge creation also becomes more geographically dispersed within the MNE itself (Dunning and Lundan, 2009). Indeed, in the International Business (IB) literature, a decisive feature of the MNE is its capacity to internalise knowledge production over geographic borders (Buckley and Casson, 1998).

Cooperation for innovation with domestic partners may, however, pose difficulties. Multinationals may be less reliant on external networks than domestic firms for the provision of R&D resources. High transaction costs in the host-country could limit their ability to network (Nachum and Keeble (2001) since the subsidiary may lack the social capital which facilitates networking and joint-innovation (Ahuja, 2000; Hitt et al., 2002). Building relationships with partners who are willing to transmit knowledge requires the development of trust among the partners (Hitt et al., 2002). Moreover, subsidiaries might find the resources they need within the multinational network. Also, opting for international relations with institutions or independent firms may be easier for multinationals, given their greater resources for establishing international relations. These circumstances may limit their local embeddedness and consequently their potential for transfer of international technological knowledge to the local economy. Certain authors maintain that MNEs are unable to build networks similar to those of domestic firms which are active in similar industries and locations because of their *liability of foreignness* (LOF) i.e. the additional costs of doing business abroad which are not incurred by domestic firms (Caves, 1996; Nachum and Keeble, 2003). Subsidiaries may find it difficult to copy the successful strategies of domestic firms (Zaheer, 1995). This situation may also affect the decision to outsource R&D locally. These analyses suggest that the transaction costs of establishing external relationships may be higher for subsidiaries than for domestic firms. The alternative viewpoint maintains that subsidiaries are able to compensate for such costs in specific national environments. Despite their international nature, MNEs may have networking behaviour similar to domestic firms due to common externalities and similar competitive conditions in specific locations (Bellandi, 2001). Foreign firms, some argue, should not necessarily be expected to be less embedded in local economies than other companies (Perkmann, 2006). In short, empirical research has not yet provided a clear answer to the question of whether subsidiaries are able to build local linkages similar to those of domestic firms (for reviews of studies on backward linkages of MNEs, see Belderbos et al., 2001; UNCTAD, 2001).

Concerning more specifically the R&D activities of subsidiaries, Florida (1997) finds that foreign R&D laboratories in the US tend to adopt "American-style" innovation management. Westney (1987) also finds that in Japan foreign R&D laboratories tend to imitate the innovation organisation of indigenous R&D laboratories, and attributes such strategy to isomorphism (DiMaggio and Powell, 1983). Almeida (1996) rejects the idea of a LOF since, in his sample of US semiconductor companies, subsidiaries use local knowledge to a greater extent than domestic firms.

Early studies on the local technology sourcing of MNEs analysed the citation of patents produced in the host-country by patents granted to the subsidiary as a proxy of these companies' local sourcing (see, for instance (Almeida, 1996 and 2004). With the publication of the Community Innovation Surveys (CIS) of the European Union (EU), other studies have been able to focus, more specifically, on MNE's patterns of cooperation for innovation. Most of those studies find that cooperation for innovation with external partners is positively related to foreign status. However, evidence is not concluding. In Southern Europe or transition European countries, subsidiaries may be less likely to engage in external cooperation than domestic firms or, at least, than domestic unaffiliated firms (Shrolec 2011; Molero and Heijs, 2002). In other cases, subsidiaries are less likely than domestic firms to engage in *local* cooperation for innovation (Knell and Srholec, 2006). There is very little evidence on the patterns of R&D outsourcing and R&D offshoring outsourcing of subsidiaries (see, for instance, Boehe, 2007).

Previous studies have shown mixed results regarding the role of subsidiary status in technology sourcing patterns. This is mainly due to differences in the main focus or purpose of the studies and how subsidiary status has been controlled for; specifically to what control group foreign subsidiaries are compared to. Because our key objective is to investigate whether foreign subsidiaries show different traits in their technology sourcing behaviour, we compare them not only to domestic firms but specifically to domestic firms that also belong to a group – while controlling for other firm specific characteristics. Group affiliation is an important organisational attribute that could account for difference in technology sourcing even though we focus on technology sourcing from partners outside the own group (see, for example, Molero and Jeijs, 2002; Dachs and Ebersberger, 2009).

In this paper we study two mechanisms that firms can use to acquire knowledge externally: First, we study R&D outsourcing which include either the acquisition of R&D services through arm-length contracts or through subcontracting relationships meaning that task and processes are contracted to a third party company. Second, we study cooperative arrangements, defined as two or more separate organisations joining forces to share and develop knowledge in order to enhance their innovative performance. Other studies have also selected these two mechanisms for analyses of the technology sourcing of subsidiaries (Boehe, 2007). Boehe (2007) studies different types of local technology sourcing of foreign subsidiaries as determined by the organisation of the multinational network, but not their interrelations.

We propose the following research questions:

Q1: Do foreign subsidiaries show a different pattern of external technology sourcing than comparable domestic firms?

Q2: Are they able to build local cooperation networks similar to those of domestic firms?

The last question investigates the possible impact of the L.O.F. on foreign subsidiaries external linkages.

3. Research context, data and some descriptive results

Spain has been an important receiver of FDI. Inward FDI quadrupled from US$ 156 billion at the end of 2000 to US$ 604 billion at the end of 2010 (Clifton et al., 2011). 85% of the FDI stock originates in the rest of Europe Most of it actually arrived after 1986, when Spain joined the EU. FDI is strongly concentrated in export-oriented manufacturing, such as automobiles, and local market services, such as retailing. Foreign subsidiaries in Spain seem to display a high level of domestic embeddedness. A study on foreign subsidiaries in four EU countries (Ireland, Portugal, Spain and the United Kingdom) shows that in Spain, foreign subsidiaries have a greater propensity than their counterparts to source locally (Tavares and Young, 2006).

Analysing the innovative potential of different nations, Fagerberg and Godinho (2006) mention Spain among a few catch-up European economies, owing to its impressive increase in higher education enrolment and the emphasis placed on natural sciences and engineering. Hence, the interest of analysing the Spanish case.

Our data come from a survey of Spanish firms (Panel de Innovación Tecnológica, PITEC) collected by the Spanish National Statistics Institute (INE). The PITEC survey includes information on the technological innovation activities of all the main sectors in the Spanish economy, including services and manufacturing.

We use data for the year 2005-2009 which provides annual information on more than 12,000 firms.[1] In this sample about 10% of all companies are foreign subsidiaries.[2] We

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[1] We use the anonymized data set that is freely available. López (2011) compares regression results based on the anonymized and original data and shows that using the anonymized data from PITEC produces reliable results.

focus on differences between foreign subsidiaries and domestic private companies, and specifically domestic private affiliated firms, regarding their R&D outsourcing and cooperation behaviour in the domestic and international market. Regarding the latter, note however that for cooperation activities, only innovation active firms were asked questions related to their cooperation behaviour.[3] Thus, the sample for our empirical analysis is restricted to innovative active firms. In total, we have 42,020 observations for 10,229 private companies.

We define foreign subsidiaries as firms belonging to a company group with its headquarters outside the host country and domestic affiliated firms as those firms which belong to a company group with its headquarters in the host country. The remaining firms are those which do not belong to any company group.[4]

As noted by Dunning and Lundan (2009), data on the R&D activities of MNEs as part of comprehensive national surveys are rare and most evidence on this topic has been obtained through smaller academic surveys. Moreover, most of these surveys have been carried out in highly industrialised countries, a circumstance which may limit our global understanding of the technology sourcing of subsidiaries (Boehe, 2007). In the last period, some analyses on this topic based on the Community Innovation Survey of the European Union have been published (Cassiman and Veugelers, 2006; Lööf, 2009; McCann and Mudambi, 2004; Molero et al., 2009; Veugelers and Cassiman, 2004), but these studies focused mainly on technology sourcing via cooperation and not via the external outsourcing of R&D services.

To understand the possible specificities of the sourcing behaviour of foreign subsidiaries in the host-country, we compare foreign subsidiaries to affiliated domestic firms. Using domestic affiliated firms as control group enables us to establish that foreign subsidiaries

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[2] Note, we exclude public sector companies and research organisations from our analysis.
[3] These are firms that have at least introduced new products or new processes or that have innovative activities ongoing or abandoned during the two years prior to the survey date.
[4] This group also includes firms with foreign portfolio investment (but not FDI).

adopt certain technological sourcing strategies to a greater (or lesser) degree than expected, given general patterns of technology sourcing in the host-country.

Table 1 shows the percentage of firms that report R&D outsourcing among domestic unaffiliated companies, domestic affiliated firms, and foreign subsidiaries. Foreign subsidiaries show a greater percentage of R&D outsourcing compared to unaffiliated domestic firms, but a smaller percentage compared to affiliated domestic firms. For R&D outsourcing from outside the own company group, i.e. the external outsourcing, the percentage for foreign subsidiaries is about 28% which is very similar to the percentage of domestic unaffiliated firms but significantly lower than the percentage for domestic affiliated companies among which about 35% report R&D outsourcing from independent companies. The greater percentage of R&D outsourcing in general among foreign subsidiaries compared to domestic unaffiliated firms is primarily due to greater within company group outsourcing. Table 1 also shows that domestic firms rely to a greater extent on domestic R&D sourcing. Table 2 shows the respective numbers for cooperation for innovation. About 35 % of the sample foreign subsidiaries engage in external cooperation for innovation. To put this figure in perspective note that, in Sweden, 62.0% of innovative MNE (both foreign and indigenous) participates in external R&D collaboration (Lööf, 2009). However, the relatively low level of external R&D cooperation is not a specificity of the sample MNEs. In fact, they show a greater percentage of cooperation than domestic unaffiliated firms and only a slightly smaller percentage compared to affiliated domestic firms. However, compared to domestic unaffiliated as well as affiliated firms, foreign subsidiaries rely to a greater extent on domestic cooperation.

Table 3 further illustrates how firms combine these four different sources of technology in their technology sourcing strategies. About 25% of all our sample foreign subsidiaries report more than one source. This compares to about 28% in the case of affiliated domestic firms and about 16% among unaffiliated domestic firms. The most frequent combination is the domestic outsourcing of R&D together with foreign cooperation for innovation. However, in the case of foreign subsidiaries, the percentage of domestic cooperation and domestic R&D sourcing is very similar to the percentage of firms reporting foreign cooperation and domestic R&D sourcing.

4. Econometric model

We are interested in whether multinationals in their host country show differences in their technology sourcing behaviour compared to "comparable" domestic firms. The simple comparisons in Table 1 to 3 indicate some differences. These observed differences could, however, be due to differences in other firm characteristics apart from foreign subsidiary status. Thus, in the following we explore the importance of foreign subsidiary status in a multivariate probit regression which includes the most important control variables suggested by the literature.

The firm decision to source technology can be modelled by a dummy variable y_k, which takes the value of one when the firm sources technology externally and zero otherwise. We distinguish between technology sourcing via the outsourcing of R&D services and technology sourcing via cooperation for innovation both in the domestic and international market.

Specifically we construct the following four dependent variables:

Coopdom = Dummy variable with value 1 if the firm had a cooperation arrangement on innovation with a non-affiliated partner in Spain.

Coopint = Dummy variable with value 1 if the firm had a cooperation arrangement on innovation with a non-affiliated partner in another country.

Outdom = Dummy variable with value 1 if the firm had acquired R&D services from a non-affiliated partner in Spain.

Outint = Dummy variable with value 1 if the firm had acquired R&D services from a non-affiliated partner in another country.

Firms may consider the different technology sourcing choices simultaneously since there may be complementarities or substitutabilities between the different choices. Thus, owing to the potential interdependence of the different technology sourcing decisions, we use a multivariate probit specification to identify specific drivers of each type of technology sourcing.

The (MV) probit model allows estimation of several correlated binary choices jointly (Chib and Greenberg, 1998) by taking into account the potential interdependence in technology sourcing choices and the possible correlations among the error terms due to unobservable characteristics influencing the different sourcing choices.

The probability of choosing a particular mechanism of technology sourcing is estimated conditional on the choice of any other related sourcing choice.[5]

The estimation equations have the following form:

$$y_k = c + \beta_k x + u_k \forall k = 1,2,3,4 \qquad (1)$$

where y_k corresponds to the sourcing of technology via channel k, and takes values of one if the firm sources technology via channel k , otherwise the value is zero. The errors u_k have an assumed multivariate normal distribution. The independent variables are denoted by vector X and are described below.

Our independent variable of interest is the dummy FSUB taking the value 1 if the firm belongs to foreign subsidiary and 0 otherwise.

[5] The estimation is carried out using Stata's mvprobit code written by Cappellari and Jenkins (2003) which uses the Geweke-Hajivassiliou-Keane simulation method for maximum likelihood. In the field of cooperation for innovation, this approach was, for example, applied by Belderbos et al. (2004), Lenz-Cesar and Heshmati (2012), Schmidt (2008) and Carboni (2010).

In what follows, we describe the selection of control variables which could influence the technology sourcing behaviour of firms apart from belonging to a foreign multinational company. We include variables which, according to the literature, influence cooperation for innovation and R&D outsourcing in the domestic and international market. Though the literature on R&D outsourcing is still relatively scarce and mostly concentrates on ICT (Rilla and Squicciarini, 2011; Teirlinck et al., 2010), we also discuss some previous results concerning predictors of R&D outsourcing.

Group. While our interest is to compare the technology sourcing behaviour of foreign subsidiaries in the host country to domestic firms, the group of domestic firms is heterogeneous. Especially, belonging to a company group may facilitate the search for partners for external technology sourcing. Firms belonging to a company group may have greater organizational resources as well as experience to establish and maintain contacts with potential partners even outside the own company group. At the same time, the spatial network of the group can be important in overcoming friction costs of geographical distance in the search for partners in other locations. Some evidence suggests that firms pertaining to a group are more likely to cooperate for innovation or outsource R&D because they may be able to use their internal networks to recruit and supervise external R&D partners or providers of technology (Molero and Heijs, 2002; Segarra-Blasco and Arauzo-Carod, 2008; Teirlinck, et al., 2010). A different technology sourcing behaviour of MNE subsidiaries might not be due to the foreign ownership *per se*, but rather the fact that those firms operate within a company network (Pfaffermayr and Bellak, 2002). In this respect, foreign subsidiaries could follow patterns of technology sourcing similar to domestic firms belonging to a company group. Thus, to analyse the specificities of foreign subsidiaries, controlling for belonging to a company group turns out important (Molero and Heijs, 2002). Thus, in our specification we include a dummy for unaffiliated companies and use domestic affiliated companies as our reference group.[6]

Size. Size of the firm seems to be positively associated to external cooperation for innovation. Empirical evidence in this regard has been provided for a variety of countries such as Germany, Italy, South Korea and Spain (Carboni, 2010; Segarra-Blasco and Arauzo-Carod, 2008; Chun and Mun, 2012; Lopez, 2008; Schmiedeberg, 2008). The panorama might differ concerning R&D outsourcing. Hsuan and Mahnke (2011) contend that most research on this topic is based on qualitative research of large firms. There is a need, she argues, to correct a "large firm bias" (p.6). Moreover, she reports on a few studies that have found a positive association between small size of the firm and R&D outsourcing. We also control for possible non linear relationships between size and the four forms of technology sourcing analysed here.

R&D intensity. Policy-makers prefer to attract MNEs enjoying high levels of R&D intensity since such companies are potentially able to transfer updated technology to the host-country. This consideration is especially important for host-countries which are not at the forefront of sciences and techniques, and expect to benefit from voluntary or involuntary spillovers of knowledge from subsidiaries. However, the available evidence concerning the relationship of this variable and technology sourcing is not conclusive. R&D may be more related to cooperation in more advanced countries while internal resources of the focal firm matter less for cooperation in less advanced countries; in those countries, the company may use cooperation for innovation as a substitute (Shrolec, 2011). Analyses for Belgium, Canada and Spain have found complementarities between internal R&D and cooperation for innovation (Bayona et al., 2001; Beneito, 2006; Cassiman and Veugelers,

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[6] Unfortunately, with the data available in PITEC we don't know whether the domestic group network is national or international. Other studies have compared multinational subsidiaries to domestic unaffiliated companies while controlling for belonging to a domestic group as, for example, Belderbos et al. (2004), Faria and Schmidt (2012), or Shrolec (2011).

2006; Schmidt, 2007; Segarra-Blasco and Arauzo-Carod, 2008). However, other studies find complementarities or substitution effects in some specific sectors or concerning some types of partners, and not others (Carboni, 2010; Miotti and Sachwald, 2003; Molero et al., 2009). Some studies assume that R&D outsourcing is driven by the lack of in-house R&D and technical expertise (Teirlinck et al., 2010). This implies that R&D outsourcing is a substitute for internal R&D. One of the few articles comparing different forms of technology sourcing finds that internal R&D is more complementary to R&D cooperation while the association between internal R&D and R&D contracting is weaker (Schmiedeberg, 2008).

Patenting. The number of patents granted to a firm provides some indication of its technological capabilities and is usually accepted as a proxy for innovative activities (Schmiedeberg, 2008). The use of formal means of protection was associated to cooperation in Finland but not in Austria (Dachs et al., 2008). Canadian biotechnology firms that patented more intensively were more likely to tap into global knowledge flows (Gertler and Levitte, 2005).

Productivity. Productivity may be viewed as a proxy for the skills of the work force which, in turn, may positively influence the absorptive capacity of firms (Beneito, 2002).

Exports. Exporters are more exposed to competition than other firms. They may need to tap into different sources of knowledge in order to be competitive in international markets. Their presence in those markets may facilitate their access to international sources of technology. However, the evidence in this respect is not conclusive. Italian exporters are not more likely to engage in cooperation for innovation than Italian non exporters (Carboni, 2010). By the same token, Portuguese exporters are not more inclined to cooperate with international partners than Portuguese non exporters; in contrast, German exporters are more likely to engage in such cooperation than German non exporters (Faria and Schmidt, 2012). Similarly, Spanish exporters are more likely than Spanish non exporters to engage in R&D offshoring outsource (García-Vega and Huergo, 2011).

Newness. Firm may need some time to create reliable and effective collaborative linkages with external partners. This is especially true for foreign subsidiaries which have recently entered the host country and may be subject to a higher LOF than "older" subsidiaries, probably more embedded in local social networks. This circumstance may limit their possibilities to cooperate for innovation with local partners or find suitable providers of technology in the host-country.

Location. The propensity of firms for external technology sourcing might also be influenced by their local environment (see, for example, Tödtling et al., 2012). Patent analyses suggest that subsidiaries are sensitive to localised spillovers of knowledge in their location strategy (Cantwell and Santangelo, 2002). This circumstance may influence the spatial patterns of technology sourcing of these firms, given the importance of physical proximity for cooperation for innovation and R&D outsourcing (Audretsch and Feldman, 1996). However, few articles on technology sourcing control for this variable.

In other cases, the association between location and cooperation for innovation is not statistically significant (Chun and Mun, 2012). We include regional dummies for the four main industrial areas in Spain: Madrid, Catalonia, Basque Country and Valencia. Here, we take into account the location of the main R&D facilities of the firms.

Sectors. Different sectors may have different propensities for external technology sourcing. Some evidence suggests that firms operating in high tech sectors are more likely to engage in cooperation for innovation (Molero et al., 2009, Schmidt, 2007; Segarra-Blasco and Arauzo-Carod, 2008). Those operating in scale intensive industries, as defined in Pavitt's taxonomy, seem less likely to cooperate for innovation than other firms (Carboni, 2010). The relationship between sectors and the decision to outsource R&D is less clear. Boehe

(2007) find that subsidiaries operating in the Brazilian electronics industries are more likely to engage in local R&D outsourcing than subsidiaries operating in other Brazilian industries. Schmiedeberg (2008), by contrast, concludes that the decision to cooperate or engage in R&D outsourcing depends on the characteristics of German firms, not on industries.

The PITEC survey provides sector information for an aggregation of the CNAE (the Spanish acronym for National Classification of Economic Activities) classification to 44 sectors. Based on this information we include industry dummies at this sectoral aggregation.

Appendix Table A1 provides a summary of our independent variables.

5. Results

Table 4 reports the results of the multivariate probit estimation. Estimations are reported with standard errors robust to clustering at the firm-level because we have pooled cross section data and thus repeated observations on individual firms.

The data reveal the presence of an interplay between different types of technology sourcing (see values of rho at the bottom of the table). Firms operating in Spain seem to use the four types of external technology sourcing analysed in this article and these mechanisms are not mutually exclusive.

In the domestic market, we find that foreign subsidiaries show a greater propensity for domestic cooperation for innovation and a smaller propensity for domestic R&D outsourcing compared to domestic affiliated firms. If we look at the coefficients for domestic unaffiliated firms, we also see that foreign subsidiaries are more likely than both kinds of domestic firms to engage in cooperation for innovation in the domestic market but less likely than them to undertake local outsourcing of R&D.

With regard to cooperation for innovation with international partners and R&D outsource offshoring, we find a different pattern. Compared to affiliated domestic companies, foreign subsidiaries have a lower propensity for both forms of international sourcing of technology. Compared to domestic unaffiliated firms, foreign subsidiaries show fairly similar propensity to engage in sourcing of technology with international partners or providers of technology.[7]

As for our other control variables, we find that larger firms and firms enjoying higher levels of R&D intensity show a higher propensity to engage in each of the four forms of external technology sourcing analysed here. Moreover, the number of patented inventions, productivity and exporting are also positively related to the propensity for each type of technology sourcing. Exporting seems to relate specifically to greater possibilities for interacting with international partners or suppliers of technology.

New firms are also more likely to engage in all forms of external technology sourcing, except R&D outsoucing offshoring. Finally, our results show that external technology sourcing is enhanced in industry agglomerations.

Some previous studies have found that the type of R&D in which the firm is engaged is related to its technology sourcing pattern. For example, Dachs et al. (2008) find that Austrian and Finn firms strongly engaged in basic R&D are more likely to cooperate for innovation probably because this exchange of information is far away from immediate application. By contrast, strong engagement in applied research could discourage cooperation, they argue, because knowledge may leak to a rival. As a robustness check we

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[7] So they show a somewhat higher propensity than unaffiliated domestic firms, the difference is not statistically significant for international cooperation and only marginally significant for R&D outsource offshoring.

have re-estimated our model controlling for firms' main type of R&D expenditure distinguishing between basic research, applied research and technological development.[8] Results are shown in Appendix Table 2 and confirm our main results regarding the role of foreign subsidiary status in technology sourcing. However, we find no evidence that companies strongly engaged in applied research tend to be reluctant to engage in cooperation for innovation owing to risks of free-riding (Dachs et al., 2008). In fact, our results indicate a greater propensity to cooperate internationally compared to firms that focus on basic research. The results also show a higher propensity for cooperation with local and international partners for firms that are mainly engaged in technological development. While most coefficients of other control variables remain stable, those for our location dummies experience change indicating that the type of R&D in which firms are involved is related to their location.

Our finding regarding foreign subsidiary status is different from that of Veugelers and Cassiman (2004) and (Knell and Srholec, 2006) who find a negative association between foreign status and domestic cooperation for innovation. Shrolec (2009), in contrast, does find a positive association. Note, however, that these studies compare foreign subsidiaries with all domestic firms regardless of whether they are affiliated or not. As for external technology sourcing from abroad, these studies find a positive association, but our results show that foreign subsidiaries cooperate and source R&D less in the international market compared to domestic groups and with no clear difference to domestic unaffiliated firms.

Our results also differ from Faria and Schmidt (2012) and Shrolec (2011) who control for domestic group status and foreign subsidiary group status and use domestic unaffiliated firms as control groups. The results in Faria and Schmidt (2012) indicate for Portugal, that

[8] Note, we include a dummy for firms that mainly spend on applied research, a dummy for firms that mainly spend on technological development, and a dummy for firms that have no single dominant type of R&D expenditure. Firms that mainly spend on basic research are the reference group. To control for firms that have no R&D expenditure, we further include a dummy variable taking on 1 if the company reports R&D expenditure.

foreign subsidiaries cooperate more than domestic firms in the international market but in the home market they cooperate less than domestic affiliated firms. This is similar to Shrolec (2011) where the results also indicate that foreign subsidiaries cooperate less than domestic affiliated firms in the domestic market, with particularly marked difference in Southern European and New EU Member countries.

A possible explanation for the willingness of foreign subsidiaries to establish greater cooperation for innovation with local partners in Spain compared to domestic affiliated firms and not in some of the countries previously studied may depend on the production structure of the host-countries. Spain has one of the most important subcontracting industries in the EU and foreign subsidiaries seem to be often involved in product subcontracting with local partners (Cámaras de Comercio, 2008; European-Commission, 2008; Holl et al., 2012). In R&D cooperation, each partner may act as a free rider (Dhont-Peltrault and Pfister, 2011); hence, the importance of a framework such as production subcontracting relationships for the joint-innovation, especially for foreign subsidiaries lacking social capital in the host-country. Other authors also point to a relationship between national industries characterised by subcontracting relationships and the potential for technological collaboration between partners (Love and Roper, 2009). In our sample, foreign subsidiaries seem to especially value cooperation for innovation with local suppliers. 30% of them declare that they cooperate with this type of partner versus only 5.4% of domestic firms (significant at 1%). Though we cannot put to test this proposition with the available data, the positive association of foreign status and local cooperation for innovation may be related, in our sample, to the engagement of foreign subsidiaries in subcontracting production networks with local suppliers.

By contrast, in our sample, foreign status is negatively associated with local R&D outsourcing. In other words, following Dhont -Peltrault and Pfister (2011), the foreign subsidiaries of our sample are relatively more willing than domestic groups to develop a technology or product with local partners. By contrast, they seem less willing than domestic firms to delegate these tasks to local partners. These preferences may be related to the respective characteristics of those arrangements. Cooperation for innovation is more likely to be selected when the firm enters a new market since products needs to be adapted to local tastes, a process often implying repeated interactions between firms (Dhont-Peltrault and Pfister, 2011). Since foreign subsidiaries often need to adapt their products to the host-country, they may be more interested in local cooperation for innovation than domestic firms. By contrast, companies are more likely to use R&D outsourcing for incremental innovation and standardized tasks (Beneito, 2006).

Concerning other control variables, our results support those of previous studies (Carboni, 2010; Chun and Mun, 2012; Lopez, 2008; Schmiedeberg, 2008; Segarra-Blasco and Arauzo-Carod, 2008) in that a large size predicts cooperation for innovation but not those of Hsuan and Mahnke (2011) which propose that small size predicts the adoption of R&D outsourcing. A large size, in our sample, is a predictor of all types of external technology sourcing. Our results differ from those of Schmiedeberg's (2008) who finds, for German firms, that internal R&D is more complementary to cooperation for innovation while the relationship is weaker concerning internal R&D and R&D outsourcing. We also find complementarities between R&D internal efforts and all forms of technology sourcing. Our results do not support the idea that R&D outsourcing is driven by the lack of in-house R&D and technical expertise (Teirlinck et al., 2010). In contrast to Schmiedeberg's results, in our sample, complementary is weaker for domestic cooperation for innovation.

Regarding our main research questions, we find that subsidiaries use local knowledge basically by implementing cooperation mechanisms with domestic partners. By contrast, their connections via local R&D outsourcing seem weaker than those of domestic firms. The latter, whether unaffiliated or pertaining to a group, show a greater propensity to source technology through domestic R&D outsourcing. This is an interesting finding since the linkages of foreign subsidiaries with the national innovation system of the host-county are often analysed exclusively from the perspective of cooperation for innovation. This approach, however, may overvalue the embeddedness of foreign subsidiaries and their potential to transfer technology to the local economy.

Domestic cooperation for innovation does not seem to require an especially important R&D endowment on the part of the focal firm, a circumstance which may limit the possibilities for transfers of technology from the subsidiary to its domestic partners. By contrast, foreign subsidiaries are less likely to take part in domestic R&D outsourcing, a form of local technology sourcing which seems especially suitable for R&D intense companies.

Domestic firms and foreign subsidiaries use different mechanisms for external technology sourcing. For the former, the structure more beneficial to profit from external knowledge is the group since pertaining to such an organization seems to facilitate the external sourcing of new ideas.

5. Conclusions

In this paper we draw on a large survey of companies in Spain to examine whether foreign subsidiaries engage in different patterns of technology sourcing compared to domestic companies.

Firms use different ways of incorporating technology and we distinguish in our analysis the sourcing of technology via R&D outsourcing and via cooperation for innovation both in the domestic and international markets. Our results confirm that there are significant complementarities between these different technology sourcing choices. We also find that the external technology sourcing via all four channels analysed is complementary to internal R&D efforts.

Regarding our main variable of interest, we find that foreign subsidiaries engage in a different pattern of technology sourcing. Specifically, we find that foreign subsidiaries show a smaller propensity for external technology sourcing via R&D outsourcing from independent firms in the domestic and international market compared to domestic affiliated firms. This is in contrast to their cooperation pattern. Here, they engage in greater domestic cooperation both compared to unaffiliated domestic firms as well as affiliated domestic firms and less international cooperation than domestic affiliated firms. Our analysis shows that even when controlling for structural differences between foreign subsidiaries and domestic firms, we observe significant differences. The finding that foreign subsidiaries engage in domestic cooperation for innovation to a greater extent than similar domestic firms does not support the LOF hypothesis.

This paper has presented results which open up several possible directions for future research. In our pooled cross section analysis we do not find support that the liability of foreignness limits the possibility of multinationals to network in host countries and host regions. However, longitudinal research should investigate how technology sourcing behaviour of subsidiaries changes over time as they increase their experience in a particular location. Maskel et al (2007) show how the motivations of firms to outsource in foreign lower cost locations may change with time. Further research also needs to pay attention to the emergence and growth of global value chains and the leading role of multinationals in those relations. From a policy point of view it would be important to stimulate the incorporation of subsidiaries into the national system of innovation as multinational networks provide a way to access international knowledge bases. Policies need to value the presence of competent domestic suppliers as a major factor of attraction for subsidiaries which are willing to network for innovation. Finally, in this study we have only analysed the incidence of technology sourcing but not the intensity of different sourcing relations and their impact on economic outcomes. This would be another interesting avenue for further research.

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Table 1. Technology sourcing via R&D outsourcing

	Domestic unaffilated firms		*Domestic groups*		*Foreign subsidiaries*		*t-test of means difference domestic groups versus foreign subsidiaries*	*sig.*
	No	*%*	*No*	*%*	*No*	*%*		
No R&D outsourcing	18.673	72,8	6.879	60,4	3.210	64,7	5,218	***
No external R&D sourcing	18.673	72,8	7.359	64,6	3.583	72,2	9,543	***
Only domestic external R&D outsourcing	6.324	24,6	3.323	29,2	1.080	21,8	9,841	***
Only foreign external R&D outsourcing	167	0,7	104	0,9	62	1,3	-1,975	**
Domestic and foreign external R&D outsourcing	501	2,0	602	5,3	235	4,7	1,462	
Total	25.665	100,0	11.388	100,0	4.960	100,0		

Note: *** significant at the 1% level; ** significant at the 5% level; *significant at the 10% level

Table 2. Technology sourcing via cooperation for innovation

	Domestic unaffilated firms		***Domestic groups***		***Foreign subsidiaries***		***t-test of means difference domestic groups versus foreign subsidiaries***	***sig.***
	No	***%***	***No***	***%***	***No***	***%***		
No cooperation for innovation	18.161	70,8	6.308	55,4	3.010	60,7	6,293	***
No external cooperation for innovation	19.033	74,2	7.109	62,4	3.192	64,4	2,349	***
Only external domestic cooperation for innovation	1.263	4,9	821	7,2	585	11,8	-9,639	***
Only external foreign cooperation for innovation	3.787	14,8	1.739	15,3	318	6,4	15,820	***
Domestic and foreign external cooperation for innovation	1.582	6,2	1.719	15,1	865	17,4	-3,779	***
Total	25.665	100,0	11.388	100,0	4.960	100,0		

Note: *** significant at the 1% level; ** significant at the 5% level; *significant at the 10% level

Table 3. Technology sourcing via a combination of R&D sourcing and cooperation for innovation

	Domestic unaffilated firms		Domestic groups		Foreign subsidiaries	
	No	%	No	%	No	%
Firms reporting any form of technology sourcing	10.377	40,4	5.959	52,3	2.320	46,8
Firms reporting more than one form of technology sourcing	4.170	16,2	3.144	27,6	1.239	25,0
domestic cooperation and domestic R&D sourcing	1.277	5,0	1.322	11,6	629	12,7
domestic cooperation and foreign R&D sourcing	169	0,7	304	2,7	168	3,4
foreign cooperation and foreign R&D sourcing	310	1,2	422	3,7	172	3,5
foreign cooperation and domestic R&D sourcing	2.762	10,8	2.067	18,2	663	13,4
domestic and foreign cooperation and R&D sourcing	111	0,4	240	2,1	121	2,4

Note: groups of combinations are note exclusive groups.

Table 4: Drivers of technology sourcing: multivariate probit regression.

	COOPDOM (1)	COOPINT (2)	OUTDOM (3)	OUTINT (4)
FSUB	0.193*** (0.040)	-0.184*** (0.041)	-0.285*** (0.039)	-0.152** (0.059)
UNAFF	-0.309*** (0.028)	-0.247*** (0.027)	-0.140*** (0.026)	-0.266*** (0.043)
SIZE	0.130*** (0.018)	0.094*** (0.019)	0.081*** (0.018)	0.163*** (0.045)
SIZE squared	-0.003*** (0.001)	-0.003*** (0.001)	-0.002*** (0.001)	-0.011** (0.005)
RDINTENS	0.301*** (0.054)	0.858*** (0.052)	0.868*** (0.051)	0.885*** (0.078)
PATNUM	0.015*** (0.004)	0.018*** (0.004)	0.014*** (0.005)	0.005** (0.002)
PROD	0.091*** (0.014)	0.021* (0.013)	0.100*** (0.012)	0.095*** (0.022)
EXPORT	0.147*** (0.028)	0.262*** (0.026)	0.220*** (0.024)	0.376*** (0.049)
NEW	0.152** (0.055)	0.171*** (0.051)	0.102** (0.048)	-0.008 (0.088)
Regional controls:				
Dummy Madrid	0.145*** (0.040)	0.194*** (0.037)	0.263*** (0.037)	0.158*** (0.061)
Dummy Catalonia	0.064** (0.032)	0.046 (0.031)	0.198*** (0.029)	0.238*** (0.045)
Dummy Basque Country	0.290*** (0.041)	0.509*** (0.039)	0.517*** (0.038)	0.146*** (0.060)
Dummy Valencia	0.139*** (0.044)	0.277*** (0.042)	0.483*** (0.039)	0.231*** (0.062)
ρ_{2k}	0.542*** (0.011)			
ρ_{3k}	0.240*** (0.012)	0.388*** (0.011)		
ρ_{4k}	0.213*** (0.019)	0.255*** (0.019)	0.450*** (0.016)	
Log likelihood		-63211.50		
Number of observations		41584		

Notes: (1) Standard errors robust to clustering at the firm level are presented in parenthesis; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) All estimations furthermore include 43 unreported sector dummies, year dummies and a constant. (3) Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: $\chi 2$ (6)= 7341.8,Prob>$\chi 2$=0.0000

Appendix Table A1. Survey variable description

Variable	Definition
FSUB	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain.
UNAFF	Dummy variable taking on 1 if the company does not belong to a company group.
DGROUP	Dummy variable taking on 1 if the company belongs to a group with its headquarters in Spain (=reference group).
SIZE	Total number of employees (in thousands)
SIZE squared	Total number of employees squared
RDINTENS	% of total R&D employees among total employees
RDEXPENS	Dummy variable taking on 1 if the company reports R&D expenditure.
INFUN	Dummy variable taking on 1 if the company's main R&D expenditure is dedicated to basic research (=reference group).
INAPL	Dummy variable taking on 1 if the company's main R&D expenditure is dedicated to applied research.
DESTEC	Dummy variable taking on 1 if the company's main R&D expenditure is dedicated to technological development.
NOMAIN	Dummy variable taking on 1 if the company reports no single main type of R&D expenditure.
PATNUM	Number of patents
PROD	ln(sales/employees)
EXPORT	Dummy variable taking on 1 if the company reports sales in international markets and 0 otherwise.
NEW	Dummy variable taking on 1 if the company was newly created between 2005-2009.
Dummy Madrid	R&D employment >0 in Madrid region
Dummy Catalonia	R&D employment >0 in Catalonia region
Dummy Basque Country	R&D employment >0 in Basque Country region
Dummy Valencia	R&D employment >0 in Valencia region

Appendix Table A2: with additional controls for main type of R&D

	COOPDOM (1)	COOPINT (2)	OUTDOM (3)	OUTINT (4)
FSUB	0.222***	-0.154***	-0.250***	-0.127**
	(0.040)	(0.041)	(0.039)	(0.059)
UNAFF	-0.297***	-0.234***	-0.119***	-0.254***
	(0.028)	(0.027)	(0.026)	(0.044)
SIZE	0.129***	0.091***	0.078***	0.168***
	(0.018)	(0.019)	(0.018)	(0.047)
SIZE squared	-0.003***	-0.003***	-0.002***	-0.011**
	(0.001)	(0.001)	(0.001)	(0.005)
RDINTENS	0.087	0.522***	0.455***	0.665***
	(0.058)	(0.053)	(0.050)	(0.082)
RDEXPENS	0.207**	0.354***	0.744***	0.459***
	(0.091)	(0.077)	(0.069)	(0.124)
INAPL	0.106	0.277***	0.042	0.027
	(0.087)	(0.072)	(0.064)	(0.109)
DESTEC	0.232***	0.289***	0.086	0.099
	(0.086)	(0.073)	(0.064)	(0.110)
NOMAIN	0.080	0.192**	-0.087	0.041
	(0.092)	(0.078)	(0.069)	(0.121)
PATNUM	0.014***	0.017***	0.012***	0.005**
	(0.003)	(0.004)	(0.004)	(0.002)
PROD	0.092***	0.021*	0.104***	0.098***
	(0.014)	(0.013)	(0.013)	(0.023)
EXPORT	0.122***	0.226***	0.175***	0.353***
	(0.028)	(0.027)	(0.025)	(0.050)
NEW	0.167***	0.195***	0.136***	0.004
	(0.055)	(0.051)	(0.048)	(0.087)
Regional controls:				
Dummy Madrid	0.001	-0.031	-0.019	0.009
	(0.042)	(0.039)	(0.038)	(0.062)
Dummy Catalonia	-0.090**	-0.195***	-0.109***	0.073
	(0.036)	(0.033)	(0.032)	(0.048)
Dummy Basque Country	0.144***	0.279***	0.228***	-0.007
	(0.043)	(0.041)	(0.039)	(0.061)
Dummy Valencia	-0.013	0.038	0.176***	0.071
	(0.046)	(0.044)	(0.041)	(0.063)
ρ_{2k}	0.534***			
	(0.011)			
ρ_{3k}	0.219***	0.359***		
	(0.012)	(0.011)		
ρ_{4k}	0.197***	0.233***	0.434***	
	(0.019)	(0.019)	(0.017)	
Log likelihood		-62149.56		
Number of observations		41584		

Notes: (1) Standard errors robust to clustering at the firm level are presented in parenthesis; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) All estimations furthermore include 43 unreported sector dummies, year dummies and a constant. (3) Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: $\chi2$ (6)= 6531.6,Prob>$\chi2$=0.0000