Foreign subsidiaries and technology sourcing in Spain

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30. October 2012

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This version: October 2013

Abstract. Firms acquire external technological knowledge via different channels. In this paper we compare the technology sourcing of foreign subsidiaries and domestic firms looking at domestic R&D outsourcing, international R&D outsourcing, domestic cooperation for innovation and international cooperation for innovation. We use data from the Spanish Technological Innovation Panel (PITEC) for the years 2005-2009 for 10,206 innovative firms operating in Spain. 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 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 international R&D outsourcing, and for international cooperation for innovation. In contrast, foreign subsidiaries show a greater propensity for domestic cooperation for innovation. However, foreign subsidiaries are not a homogenous group in this respect.

Keywords: Multinational enterprises, foreign subsidiaries, R&D outsourcing, cooperation for innovation.

[1] We gratefully acknowledge the financial support of the Spanish Ministry of Science and Innovation (ECO2010-17485). We are also grateful to anonymous referees for their helpful comments and suggestions on an earlier version of this paper.
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1. Introduction

In today's fast-paced, knowledge-intensive 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 to economic growth, there is still relatively little knowledge on the patterns of technology sourcing and the mechanisms underlying technology transfer at the firm level.

There is now a growing body of literature that focuses on the determinants of cooperation for innovation (see, for example Veugelers & Cassiman, 2004; Knell & Shrolec, 2006; Shrolec, 2009 and 2011). There is also some literature on the external sourcing of R&D services (see, for example, García-Vega and Huergo, 2011; Veugelers and Cassiman, 2004; Veugelers and Cassiman, 1999; Jabbour and Zuniga, 2009). These two bodies of literature have, however, largely developed separately. Recent exceptions in this regard are studies that analyse both cooperation for innovation as well as the external sourcing of R&D (Dhont-Peltrault & Pfister, 2011; Ebersberger et al., 2011; Schmiedeberg, 2008; Vega-Jurado et al., 2009). But with the exception of the pan-European study by Ebersberger et al. (2011), they do not distinguish between domestic and international open innovation. More importantly, these studies do not analyse the *simultaneous decisions* of the firm to engage in different types of technology sourcing. To the best of our knowledge, there are no studies that jointly analyse the decision of the subsidiary to cooperate for innovation and outsource R&D in the domestic and international markets. We will argue that there may be important complementarities between these sources of technology.

We aim particularly at understanding how foreign subsidiary status may be related to different patterns of technology sourcing. 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 & Cassiman, 2004). Consequently, many countries attempt to attract foreign direct investment (FDI), with the expectation that foreign multinational enterprises will provide skills and new technology that will ultimately enhance the competitiveness of domestic firms. However, foreign MNEs may become enclaves within a host-country economy, rarely establishing external ties with domestic firms or the rest of the national innovation system (UNCTAD, 2001). This may cause a "branch plant syndrome" (Phelps, 1993).

A variety of reasons may explain why foreign subsidiaries do or do not establish local R&D linkages in a specific host country. Multiple embeddedness implies that companies balance embeddedness in the host-country and embeddedness in the multinational network (Meyer et al., 2011). As a MNE pursues globally integrated strategies, its subsidiaries are more likely to exploit the location advantages of host-countries in order to complement the existing advantages of the firm (Cantwell, 2004). However, building relationships with partners who are willing to transmit knowledge requires the development of mutual trust (Hitt et al., 2002). According to the transaction cost school, certain forms of entry may help firms minimise net transaction costs in a new market. The specific mandate of a foreign subsidiary in a host country may also affect its level of local embeddedness (Cantwell & Mudambi, 2005).

Understanding the patterns of technology sourcing of foreign subsidiaries in the host-country is a particularly pressing task for those countries which are not at the forefront of sciences and technologies, and may potentially profit from the presence of foreign subsidiaries. We further contend that foreign subsidiaries may behave differently according to the specific channel of technology sourcing; hence, the need to study their patterns of R&D service outsourcing and their patterns of cooperation for innovation in the domestic and international market simultaneously.

Most evidence on the R&D behaviour of MNEs is based on results for highly industrialised countries, a circumstance which may limit our understanding of these firms' technology sourcing (Boehe, 2007). Models dealing with differences in the cooperative behaviour of foreign subsidiaries and domestic firms chiefly analyse technology leader countries (see, for instance, Ebersberger & Herstad, 2012; Schmiedeberg, 2008); thus, their results may not be generalisable to other countries. The pan European study by Ebersberger et al. (2011) actually finds that foreign subsidiaries adopt a different cooperative behaviour in different host countries, for instance, in technology leader countries, such as the Scandinavian countries, and in high income, low R&D countries, such as Spain. Therefore, detailed studies on a non technology leader country, such as Spain, can help to complement the picture. In addition, Spain is also one of the largest receivers of FDI in the European Union (EU)(UNCTAD, 2011).

The rest of this paper is organized as follows. Section 2 presents the literature which informed our research. In Section 3, we describe the data set we use and present some descriptive results. Section 4 presents the econometric model. A discussion of the main results follows in Section 5. Section 6 concludes.

2. Literature review and research questions

Technology is becoming increasingly complex, multi-disciplinary and dynamic. This means that developing all necessary technological know-how internally is increasingly costly. To cope with this situation and stay competitive, firms rely on necessary knowledge from institutions and other firms. 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). This has also brought with it a rise in international R&D sourcing and international collaboration for innovation (Abramovsky et al., 2008).

Innovation in multinationals has traditionally been concentrated in their headquarters, but is now increasingly dispersed among their subsidiaries (Dunning & Lundan, 2009). MNEs source technology in a 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 the technology development of the national innovation system (Edler, 2008). However, the technology sourcing behaviour of foreign subsidiaries, and especially the degree of their local embeddedness in a host country could be negatively influenced by the degree of embeddedness in their corporate network.[2] Foreign subsidiaries might find the resources they need within the multinational network, limiting their local involvement. Pointing to double embeddedness, however, other authors argue that a trade-off between both types of embeddedness is not necessarily the norm (Almeida, 2004; Andersson et al., 2002; Boehe, 2007). The different levels of capabilities at home and in the host country seem to play some role in the internationalisation of corporate R&D. Patterns of technological specialisation within industries across countries may explain FDI R&D (Cantwell & Kosmopoulou, 2009), eventually contributing to the presence of local R&D linkages in certain countries and not in others.

Foreign subsidiaries, however, may find it difficult to cooperate for innovation with domestic partners. High transaction costs in the host-country could limit their ability to network (Nachum & Keeble, 2003), since they may lack the social capital which facilitates networking

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2 We thank one anonymous referee for drawing our attention to this point.

and joint-innovation (Hitt et al., 2002). These analyses suggest that the transaction costs of establishing external relationships may be higher for foreign subsidiaries than for domestic firms, limiting their willingness to source locally. As stated, the form of entry selected by the MNE may mitigate those problems. The acquisition of a well linked domestic firm or a joint-venture with a local partner may help the foreign subsidiary to expand its social capital and engage in local collaboration.

Empirical research has not yet provided a clear answer to the question of whether foreign subsidiaries are able to source technology through local linkages similar to those of domestic firms. Some studies use patent analysis to proxy foreign subsidiaries' local sourcing (see, for instance, Almeida, 2004;Álvarez & Cantwell, 2011). With the publication of the Community Innovation Surveys (CIS) of the EU, other studies have been able to focus more specifically on foreign subsidiaries' patterns of cooperation for innovation (Cassiman & Veugelers, 2006; Ebersberger et al., 2011; Lööf, 2009; Molero et al., 2009; Veugelers & Cassiman, 2004). Most of them find that cooperation for innovation with external partners is positively related to foreign status. However, the evidence is not conclusive. In Southern Europe or transition European countries, foreign subsidiaries may be less likely to engage in external cooperation than domestic firms or, at least, than domestic unaffiliated firms (Molero & Heijs, 2002; Srholec, 2011). In other cases, foreign subsidiaries are less likely than domestic firms to engage in *local* cooperation for innovation (Knell & Srholec, 2006). Ebersberger and Herstad (2012), comparing Norwegian MNEs and foreign subsidiaries operating in Norway, find that the latter are less likely to engage in local cooperation for innovation. They conclude that eventual "branch plant syndrome" in host-countries may be attributable to foreign status rather than to multinationality "per se". Ebersberger et al. (2011), in their pan European study, find a positive effect of foreign ownership status on international cooperation for innovation but a negative effect on domestic cooperation. This suggests that in foreign subsidiaries, openness to international partners may come at the expense of domestic embeddedness. Regarding the external sourcing of R&D by foreign subsidiaries, Ebersberger et al. (2011) find a positive effect of foreign subsidiary status. Veugelers and Cassiman (2004) and García-Vega & Huergo (2011) show that foreign subsidiaries have a greater propensity for international R&D outsourcing. Jabbour & Zuniga (2009) find that foreign subsidiaries source R&D less domestically and more internationally compared to domestic firms.

Previous studies have shown mixed results regarding the role of foreign 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 differences in technology sourcing even though we focus on technology sourcing from partners outside the own group (see, for example, Molero & Heijs, 2002; Dach & Ebersberger, 2009). 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, and therefore may be better able 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 the 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 & Heijs, 2002; Segarra-Blasco & Arauzo-Carod, 2008; Teirlinck et al., 2010).

Comparisons between foreign subsidiaries and domestic firms may also be distorted given the presence of technological leadership in the industry. In the literature, the role of the technological leadership of foreign subsidiaries in the host country is controversial. MNEs which are technological laggards in a specific sector may seek to augment their capabilities by internationalising their R&D (Cantwell & Janne, 1999). In contrast, Berry (2006) finds that Japanese MNEs investing in foreign R&D laboratories tend to be technologically leading firms compared to their domestic competitors. On the other hand, in some countries, technologically leading domestic firms may secure the most suitable domestic partners for R&D collaboration (Álvarez & Cantwell, 2011; Cantwell & Mudambi, 2011). According to these studies, this may indirectly limit the possibilities of local partnerships for foreign subsidiaries and, hence, reduce their embeddedness in the host country. However, in less advanced host-countries foreign subsidiaries may tend to be technological leaders and domestic firms may tend to be technological laggards. Therefore, technological leadership in the local industry needs to be taken into account when comparing foreign subsidiaries and domestic firms.

In this paper we study two mechanisms that firms can use to acquire knowledge externally.[3] First, we study R&D outsourcing, which includes either the acquisition of R&D services through arm's length contracts or through subcontracting relationships, meaning that tasks 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. Dhont-Peltrault and Pfister (2011), for example, find that French firms may use each of these mechanisms for a different technological purpose. We argue that these different channels of technology sourcing do not exclude each other, since firms are likely to make joint decisions regarding their adoption. Our main research questions are: 1) Do foreign subsidiaries show a different pattern of external technology sourcing than comparable domestic firms? 2) Are foreign

[3] Refers to technology sourcing from sources external to the firm and its entrepreneurial group.

subsidiaries able to build local cooperation networks similar to those of comparable domestic firms? The above discussion also suggests that within the host-country foreign subsidiaries are not a homogeneous group. Therefore, we will also inquire whether the mandate from or the relationships of these firms with their respective multinational networks affect their technology sourcing patterns.

3. Data and some descriptive results

Our data come from the Spanish Technological Innovation Panel (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 2005-2009.[4] Note, however, that only innovation active firms were asked questions related to their cooperation behaviour. Thus, the sample for our empirical analysis is restricted to innovative active firms. These are firms that have introduced new products or new processes or that have ongoing innovative activities or that have abandoned innovative activities during the two years prior to the survey date. In total, we have over 41,000 observations for 10,206 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. In our sample, 11.7% of all companies are foreign subsidiaries. The data do not allow us to identify their modes of entry or to correctly identify native MNEs. It should be stressed that our inquiry is thus about foreign status, not multinationality.

4 We use the freely available data set that has been anonymized through microaggregation. For more details see López (2011).

Table 1 shows the percentage of firms that report R&D outsourcing from partners outside the own group among domestic unaffiliated companies, domestic affiliated firms, and foreign subsidiaries. We distinguish between those firms with internal R&D expenditure and those firms that have no internal R&D, two groups displaying different behaviour. As shown by Table 1 and Table 2, the latter are more frequently engaged in external R&D sourcing, whatever the type of company. However, the percentage of foreign subsidiaries with external R&D outsourcing is below 40%, which is lower than the percentage for domestic affiliated companies, with about 47% reporting R&D outsourcing from independent companies. Table 1 also shows that domestic firms rely to a greater extent on domestic R&D outsourcing. Table 2 shows the respective numbers for cooperation for innovation. About 45% of the sample foreign subsidiaries as well as the domestic groups with internal R&D engage in external cooperation for innovation. However, foreign subsidiaries engage to a greater degree in domestic cooperation compared to both domestic groups and domestic unaffiliated firms.

In our sample, we also observe that firms combine the different technology sourcing channels. Approximately 40% of domestic unaffiliated firms and approximately 53% of domestic affiliated and foreign subsidiary firms that are engaged in some form of technology sourcing actually report using more than one channel.

4. Econometric model

We are interested in whether foreign subsidiaries in their host country show differences in their technology sourcing behaviour in comparison to "comparable" domestic firms. The simple comparisons in Tables 1 and 2 indicate some differences. These observed differences could, however, be due to differences in other firm characteristics apart from foreign subsidiary status. Thus, in what follows we explore the importance of foreign subsidiary status in a multivariate probit regression which includes the most important control variables suggested by the literature.

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. We use a multivariate probit (MV) specification to identify specific drivers of each type of technology sourcing. This approach takes 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 (Chib and Greenberg, 1998). The MV approach allows us to test for the possibility of complementarities regarding the adoption of the four different channels of external technology sourcing.

Channels can be considered as complementary when the equations defining them are significantly and positively associated. This is in line with the adoption approach as, for example, in Cassiman and Veugelers (2006).

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

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[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 applied, for example, by Belderbos et al. (2004), Lenz-Cesar and Heshmati (2012), Schmidt (2008) and Carboni (2013).

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 a foreign subsidiary and 0 otherwise.

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.

Group. A different technology sourcing behaviour of foreign subsidiaries might not be due to foreign ownership *per se*, but rather to the fact that these 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. In our specification we include a dummy for unaffiliated companies and use domestic affiliated companies as our reference group. As stated, with the available data we do not know whether the domestic group network is national or international. However, it should be noted that Spain has very few native MNEs (12 in Fortune Global 500 as compared to 140 US MNEs). 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 Srholec (2011).

Leaders and laggards. Since firms commonly engage in networking to gain access to new technology and skills, the literature assumes that weaker contenders may not be considered worthwhile partners (Pittaway et al., 2004). Consequently, laggard firms may find fewer opportunities to engage in R&D networks. Foreign subsidiaries may be more likely to be leaders, and domestic firms, laggards – at least in some home countries. In this case, the distinction between foreign subsidiaries and domestic firms may be picking-up a leader-laggard distinction and not a foreign-domestic one. Therefore, we control for leader and laggard status at sector level. We operationalise this control variable following Berry's (2006) methodology.

Other control variables: We control for firm size (number of employees and in squared terms to allow for possible non-linearities). We also include the number of patents granted to a firm. The use of formal means of protection was, for example, associated with cooperation in Finland but not in Austria (Dachs et al., 2008). Further, we include a dummy for exporters. Exporters may need to tap into different sources of knowledge in order to stay competitive in international markets. Their presence in those markets may also facilitate their access to international sources of technology. In the case of Spain, exporters seem more likely than non exporters to engage in international R&D outsourcing (García-Vega & Huergo, 2011). Firms may need some time to create reliable and effective collaborative linkages with external partners. PITEC provides information on whether or not a company was newly created during the year of the survey or the two years previous. With this information we create a dummy variable indicating whether the firm was newly created between 2003 and 2009.[6]

Finally, all estimations include controls for location, sector, and year dummies. We include regional dummies for the four main industrial areas in Spain: Madrid, Catalonia, the Basque Country and Valencia, the remaining areas serving as reference group. The regional dummies are based on the location of the firms' R&D facilities. In addition, we include industry dummies based on the sector aggregation provided in PITEC, which is an aggregation of the

[6] Note that PITEC only provides the age of companies since the 2009 wave of the survey and thus only for those companies that responded to this wave.

CNAE (the Spanish acronym for National Classification of Economic Activities) classification of 44 sectors.

Appendix Table A1 provides a summary description of our variables and summary statistics. Appendix Table A2 shows the correlation matrix.

5. Results

5.1. Main results

Table 3 shows 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.[7]

The data shows the presence of interdependence between the different types of technology sourcing strategies. *Rho*, the correlation coefficient between the residuals of each of the probits, is significantly different from zero (bottom of the table) indicating that the multivariate probit model is more appropriate than separate univariate probits. For comparison we have also estimated individual univariate probits. Coefficient estimates are very similar. Logically enough, calculation of separate univariate probits do not provide information on the possible statistical association of different channels. As mentioned, a substantial proportion of the sample firms combine more than one channel. Whatever the location of partners, cooperation and outsourcing are always positively and significantly associated, indicating complementarities.[8] Our results suggest that firms operating in Spain use the four types of external technology sourcing analysed in this article and that these

[7] Alternatively, we have also estimated the multivariate probits for separate waves of the survey. Results are qualitatively unchanged and available upon request.

[8] The positive correlation could, however, also be driven by common omitted factors. The multivariate probit approach cannot distinguish these two possible sources for the observed correlation.

mechanisms are not mutually exclusive. Instead, these practices are clearly interdependent at the company level.

In the domestic market, we find that foreign subsidiaries show a greater propensity for cooperation for innovation and a smaller propensity for 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 even more likely than both kinds of domestic firms to engage in cooperation for innovation in the domestic market. What is also noteworthy is that, compared to affiliated domestic companies, foreign subsidiaries have a lower propensity for both forms of international sourcing of technology.

Confirming findings of the organisation and network literature, laggards are always less able to engage in open innovation than other firms operating in the same sector (Ahuja, 2000; Pittaway et al., 2004). Leadership, by contrast, seems to facilitate involvement in domestic and international networks. Only in the case of domestic cooperation for innovation do we find no significantly higher propensity to cooperate for leaders. Here we observe a similar propensity for firms in the middle ranges.

As for our other control variables, we find that larger firms show a higher propensity to engage in each of the four forms of external technology sourcing analysed here. These results support those of previous studies (Carboni, 2013; Chun & Mun, 2011; Ebersberger et al., 2011; Lopez, 2008; Schmiedeberg, 2008; Segarra-Blasco & Arauzo-Carod, 2008), in that a large size predicts cooperation for innovation, but not those of Hsuan and Mahnke (2011), who find that small size predicts the adoption of R&D outsourcing. Moreover, both the number of patented inventions 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 international R&D outsoucing.

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. Ebersberger et al (2011) also find a negative effect of foreign status in "high income, low R&D countries"; a category including Spain. Srholec (2009), in contrast, does find a positive association. Note, however, that the estimations in these studies compare foreign subsidiaries with all domestic firms regardless of whether they are affiliated or not.[9]

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 have only a higher propensity compared to 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. Their results indicate that foreign subsidiaries cooperate more than domestic firms in the international market but in the host market they cooperate less than domestic affiliated firms.

A possible explanation for the willingness of foreign subsidiaries to establish greater cooperation for innovation with local partners compared to domestic affiliated firms in Spain 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 often be involved in product subcontracting with local partners (Cámaras de Comercio, 2008; EUROSTAT, 2008; Holl et al., 2012). In R&D cooperation, each partner may act as a free rider (Dhont-Peltrault & Pfister, 2011), hence, the

[9] Ebersberger et al. (2011) study the effect of domestic multinationality in separate estimations and find a positive effect for both domestic and international cooperation for innovation.

importance of a framework such as production subcontracting relationships for 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 & Roper, 2009). In our sample, foreign subsidiaries seem to especially value cooperation for innovation with local suppliers. Twenty percent of them declare that they cooperate with this type of partner versus only 3.3% of domestic firms (significant at 1%). Foreign subsidiaries also cooperate more with local clients, compared to domestic firms (4.9% of foreign subsidiaries versus 0.8% of domestic firms, significant at 1%). In contrast, they cooperate with local private R&D laboratories to a lesser extent than domestic firms do (14.8% versus 17.4, significant at 1%). Though we cannot put this proposition to test 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.

In contrast, in our sample, foreign subsidiary 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. However, 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 need to be adapted to local tastes, a process often involving repeated interactions between firms. 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. In contrast, companies are more likely to use R&D outsourcing for incremental innovation and standardized tasks (Beneito, 2006).

Regarding our main research questions, we find that foreign subsidiaries use local knowledge basically by implementing cooperation mechanisms with domestic partners. Yet, their connections via local R&D outsourcing seem weaker than those of comparable domestic firms.

5.2. Heterogeneity in foreign subsidiary technology sourcing

So far we have compared foreign subsidiaries to domestic affiliated and unaffiliated firms. Foreign subsidiaries are, however, themselves not a homogeneous group. Their respective mandates may affect their sourcing behaviour (Álvarez & Cantwell, 2011)[10] The literature characterises the activities of foreign MNEs aimed at adapting products to local markets as knowledge exploiting and those aimed at acquiring new knowledge, for instance through access of the public research base of the host-country, as knowledge augmenting (Edler, 2008; Kuemmerle, 1999). The local embeddedness of foreign subsidiaries may therefore depend on their specific mandate in the host country (Cantwell & Mudambi, 2005). Previous studies have found that the type of R&D in which the firm is engaged may point to the nature of its mandate and, in turn, to its technology sourcing strategy. According to Cantwell and Mudambi (2005), knowledge augmenting activities, which are more complex, are mainly driven by needs of technological creativity, while knowledge exploiting activities are mainly driven by needs of technological adaptation to local tastes. In the UK, they contend, foreign subsidiaries with a knowledge augmenting mandate are more likely to be locally embedded. On the other hand, the division of labour between parents and subsidiaries "has been frequently described as basic research being pursued in the former and applied research or adaptation in the latter" (Bellak, 2004 , p 500). We interpret this as suggestive that basic research is not among the usual roles of most foreign subsidiaries; an emphasis on it, as compared to other firms operating in the same sector, may point to the presence of

[10] We thank two anonymous referees for drawing our attention to this point.

knowledge augmenting activities in the foreign subsidiaries. By the same token, an emphasis on technological development may point to knowledge exploiting activities.

In Table 4 we present estimation results where we have subdivided the group of foreign subsidiaries according to the characteristics of their internal R&D expenditure. The dummy variables indicate whether, as compared to the mean of its OECD sector[11], a given foreign subsidiary carries out a larger percentage of its R&D in fundamental research, applied research, technology development, in two of the R&D types, or if it has no internal R&D expenses (see Table A1 for variable definition). Our result that foreign subsidiaries have a greater propensity to cooperate in the domestic market is confirmed for all types of foreign subsidiaries, with the only exception being those subsidiaries with no internal R&D. These subsidiaries, which account for slightly over a third of all subsidiaries in our sample, are not significantly different from affiliated domestic firms regarding domestic cooperation (Table 4). In contrast, our results indicate that the foreign subsidiaries which are more willing to cooperate for innovation with local partners are competence creating foreign subsidiaries. However, this is a small group, accounting for only approximately 2% of foreign subsidiaries in our sample. Our results provide support to Álvarez & Cantwell‘s (2011) findings in that competence creating foreign subsidiaries that operate in Spain seem especially prone to cooperate with external agents. This is also reflected in their greater propensity for international cooperation compared to domestic firms. In general, it seems that the lower propensity of foreign subsidiaries to engage in international cooperation, as well as domestic and international outsourcing of R&D, as observed in Table 3, is mainly driven by those foreign subsidiaries with no internal R&D expenditure and, to a lesser degree, by those which

[11] We classified the manufacturing industries in which the plants operate into three groups according to the R&D intensity (average R&D/turnover) of the industry. In doing so we used the OECD classification, which establishes the following cut-off points for average R&D/turnover: 0.9%; 3%; and 5%. The cut-off points define low, medium, and medium high and high technology industries.

are knowledge exploiting ones. Only a minority of the foreign subsidiaries, notably competence creating subsidiaries, has a greater propensity to establish cooperation linkages with external international partners compared to domestic firms. This is an important consideration since policy makers often have in mind the alleged potential of foreign subsidiaries for connecting the host-country to international networks of knowledge.

As stated, some authors claim that there may be a trade-off between the local embeddedness of the subsidiary and its embeddedness in the corporate network.

In some unreported estimations we have proxied the embeddedness of the subsidiary in the corporate network by the importance attributed to the own company and company group in the innovation process. These estimations confirm our main result that foreign subsidiaries cooperate more than domestic firms in the domestic market, but also indicate that local embeddedness is stronger for those subsidiaries that rely only weakly on the corporate network in their innovation process. However, PITEC displays clear limitations to operationalise embeddedness in the multinational network, as the questionnaire does not distinguish between the importance of the own company and the importance of the corporate network in the innovation process. Moreover, the degree of embeddedness of a subsidiary may also depend to some extent on the nature of the embeddedness of all other subsidiaries in the MNE network. Unfortunately, the PITEC data does not provide information on other than Spanish host locations. Thus, we cannot explore this concept of multiple embeddedness and the trade-off's that multinationals might seek in local sourcing in different host countries (Meyer et al., 2011).

6. 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 than 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 indicate that there are significant interdependencies between these different technology sourcing choices. Cooperation for innovation and R&D service outsourcing are both important instruments to acquire external technological knowledge, and firms simultaneously combine knowledge from these different external sources in their innovation strategy. The joint empirical consideration of these different sources is a contribution of our study.

Regarding our main variable of interest, we find that foreign subsidiaries engage in a different pattern of technology sourcing. Specifically, we find that they 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 than both unaffiliated and affiliated domestic firms and less international cooperation than domestic affiliated firms. 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.

Our results also suggest the need to investigate differences within the group of foreign subsidiaries concerning their propensities to source technology locally. This is another contribution of our article, as most previous studies do not discriminate between different types of foreign subsidiaries when comparing them to domestic firms; this is an important consideration given the current competition between host-countries to attract high quality FDI. Further research should provide more evidence on technology sourcing patterns of different types of foreign subsidiaries and how such sub-groups compare to domestic firms.

However, our research is not without limitations. The available data did not allow us to consider licensing, an important form of technology sourcing (Contractor, 1981), nor the forms of entry selected by foreign subsidiaries or the multiple embeddedness of these firms at the international level. All are potentially important determinants of the technology sourcing pattern of these companies.

Further research also needs to pay attention to the emergence and growth of global value chains and the leading role of multinationals in them. Our preliminary results about the importance of relationships within the value chain for foreign subsidiaries engaged in local technology sourcing point in this direction.

From a policy point of view it would be important to stimulate the incorporation of foreign subsidiaries into the national system of innovation as multinational networks may provide a way to access international knowledge bases. However, affiliated domestic firms seem as capable as foreign subsidiaries in linking the host country to external international partners. This finding seems to suggest different possibilities for policies pursuing an opening of the host country to international networks of knowledge. Policies also need to value the presence of competent domestic suppliers as a major factor of attraction for foreign 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. Better knowledge on those issues would also be important both from an academic point of view as well as for policy makers.

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Table 1. External technology sourcing via R&D outsourcing [1]

	Domestic unaffilated firms		***Domestic groups***		***Foreign subsidiaries***		***t-test of means difference domestic groups versus foreign subsidiaries sig.***	
	% *With internal R&D*	% *Without internal R&D*	% *With internal R&D*	% *Without internal R&D*	% *With internal R&D*	% *Without internal R&D*	*With internal R&D*	*Without internal R&D*
No external R&D outourcing	65.0	89.1	53.4	90.4	60.8	91.9	-7.045***	1.781*
Only domestic external R&D outsourcing	31.5	10.3	38.1	8.7	30.3	7.1	7.629***	1.996**
Only foreign external R&D outsourcing	0.8	0.3	1.1	0.5	1.7	0.5	-2.612***	-0.028
Domestic and foreign external R&D outsourcing	2.7	0.3	7.4	0.4	7.1	0.5	0.518	-0.533
Total number of observations	17,305	8,217	7,825	3,366	3,110	1,761		

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

(1) Refers to sources external to the firm and its entrepreneurial group

Table 2. External technology sourcing via cooperation for innovation (1)

	Domestic unaffilated firms		***Domestic groups***		***Foreign subsidiaries***		***t-test of means difference domestic groups versus foreign subsidiaries sig.***	
	% *With internal R&D*	% *Without internal R&D*	% *With internal R&D*	% *Without internal R&D*	% *With internal R&D*	% *Without internal R&D*	*With internal R&D*	*Without internal R&D*
No external cooperation for innovation	68.9	85.2	54.8	80.0	54.8	81.1	0.041	0.954
Only external domestic cooperation for innovation	4.5	5.6	6.2	9.5	11.4	12.3	-9.301***	-3.057***
Only external foreign cooperation for innovation	18.3	7.4	19.1	6.7	8.8	2.3	13.284***	6.807***
Domestic and foreign external cooperation for innovation	8.3	1.8	19.9	3.8	25.0	4.3	-5.754***	-0.946
Total number of observations	17,305	8,217	7,825	3,366	3,110	1,761		

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

(1) Refers to sources external to the firm and its entrepreneurial group

Table 3: Drivers of technology sourcing: multivariate probit regression.

	COOPDOM (1)	COOPINT (2)	OUTDOM (3)	OUTINT (4)
FSUB	0.235***	-0.144***	-0.228***	-0.105*
	(0.040)	(0.041)	(0.039)	(0.058)
UNAFF	-0.328***	-0.249***	-0.161***	-0.285***
	(0.028)	(0.027)	(0.025)	(0.044)
LEADER	-0.037	0.159***	0.113***	0.121***
	(0.028)	(0.025)	(0.024)	(0.042)
LAGGARD	-0.398***	-0.634***	-0.800***	-0.579***
	(0.035)	(0.033)	(0.032)	(0.061)
SIZE	0.121***	0.082***	0.068***	0.144***
	(0.018)	(0.019)	(0.017)	(0.044)
SIZE squared	-0.003***	-0.002***	-0.002***	-0.010**
	(0.001)	(0.001)	(0.001)	(0.005)
PATNUM	0.015***	0.017***	0.012***	0.005**
	(0.004)	(0.004)	(0.005)	(0.002)
EXPORT	0.146***	0.228***	0.205***	0.370***
	(0.028)	(0.026)	(0.024)	(0.049)
NEW	0.151***	0.250***	0.140***	0.056
	(0.054)	(0.050)	(0.046)	(0.087)
ρ_{2k}	0.605***			
	(0.011)			
ρ_{3k}	0.256***	0.411***		
	(0.013)	(0.011)		
ρ_{4k}	0.226***	0.259***	0.487***	
	(0.022)	(0.020)	(0.018)	
Log likelihood		-62016.8		
Number of observations		41584		

Notes: (1) Standard errors robust to clustering at the firm level are presented in parentheses; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) All estimations include 4 unreported regional dummies and 43 unreported sector dummies, year dummies and a constant. (3) Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: $\chi 2$ (6)= 7650.8,Prob>$\chi 2$=0.0000

Table 4: Foreign subsidiaries' mandate and technology sourcing

	COOPDOM (1)	COOPINT (2)	OUTDOM (3)	OUTINT (4)
FSUB_fundamental	0.737***	0.464***	-0.064	-0.357
	(0.178)	(0.179)	(0.154)	(0.242)
FSUB_applied	0.315***	-0.118*	-0.235***	-0.137*
	(0.064)	(0.062)	(0.060)	(0.084)
FSUB_development	0.251***	-0.072	-0.183***	-0.031
	(0.060)	(0.063)	(0.058)	(0.079)
FSUB_twotypes	0.627***	0.273**	0.085	0.077
	(0.105)	(0.109)	(0.099)	(0.134)
FSUB_no internal R&D	0.029	-0.443***	-0.373***	-0.219**
	(0.059)	(0.069)	(0.072)	(0.111)
UNAFF	-0.331***	-0.252***	-0.162***	-0.287***
	(0.028)	(0.027)	(0.025)	(0.044)
LEADER	-0.023	0.173***	0.120***	0.126***
	(0.028)	(0.026)	(0.025)	(0.043)
LAGGARD	-0.352***	-0.585***	-0.776***	-0.557***
	(0.036)	(0.034)	(0.033)	(0.065)
SIZE	0.122***	0.082***	0.068***	0.141***
	(0.018)	(0.019)	(0.017)	(0.044)
SIZE squared	-0.003***	-0.002***	-0.002***	-0.010**
	(0.001)	(0.001)	(0.001)	(0.005)
PATNUM	0.015***	0.017***	0.012***	0.005**
	(0.003)	(0.004)	(0.005)	(0.002)
EXPORT	0.151***	0.233***	0.207***	0.371***
	(0.028)	(0.026)	(0.024)	(0.049)
NEW	0.150***	0.248***	0.139***	0.054
	(0.054)	(0.050)	(0.046)	(0.087)
ρ_{2k}	0.603***			
	(0.011)			
ρ_{3k}	0.255***	0.409***		
	(0.013)	(0.011)		
ρ_{4k}	0.226***	0.228***	0.487***	
	(0.022)	(0.020)	(0.018)	
Log likelihood		-61948.7		
Number of observations		41584		

Notes: (1) Standard errors robust to clustering at the firm level are presented in parentheses; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) All estimations include 4 unreported regional dummies and 43 unreported sector dummies, year dummies and a constant. (3) Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: $\chi2$ (6)= 7603.4,Prob>$\chi2$=0.0000

Appendix Table A1. Survey variable description

Variable	Definition	Mean	Stdv.
FSUB	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain.	0.117	0.322
UNAFF	Dummy variable taking on 1 if the company does not belong to a company group.	0.614	0.487
DGROUP	Dummy variable taking on 1 if the company belongs to a group with its headquarters in Spain (=reference group).	0.269	0.444
LEADER	Dummy variable taking on 1 if the company is in the top quartile in terms of the number of R&D employees per total sales in its respective technology sector* and year.	0.319	0.466
LAGGARD	Dummy variable taking on 1 if the company is in the bottom quartile in terms of the number of R&D employees per total sales in its respective technology sector* and year.	0.324	0.468
SIZE	Total number of employees (in thousands)	0.263	1.304
SIZE squared	Total number of employees squared	1.769	35.686
PATNUM	Number of patents	0.619	6.706
EXPORT	Dummy variable taking on 1 if the company reports sales in international markets and 0 otherwise.	0.657	0.475
NEW	Dummy variable taking on 1 if the company was newly created between 2003-2009.	0.052	0.221
FSUB_fundamental	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain and dedicates a greater percentage of its internal R&D expenditures to fundamental research compared to its technology sector* mean.	0.002	0.045
FSUB_applied	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain and dedicates a greater percentage of its internal R&D expenditures to applied research compared to its technology sector* mean.	0.031	0.174
FSUB_development	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain and dedicates a greater percentage of its internal R&D expenditures to technological development compared to its technology sector* mean.	0.034	0.182
FSUB_twotypes	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain and dedicates a greater percentage of its internal R&D expenditures in two of the above groups compared to its technology sector* mean.	0.007	0.084
FSUB_no internal R&D	Dummy variable taking on 1 if the company belongs to a group with its headquarters outside Spain and reports no internal R&D expenditure.	0.042	0.201

Note: (*) Manufacturing: OECD classification of industries by percentage of R&D expenditure in total turnover: Low Technology Intensity, Medium Low Technology Intensity, and Medium High and High technology Intensity. Services: EUROSTAT classification: High-Tech Services, Low tech Services and Other Services.

Appendix Table A2. Correlation matrix

	FSUB	UNAFF	DGROUP	LEADER	LAGGARD	SIZE	SIZE Squared	PATNUM	EXPORT	NEW	FSUB_ fundamental	FSUB_ applied	FSUB_ development	FSUB_ twotypes	FSUB_no internal R&D
FSUB	1														
UNAFF	-0.459	1													
DGROUP	-0.221	-0.765	1												
LEADER	-0.152	0.177	-0.084	1											
LAGGARD	0.040	-0.003	-0.026	-0.474	1										
SIZE	0.101	-0.175	0.120	-0.068	0.020	1									
SIZEsquared	0.029	-0.058	0.043	-0.008	0.007	0.860	1								
PATNUM	0.034	-0.050	0.030	0.004	-0.052	0.042	0.007	1							
EXPORT	0.153	-0.118	0.019	-0.028	-0.152	-0.014	-0.015	0.045	1						
NEW	-0.057	0.053	-0.017	0.150	-0.057	-0.039	-0.011	0.002	-0.109	1					
FSUB_fundamental	0.124	-0.057	-0.027	-0.006	-0.030	0.002	-0.002	0.003	0.025	-0.006	1				
FSUB_applied	0.494	-0.227	-0.109	-0.042	-0.116	0.026	-0.003	0.019	0.093	-0.026	-0.008	1			
FSUB_development	0.518	-0.238	-0.115	-0.052	-0.122	0.059	0.016	0.053	0.099	-0.025	-0.009	-0.034	1		
FSUB_twotypes	0.231	-0.106	-0.051	-0.034	-0.055	0.020	-0.002	0.017	0.047	-0.011	-0.004	-0.015	-0.016	1	
FSUB_no internal R&D	0.577	-0.265	-0.128	-0.144	0.304	0.076	0.034	-0.017	0.049	-0.039	-0.010	-0.038	-0.040	-0.018	1