

Paper no. 2014/05

Collaboration in innovation between foreign subsidiaries and local universities: evidence from Spain

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This is a pre-print version of a paper that has been submitted for publication to a journal.

This version: May 2014

WP 2014/05

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Keywords: collaboration in innovation, FDI, foreign subsidiaries, global innovation networks, multinational companies, open innovation, spillovers, university-industry collaboration

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1. Introduction

It has long been stressed that the innovative performance of firms is related to their capacity to access external knowledge and integrate it with internal knowledge (Steensma, 1996; Teece, 1986). Among the wide variety of formal and informal mechanisms to link with external sources of knowledge (Hagedoorn et al., 2000), firms may opt for collaboration in innovation with their suppliers, customers and competitors, as well as with public research institutes and universities. With regard to the latter, which forms the focus of this paper, recent empirical research across a broad range of European countries has found a positive relationship between firms' openness towards the science system and innovation outcomes like sales from new products (Ebersberger et al., 2011).

In addition, as globalization proceeds and the complexity and speed of technological change intensify, firms often need to link with international sources of knowledge to remain competitive. Multinational companies (MNC) can establish such global linkages through their subsidiaries abroad, which represent a vehicle for reverse technology transfer from distant sources of knowledge. In particular, several recent studies have found that the aim to collaborate with universities abroad constitutes one of the main drivers of the internationalization of business R&D (Abramowsky et al., 2007; OECD, 2011; Thursby and Thursby, 2006). Enhancing these global-local, university-industry knowledge interfaces is not only of relevance for the innovation strategies of MNCs, but also for national/regional policymakers who aim at maximizing knowledge spillovers associated with foreign direct investment (FDI) (D'Este et al., 2013).

The objective of this paper is to explore how MNC subsidiaries collaborate in innovation with local universities, addressing the scale and scope of such collaborations, and their evolution over time. Although there is a rich body of literature analyzing university-industry collaboration in innovation, it has been only very recently that some studies have

analyzed empirically the interactions between foreign subsidiaries and local universities (Britto et al., 2013; Broström et al., 2009; Chaves et al., 2013; Herstad et al., 2013). The international business literature has traditionally focused on measuring the spillovers deriving from linkages between foreign subsidiaries and local firms, leaving linkages with universities relatively underexplored (Meyer and Sinani, 2009; Nell and Andersson, 2012). Conversely, research and innovation studies have widely analyzed university-industry links, but rarely differentiate between domestically-owned and foreign-owned firms. Against this background, the general objective of this paper is to provide a more integrative and nuanced perspective of collaboration between foreign subsidiaries and local universities.

The empirical contribution of this paper consists on new evidence from Spain combining quantitative and qualitative methods and building on different sources of information. During the last decades, and especially since Spain joined the European Union in 1986, MNCs have played a critical role in the diversification and restructuring of the country's economy, as well as in shaping its national innovation system. More recently, several MNCs have established new R&D sites in areas where Spain has built technological strengths, such as renewable energies, civil engineering, or the aerospace industry, among others¹. However, Spain's below-average performance in science and technology is characteristic of a 'moderate innovator' within the European Union (European Commission, 2011). Moreover, Spanish firms exhibit a low propensity to collaborate in innovation (including with universities) compared with firms from other European countries, as evidenced in the Community Innovation Survey data published by Eurostat. The innovation performance of Spain is likely to shrink further following severe cuts in the budget for public universities and R&D from 2009 to 2014, as part of the country's fiscal consolidation plan. In

¹ According to the FDI Markets database from 2003-2010 a total of 71 new R&D centres were located by foreign firms in Spain, making for an estimated 5,437 new jobs and 1.1 USD billion investment (on average, 77 jobs and 15.6 USD million per investment project). The FDI Markets database is compiled by Financial Times Group and comprises only greenfield FDI project announcements, excluding mergers and acquisitions.

this context, public-private partnerships and international sources of finance are becoming of ever-greater importance in Spain's innovation system (Santamaría et al., 2013). For these reasons, Spain constitutes an interesting empirical setting for the purposes of our research.

The remainder of this paper is organized as follows. Section 2 discusses further the theoretical framework, research questions and contributions of this paper to the literature. Section 3 explains the methodology and Section 4 presents the results for the three complementary empirical studies conducted in Spain. To conclude, Section 5 summarizes the main findings and implications for theory and policy.

2. Theory and research questions

2.1. Localized collaboration in innovation within global innovation networks

The transition from a closed to an 'open innovation' model (Chesbrough, 2003) implies that corporate innovation strategies increasingly rely on external sources of knowledge. In addition to other informal channels, firms access external knowledge mainly through contracting and collaboration with other firms and organizations (Fey and Birkinshaw, 2005). Contracting refers to the acquisition of knowledge to a third party on a market basis while collaboration, which is the focus of this paper, involves deeper interactions between two or more organizations to share and co-produce knowledge. The OECD Oslo Manual - and hence Eurostat in the Community Innovation Surveys (CIS) - defines collaboration in innovation as "joint innovation projects" involving "active participation – and knowledge or technology transfer – for all partners" (OECD, 2005). This is a somehow narrow definition of collaboration that focuses on development work excluding other innovative activities such as training, explorative activities where only information is transmitted, and R&D outsourcing (Herstad et al., 2014).

In parallel to open innovation and the rise of collaboration, a complementary trend is the increasing globalization of corporate innovation (Narula and Zanfei, 2004). While

multinational companies still tend to concentrate their R&D and innovation centers close to headquarters, recent empirical evidence suggests that innovation is evolving from a centralized and hierarchical function of global value chains towards one that builds upon a network of geographically dispersed R&D centers (OECD, 2011). Through R&D internationalization, MNCs aim at tapping into resources and capabilities from multiple local contexts in order to integrate and leverage them into competitive advantages (Meyer *et al.*, 2011). According to Blanc and Sierra (1999), the process of R&D internationalization can be interpreted as a trade-off between external and internal proximity. The search for external proximity involves scanning and absorbing foreign knowledge by connecting with a diverse set of external actors. But this should not come at the expense of the firm's organizational coherence, thus the need to simultaneously search for internal corporate proximity. Foreign subsidiaries represent a conduit for combining internal (to the MNC) and external (local) knowledge.

In sum, business innovation is simultaneously becoming more open and more global, such that large MNCs increasingly rely on collaboration in innovation with a variety of firms and universities from different countries through complex network relationships. The notion of 'global innovation networks' has emerged to refer to these internationally dispersed corporate R&D centers and their external collaboration partners (Chaminade, 2009; European Commission, 2013). The advent of global innovation networks opens up new windows of opportunity for foreign subsidiaries (and for host countries), which become more likely to engage in innovative activities if the appropriate conditions are in place (Narula and Guimón, 2010).

2.2. Multinational subsidiary mandates and local embeddedness

In Dunning's eclectic paradigm firms may invest in foreign locations not only to exploit their 'ownership advantages' but also to access 'location-specific advantages' that can be

internalized by the firm in order to enlarge its knowledge base (Dunning, 1980). Kuemmerle (1999) distinguished between ‘knowledge-augmenting’ and ‘knowledge-exploiting’ strategies behind FDI, and several studies have suggested a growing relevance of the former (Blanc and Sierra, 1999; Carlsson, 2006; Granstrand, 1999). From the perspective of MNC subsidiaries, this translates into the distinction between ‘competence-exploiting’ and ‘competence-creating’ mandates, with the latter involving the creation of new knowledge and the former focusing on the exploitation of the MNC’s existing technology in new countries (Cantwell and Mudambi, 2005). This strand of the literature is useful to highlight the point that spillover effects of FDI on host economies are not automatic and homogeneous across locations, but rather highly dependent on the scope of foreign subsidiaries’ mandates (Marin and Bell, 2010).

Research analyzing the evolution of MNC subsidiaries indicates that the adoption of competence-creating mandates is driven by the dynamic interplay between headquarter strategies, subsidiary capabilities, and host country advantages (Benito et al., 2003; Cantwell and Mudambi, 2005). Competence-creating subsidiaries often need access to highly skilled engineers and scientists, and actively seek to draw inputs from local sources of knowledge, including local firms and universities. In contrast, competence-exploiting subsidiaries will tend to exhibit weak linkages with the national innovation system, since they already hold the knowledge they need to develop their local business through their multinational network. As a subsidiary embraces a competence-creating mandate, the variety of external sources of knowledge that it relies upon will tend to increase. Indeed, recent research has provided evidence of a co-evolution between the scope of a subsidiary’s mandate and the extent of its regional embeddedness (Heidenreich, 2012; Nell and Andersson, 2012).

The few empirical studies comparing the propensity of foreign subsidiaries and local firms to collaborate in innovation with local partners remain far from conclusive: while some

find that foreign subsidiaries are more prone than local firms to engage in local collaboration, others find the opposite relationship (Ebersberger et al., 2011; Herstad et al., 2010; Holl and Rama, 2014). The results are not only influenced by the nature of foreign subsidiaries' mandates, but also by the characteristics of local firms and by the methodology used in the comparative analysis.

2.3. Research questions

Our review of the literature was useful to frame the two main research questions addressed in the empirical study. First, we aim at determining whether foreign ownership influences the propensity of firms to collaborate with universities, controlling for other factors. According to Yusuf (2007, p. 17), MNCs have a higher propensity to collaborate with universities than local firms since they “have the information, the finances, the organizational capacity to manage a multifaceted research program, and the commitment to routinized innovation that can induce technology links with universities”. However the few empirical studies that have addressed this question show very mixed results (Britto et al., 2013; Chaves et al., 2013; Ebersberger et al., 2011), pointing to a large heterogeneity across host countries and firms. Indeed, it seems logical to expect that the results will differ depending on the host country's technological endowments, and as a result of the ‘cumulativeness’ and ‘path dependency’ underlying the strategic orientation of foreign subsidiaries (Benito et al., 2003; Cantwell and Mudambi, 2005). Thus the interest of providing new evidence from a technologically intermediate country like Spain.

Second, we aim at exploring further the different motivations and mechanisms driving collaboration in innovation between foreign subsidiaries and local universities. Previous studies have found that the most important motivations for firms (in general) to collaborate in innovation with universities are to access complementary resources and skills; to reduce costs; to gain access to public funding; and other strategic, longer-term reasons like keeping track

with major technological developments (Caloghirou et al., 2001; Carayol, 2003). In the specific case of foreign subsidiaries, in addition to these generic motivations, the extent and scope of collaboration with local universities will also be determined by their headquarter strategies and by intra-corporate competition among the MNC's network of subsidiaries in different countries. As argued earlier, competence-creating subsidiaries are especially prone to strengthening their linkages with local universities as a mechanism for absorbing localized sources of knowledge.

Therefore, collaboration between foreign subsidiaries and local universities needs to be analyzed from a dynamic perspective, in relation with the evolution of subsidiary mandates in global innovation networks. Moreover, although our focus is on collaboration agreements, it is important to stress that there are other modes of technology sourcing such as subcontracting or informal networking which are closely interdependent (Holl and Rama, 2014; Perkmann and Walsh, 2007). A foreign subsidiary may establish simultaneously different types of linkages with one or several universities, and these relationships evolve over time (Broström et al., 2009). For instance, university-industry cooperation may start with cooperation in training and later evolve towards collaboration in research.

3. Data and methodology

The research design encompassed three complementary empirical studies in Spain, combining quantitative and qualitative research methods, and relying on different primary and secondary sources of data. The 'triangulation' of methods and sources may enable a 'convergent validation' of some research findings (Opperman, 2000) and allows to better connect the micro and macro perspectives. We found this methodological approach most appropriate for an exploratory analysis of collaboration in innovation between foreign subsidiaries and Spanish universities; a relatively recent phenomenon that has received little attention in the existing literature.

The first study focused on comparing the propensity of foreign subsidiaries to collaborate with universities with the propensity observed in local firms. We used panel data from the Community Innovation Survey (CIS), available in Spain from the Technological Innovation Panel database (Panel de Innovación Tecnológica, PITEC), collected by the Spanish National Statistics Institute (INE). Our panel for the period 2005 to 2011 comprised 9,614 Spanish firms out of which 1,171 were foreign subsidiaries. Among many different questions to capture firms' structural characteristics and innovative behavior, the CIS includes a question on whether or not the firm has collaborated with universities in innovation during the last two years. This provides the basis for a probit model to compare the propensity to collaborate with universities of foreign subsidiaries and local firms, controlling for other factors. The CIS has been widely used as a basis for empirical research as it represents a very powerful tool to analyze the innovative behavior of European firms and, in particular, their collaboration with other actors. However, it has several limitations and does not allow for a deeper understanding of the motivations, impacts and modes of collaboration (Wunsch-Vincent, 2012). Thus, for the purposes of our research we found it necessary to complement it with other primary sources.

The second study builds upon a new survey to explore further the scale and scope of collaboration in innovation between foreign subsidiaries and Spanish universities, with 89 valid replies. We cannot ensure that this is a subset of the previous study's sample because CIS data is anonymized, but it is very likely given the firms' characteristics and the sampling methods used in the CIS. This survey was conducted in 2011 by a team of researchers including the first author of this paper, and was commissioned by Invest in Spain, the national investment promotion agency. The survey was also supported by the Spanish regional governments, which were asked for assistance in sending the questionnaire to at least ten innovative foreign subsidiaries located in their regions. The survey was sent to around 300

firms, so the response rate was around 30 percent. In any case, the sample is not random and thus should not be taken as representative of the general population of foreign subsidiaries in Spain but rather of the most innovative among them. This decision to focus on the most innovative subsidiaries can be characterized as ‘extreme case sampling’ (Patton, 1990) and has the advantage of allowing us to concentrate on competence-creating subsidiaries.

Finally, the third study involved a deeper analysis of five case studies of foreign subsidiaries that collaborate extensively in innovation with Spanish universities. Following a first screening the case studies were selected based on their capacity to address our research questions. The case studies were developed through desk research and semi-structured interviews with the R&D directors of each of these subsidiaries. The interviews lasted one hour on average and were structured around a short, open questionnaire covering two dimensions: (1) evolution of the subsidiary’s R&D activities in Spain, and (2) evolution of collaboration with Spanish universities. The case study methodology was necessary to analyze the complexity of MNC-university collaboration from a dynamic perspective, in relation with the evolution of subsidiary mandates.

4. Results

4.1. Probit model with CIS data

Our panel from the Spanish CIS covers the period 2005-2011 and comprises only innovation active firms, defined as those that declare innovation expenditure, or product or process innovation, in at least one year of the period 2005-2011. This leads to a total of 9,614 firms and 64,705 observations over a seven-year period. All firms report data in at least four years.

In order to isolate properly the effect of foreign ownership, rather than comparing foreign subsidiaries with all other local firms, we distinguished between local firms that belong to a group and those that are not affiliated to a group, in line with recent empirical studies dealing with similar comparisons (Dachs and Peters 2014; Hall and Rama, 2014).

Foreign subsidiaries are defined as those belonging to a group headquartered in a different country. Local group firms are those that belong to a group headquartered in Spain, including the headquarter and any local affiliates. Finally, unaffiliated firms are those that do not belong to a company group.

On a straight comparative analysis, we found that foreign subsidiaries exhibit a lower propensity to collaborate with Spanish universities than local group firms do, while both collectives collaborate more often with universities than unaffiliated local firms (see Figure 1). However, this aggregate result should be interpreted with caution given the presence of other moderating factors that influence firms' collaborative behavior.

**** FIGURE 1 HERE ****

To better analyze differences in collaboration propensities with local universities between foreign subsidiaries and comparable local firms, we estimated a random-effects probit regression for panel data relating the probability of collaboration with the fact of being a foreign subsidiary and controlling for other variables. Table 1 summarizes the variables used in the model and provides descriptive statistics for each group of firms. Our dependent variable takes the value 1 if the firm collaborates with one or several Spanish universities, and 0 otherwise. Besides considering foreign ownership and group affiliation, we control for firm size, sector of activity, and other factors typically used in empirical studies to model firms' propensity to collaborate with universities (Caloghirou et al., 2001; Ebersberger et al., 2011; Miotti and Sachwald, 2003). These include several variables to assess firms' research and innovation strategies (expenditure in innovation, performance of basic research, access to public R&D funding, intellectual property protection) and other variables related to human capital (expenditure in training and percentage of highly educated employees). We also include a binary variable to measure whether the firm collaborates in innovation with other type of partners besides universities, since previous studies have found that collaboration with

universities is highly influenced by the firm's wider collaboration networks (Carboni, 2013; Faems et al., 2005).

Thus, the estimation equation is set as follows:

$$Pr(C_{it} = 1) = f\left(\alpha + \mu_i + \delta_t + \gamma Fsub_{it} + \rho Unaff_{it} + \sum_{k=1}^K \beta_k x_{it,k} + \sum_{s=1}^S \theta_s y_{it,s}\right) \quad (1)$$

where C_{it} is a dummy variable indicating if firm i collaborates with a local university at time t ; $Fsub_{it}$ and $Unaff_{it}$ specify whether the firm is either a foreign subsidiary or an unaffiliated firm, respectively; $x_{it,k}$, for $k = 1, \dots, 8$ are control variables defined in Table 1); and, finally, $y_{it,s}$, for $s = 1, \dots, 43$, are dummy variables for each sector of activity, following the NACE classification system. Equation (1) is estimated with a random-effects probit regression. μ_i and δ_t are, respectively, individual and time effects, and α is a constant. γ , β_k (for $k = 1, \dots, 8$) and θ_s (for $s = 1, \dots, 43$) are the coefficients associated with the explanatory variables of the model. Given the nature of our research questions, we are primarily interested in testing the relevance of the estimations for coefficient γ .

**** TABLE 1 HERE ****

The results show a negative but not-significant relation between collaboration propensity with local universities and the fact of being a foreign subsidiary (Table 2). On the contrary, being an unaffiliated firm is negatively related with collaboration propensity. These results suggest that a higher propensity to collaborate with universities is associated with group membership, regardless of foreign ownership.

**** TABLE 2 HERE ****

The results of control variable coefficients give an unsurprising description of the firm typically collaborating with local universities: an affiliated firm, often large, with high

innovation and training expenditure, doing basic research and protecting its intellectual property, receiving public funds for R&D, and almost surely collaborating with partners other than local universities. In different estimations not reported here, we examined the relative importance of the independent variables in the three groups of firms under analysis, with the aim of exploring possible differences in the factors that drive collaboration with universities, but failed to find any significant differences².

Following the estimation of the model for the whole sample, we performed different estimations for a set of more homogeneous subsamples based on sector of activity and firm size (Table 3). The results show relevant differences between foreign subsidiaries and local group firms in the propensity to collaborate with universities for specific groups of firms. In particular, we found a positive and significantly higher propensity to collaborate (with local universities) for foreign subsidiaries in the following sectors: Manufacture of medical instruments, games and toys, musical instruments, etc.; Transport, warehousing and support activities for transportation; and Administrative and support services.

Small and medium sized (SME) foreign subsidiaries have a higher propensity to collaborate with local universities in high-technology sectors (Pharmaceutical products, and Computer, electronic and optical products), and in Administrative and support services. In the case of large firms, this positive relation was found in Manufacture of basic metals, Manufacture of motor vehicles, and Legal and accounting activities, advertising and market research, architectural and engineering activities, etc.

On the contrary, foreign subsidiaries exhibit a significantly lower propensity to collaborate with local universities in the sector of Food, beverages and tobacco products, regardless the size of the firm. In the case of Pharmaceutical products, it is interesting to note that large foreign subsidiaries show a lower propensity to collaborate, while the opposite is

² The detailed results are available from the authors upon request.

true in the case of SMEs. In the sector of Manufacture of machinery and equipment, Computer programming, consultancy and related activities, and Financial and insurance services, and auxiliary activities, foreign subsidiaries also showed a lower propensity.

**** TABLE 3 HERE ****

4.2. New survey to foreign subsidiaries

This survey focused on competence-creating subsidiaries and was used to explore their motivations to collaborate in innovation with Spanish universities. Table 4 summarizes the sample characteristics. We obtained 89 valid responses. With regard to entry modes, the sample is evenly distributed between greenfield investments and mergers and acquisitions (M&A). Geographically, the firms' headquarter is most often located in other EU countries followed by the US. By year of establishment, almost 60 percent of the sampled firms had arrived to Spain before 1990.

**** TABLE 4 HERE ****

All sampled firms were intensively engaged in R&D activities in Spain with an average R&D expenditure equivalent to 9.3 percent of their sales. Ninety-two percent collaborate in innovation with external partners and 70 percent collaborate with one or several universities located in Spain (68.5 percent of firms) or in foreign countries (21.4 percent).

Firms were asked to list their collaboration agreements with universities since their establishment in Spain. The results suggest that collaboration in innovation with universities took-off in the early 2000s from a relatively low base and accelerated substantially since 2005 (Figure 2). Overall, the 89 foreign subsidiaries in the sample reported 83 formal collaboration agreements with local universities, out of which 48 percent were signed from 2006 to 2010. Considering the distribution of the sample by year of establishment, the average number of collaboration agreements per firm increased from 0.2 in the late 1980s to 0.9 by 2010.

**** FIGURE 2 HERE ****

To address our second research question, in the survey firms were asked to rate the different motivations to collaborate with universities identified in Section 2.3. Besides the general drivers of university-industry collaboration, we included an additional reason (“to improve the subsidiary’s position within the MNC network”) to reflect a subsidiary-specific motivation. The assumption is that foreign subsidiaries that aim at upgrading their mandates to become competence-creating subsidiaries within global innovation networks will find the need to strengthen linkages with local universities. The results reported in Figure 3 reveal that the most important motivations for foreign subsidiaries to engage in collaboration are to gain access to complementary knowledge, and because of strategic, long-term reasons. However, all of the motivations considered were rated relatively high, on a range from 2.75 to 4.01 in a scale from 0 (not important) to 5 (very important), meaning that cost reduction, improving the position of the subsidiary within the global network of the MNC, and the capacity to access public funding and incentives, are also significant factors driving foreign subsidiaries to collaborate with local universities.

**** FIGURE 3 HERE ****

An additional question was included to better assess the impact of public incentives on the subsidiaries’ decisions to collaborate with universities. In 58 percent of the firms, R&D collaboration originated from a joint application to public funding programs (either from regional, national or European programs). Out of those that received public funding, 79 percent stated that collaboration would not have taken place in the absence of such incentives, suggesting a strong ‘behavioral additionality’ effect of R&D grants (Cunningham and Gök, 2012).

In sum, these results point to a wide variety of motivations driving foreign subsidiaries to collaborate with universities in Spain, suggesting a combination of knowledge-seeking and

efficiency-seeking strategies. In the following section we explore in further detail the motivations to collaborate through the use of case studies.

4.3. Case studies

The five case studies comprise foreign subsidiaries that host significant R&D centers in Spain and collaborate extensively with universities. In all of them collaboration with universities has intensified substantially during the last decade, which is coherent with the previous survey's results. Table 5 summarizes these case studies with particular attention to the evolution of the subsidiaries' R&D mandates and the dynamics of collaboration with universities.

**** TABLE 5 HERE ****

The cases of HP, 3M and ThyssenKrupp were useful to illustrate how the propensity of foreign subsidiaries to collaborate with local universities and the scope of such collaborations have evolved in parallel with the sequential upgrading of the subsidiaries towards competence-creating mandates within their MNC global networks. Several of the R&D managers that we interviewed argued that the capacity of a subsidiary to collaborate efficiently with local universities was a critical ingredient for upgrading in corporate value chains, suggesting that foreign subsidiaries that strive to become centers of excellence should attempt to improve their linkages with local universities. In the words of one of the interviewees:

During the last few years we have undergone a fast transition towards an open innovation model, leading to a much stronger collaboration in R&D with Spanish universities, technology centers and local firms (...) In order to retain and expand our R&D mandate, we need to build a deep network of local R&D partners to bring in complementary knowledge and capabilities. This is something which is becoming ever more important in the minds of senior headquarter managers that evaluate our results and future potential.

The dynamics of subsidiaries' collaboration with universities was also influenced by the development of national technological capabilities. For example, the operations of 3M in Spain initially focussed on the manufacturing and commercialization of abrasive products for

households and industry, but in recent years the company has engaged in new R&D activities in the fields of renewable energies and infrastructure in response to Spain's increasing reputation in these areas. Collaboration with universities intensified as the subsidiary engaged in this new knowledge-seeking mandate, in addition to its former knowledge-exploiting operations. For instance, since the mid-2000s the company entered into a collaboration agreement with the Institute of Solar Energy of the Polytechnic University of Madrid, an internationally leading centre in this area. This has attracted the attention of 3M headquarters, which considers it a strategic collaboration within its global innovation network.

Indeed, the case studies were useful to illustrate how, besides the determinants of initial location, each R&D centre has its own dynamics and can progressively upgrade and adopt new roles within the global R&D network of its parent company, building on the establishment of collaboration agreements with local universities.

As discussed in Section 2.3, in order to understand the dynamics of foreign subsidiaries' collaboration with universities it is important to consider the interdependencies with other modes of university-subsidiary linkages such as subcontracting, technology services, cooperation in training, or informal networking. In particular, many of the case studies suggested that collaboration in innovation was closely connected to collaboration in training. For example, HP has developed training programs with the University of León and with the Polytechnic University of Catalonia whereby students work in R&D projects with joint supervision of HP managers and university professors. Many of these students were later hired by HP or by its network of subcontractors, underscoring the importance of collaboration with universities as a tool for attracting talent and providing training to future employees. Subsequently, the company initiated closer collaborative R&D projects with the university professors involved in these programs.

Similar examples were observed in other case studies like 3M and ThyssenKrupp, suggesting again a sequential path from collaboration in education and training with a focus on recruitment, towards a stronger focus on joint R&D projects. Indeed, collaboration in education and training sometimes acts as a seed which may later lead to collaboration in R&D, although the interaction is more complex because advanced training and R&D are closely intertwined activities.

Although in most cases collaboration in innovation with universities occurred sequentially as the companies upgraded their R&D mandates, in the case of Yahoo! the R&D center was born out of collaboration with a university. In 2006 the company established in Spain its first R&D center in Europe within the premises of the University Pompeu Fabra in Barcelona. Location within the university premises offered Yahoo! significant advantages such as access to equipment and infrastructure, as well as administrative support in the management of EU-funded projects. The R&D director of Yahoo! Spain refers to this as ‘research hosting’, whereby the university hosts the R&D activity of an MNC providing incentives in the form of office space, equipment, support services, etc., as well as the capacity to build linkages with university researchers and an attractive environment for its employees.

Beyond knowledge-seeking motivations, in some cases collaboration with local universities was mainly driven by the aim to access public funding, since most of the available R&D funding schemes (from the central government, the regional governments, and the EU) focus on funding research consortia. Besides bilateral agreements between the subsidiaries and Spanish universities, collaboration often occurs within the context of wider EU-funded research projects.

For example, Atos hosts in Madrid its main global R&D center, from where it coordinates the company’s participation in around 100 EU-funded research projects. Along

the way Atos has forged an increasing number of collaboration agreements with Spanish universities. In some cases, following the first collaborative consortia, collaborations with specific Spanish universities have become closer through the preparation of new proposals and the joint participation in subsequent projects. In addition to collaboration with universities in R&D projects, in recent years the company has also intensified its support to education activities, for example by launching in 2011 the so-called IT Challenge competition in collaboration with five Spanish universities, targeted to university students who present innovative IT project proposals.

Through these case studies we found further evidence in support of the behavioral additionality effect of public funding which was discussed in Section 4.2. In addition, we also found evidence of a ‘signaling effect’ within the MNC global innovation network. In the words of one of the interviewees:

Obtaining public funding for R&D projects is beneficial not only because of the funds per se, but also because of the signal effect they create (...) receiving incentives is a recognition of the project’s quality and relevance, and this contributes to attracting attention and commitment of additional resources from our headquarter office.

Despite the methodological limitations associated with case studies and the necessary caution in any attempt to generalize the results, this part of our research enabled us to deepen our understanding of the motivations and modes of collaboration between foreign subsidiaries and universities, complementing our previous empirical results with new qualitative insights.

4. Concluding remarks

This paper has contributed both theoretically and empirically to an emerging strand of research on collaboration between foreign subsidiaries and local universities, providing new evidence from an intermediate country like Spain. The econometric analysis failed to find significant differences between the propensity to collaborate with universities of foreign subsidiaries and Spanish firms, after controlling for other factors. It was only after estimating

the model for individual industries that we were able to find some relevant differences, pointing to the large heterogeneity across sectors. Building upon this result, future studies could use collaboration with universities as a proxy for identifying specific sectors where the behavior of foreign subsidiaries tends to be more knowledge-seeking versus those where a knowledge-exploiting strategy prevails.

Subsequently, we complemented the econometric study with a survey and a set of case studies, which were particularly useful to understand the complex motivations behind foreign subsidiaries' collaborations with universities, and their evolution over time in parallel with the sequential upgrading of the subsidiaries' R&D mandates in global innovation networks. Our research has revealed a wide variety of motivations and modes of collaboration, including a combination of knowledge-seeking and efficiency-seeking strategies. The latter relate to using universities as a conduit for reverse technology transfer in areas where Spain exhibits technological advantages, while the former is associated with the aim to reduce costs and with the access to public funding.

From a policy perspective, collaboration between foreign subsidiaries and local universities represents as a powerful mechanism for better linking countries/regions with the dynamics of global innovation networks. Thus policy efforts aimed merely at attracting more FDI should be accompanied with measures to induce the technological behavior of foreign subsidiaries, and in particular their propensity to collaborate with local universities (Guimón and Filippov, 2012; Mytelka and Barclay, 2004). The collaborative relation between foreign subsidiaries and local universities is positive for the national innovation system to the extent that it creates channels for mutual learning and allows local universities to establish new linkages with global knowledge pipelines. In some instances, however, collaboration between foreign subsidiaries and local universities might be detrimental to local firms, leading to a

crowding out effect whereby the best university research groups end up working for foreign subsidiaries or whereby foreign subsidiaries gain a larger share of available public funding.

Despite our efforts to combine different methods and sources of information, it is important to acknowledge here a number of limitations of this paper. First, we relied on data from a single country: Spain. Thus, the replication and elaboration of our research in other settings would be useful. In addition, given the exploratory and multi-method nature of this paper, we decided to present only the most relevant results from the three studies, at the expense of losing some detail and depth in the analysis of each individual study. Moreover, as already discussed above, the data we have relied upon has its limitations. In particular, it is worth stressing that the sample size of the survey presented in the second study is relatively small, and that we did not use a control group of local firms with similar characteristics that could have enabled us to draw better conclusions from this survey. Moreover, as is often the case in this kind of studies, our quantitative analysis may suffer from omitted variables and reverse causality.

More importantly, future research would benefit from a more comprehensive comparative analysis of collaboration with other partners besides universities, such as suppliers, customers and competitors. Furthermore, our focus on analysing the drivers of collaboration from the firm perspective could be broadened in future studies by considering more explicitly the university perspective. In particular, collaboration with foreign subsidiaries can be interpreted as a dimension of the so-called ‘global model’ of research universities, which also includes a stronger emphasis on international programs and alliances with foreign universities, the attraction of international students, and the recruitment of international researchers and professors (Mohrman et al., 2008).

Acknowledgements: Thanks are due to Cristina Chaminade and two anonymous referees for valuable comments to an earlier draft. Parts of this research were funded by Invest in Spain, the Spanish government's investment promotion agency (ICEI-Invest in Spain, Research Contract: "Collaboration of innovative foreign firms in Spain", 2011). The usual disclaimers apply.

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Table 1. Definition of variables and descriptive statistics

Explanatory variables	Description	Averages for 2011			
		All	Foreign subsidiaries	Local group firms	Unaffiliated firms
<i>Dependent variable:</i>					
Collaboration with universities	Binary response variable for collaboration with local universities	0.132	0.138	0.173	0.108
<i>Explanatory variables:</i>					
Size	Number of employees	303	638	559	101
Innovation expenditure	Innovation expenditure per employee, Euro	7575	6194	9018	7067
Training expenditure	Training expenditure per employee, Euro	33	19	31	37
Highly educated employees	Binary response variable for firms with percentage of highly educated employees above the average of their sector	0.305	0.269	0.320	0.304
Basic research	Binary response variable for firms doing basic research	0.063	0.056	0.073	0.059
Intellectual property protection	Index indicating the fraction of IP protection measures used, where patents, industrial designs, trademarks, and copyright are given as options, as in Herstad et al. (2014)	0.085	0.078	0.109	0.074
Public funding	Binary response variable for firms receiving local public funding for R&D	0.303	0.244	0.383	0.272
Collaboration with other partners	Binary response variable for collaboration with any other type of partner, excluding collaboration with local universities	0.257	0.266	0.333	0.215

Source: PITEC - Spanish Community Innovation Survey, 2011

Table 2. Estimation results

Explanatory variables	Coefficient	t-statistic	p-value
Foreign subsidiaries	-0.07	-1.05	0.29
Unaffiliated firms	-0.12	-2.72	0.01
Size	0.13	8.05	0.00
Innovation expenditure	0.08	13.46	0.00
Training expenditure	0.03	3.81	0.00
Highly educated employees	0.22	5.85	0.00
Basic research	0.12	2.64	0.01
Intellectual property	0.64	8.85	0.00
Public funding (local)	0.51	16.13	0.00
Public funding (Europe)	0.35	7.04	0.00
Collaboration with any other partners	1.8	57.0	0.00
Const.	-3.3	-17.7	0.00
Num. of firms		9614	
Num. of observations		64705.0	
LR for explanatory variables (χ^2)		7768.3	
Prob > χ^2		0.0000	
LR for individual random effects (ρ)		7933.3	
Prob > ρ		0.0000	

Note: Random-effects probit regression, estimated with unreported control dummy variables for 43 sectors of activity and 7 year dummy variables.

Table 3. Results of model estimations by sectors

Sector of activity	No. of firms	% of foreign subs.	Coefficient for <i>foreign subsidiaries</i> on different sectorial estimation		
			All sizes	SME's	Large
All sectors	9614	13.8	-0.08	-0.09	-0.11
Food, beverages and tobacco products	665	10.7	-0.62 ***	-0.90 **	-0.54 *
Manufacture of chemicals and chemical products	539	20.6	0.06	-0.08	0.50
Pharmaceutical products	153	36.6	-0.01	0.66 *	-1.09 *
Manufacture of rubber and plastic products	336	23.2	-0.34	-0.17	-
Manufacture of other non-metallic mineral products	286	12.6	-0.44	-0.29	-0.82
Manufacture of basic metals	146	21.2	0.51	-0.08	3.63 **
Manufacture of fabricated metal products	543	6.4	-0.53	-0.22	-
Manufacture of computer, electronic and optical products	290	5.9	-0.02	0.98 **	-
Manufacture of electrical equipment	257	17.5	0.01	0.10	-
Manufacture of machinery and equipment	666	10.2	-0.93 ***	-0.68 **	-
Manufacture of motor vehicles	252	40.9	0.24	-0.58	0.84 *
Manufacture of medical instruments, games and toys, musical instruments, etc.	129	8.5	2.20 ***	-	-
Construction	307	7.2	-0.52	-	-0.72
Wholesale trade, retail trade, and repair of motor vehicles	663	18.4	0.19	0.21	-0.13
Transport, warehousing and support activities for transportation	180	12.2	0.82 *	-	0.38
Computer programming, consultancy and related activities	634	9.0	-0.44 *	-0.68 **	0.75
Publishing and information service activities, programming and broadcasting activities, etc.	217	12.4	-0.31	-0.09	-
Financial and insurance services, and auxiliary activities	203	20.2	-1.14 *	-	-
Legal and accounting activities, advertising and market research, architectural and engineering activities, etc.	749	6.0	-0.14	-0.03	1.02 *
Administrative and support services	221	14.0	0.67 **	2.69 ***	0.46

Note: All estimations (64 in total) include the same control variables defined previously for the whole sample model (see Table 1), as well as 7 year dummy variables. The symbols (*), (**), and (***) stand for 80%, 90% and 95% statistical confidence, respectively, in rejecting the null hypothesis (i.e., coefficient equal to zero). The exclusion of some sectors of activity in this Table and missing data reflect that they contained less than 50 firms, or had less than 5% of foreign subsidiaries, or showed no collaboration with universities.

Table 4. Characteristics of the sample of foreign subsidiaries

Sample size	89
Total employees (average, 2011)	652
R&D employees (average, 2011)	15
R&D expenditure (% of sales, average, 2010)	9.3%
Collaboration in innovation (% , 2010)	92%
Collaboration with universities (% , 2010)	70%
<i>Distribution by country of origin:</i>	EU: 72%
	U.S.: 16%
	Other: 12%
<i>Distribution by entry mode:</i>	M&A: 53%
	Greenfield: 47%
<i>Distribution by year of establishment:</i>	1919-1980: 43.8%
	1981-1990: 14.6%
	1991-2000: 15.7%
	2001-2010: 25.8%

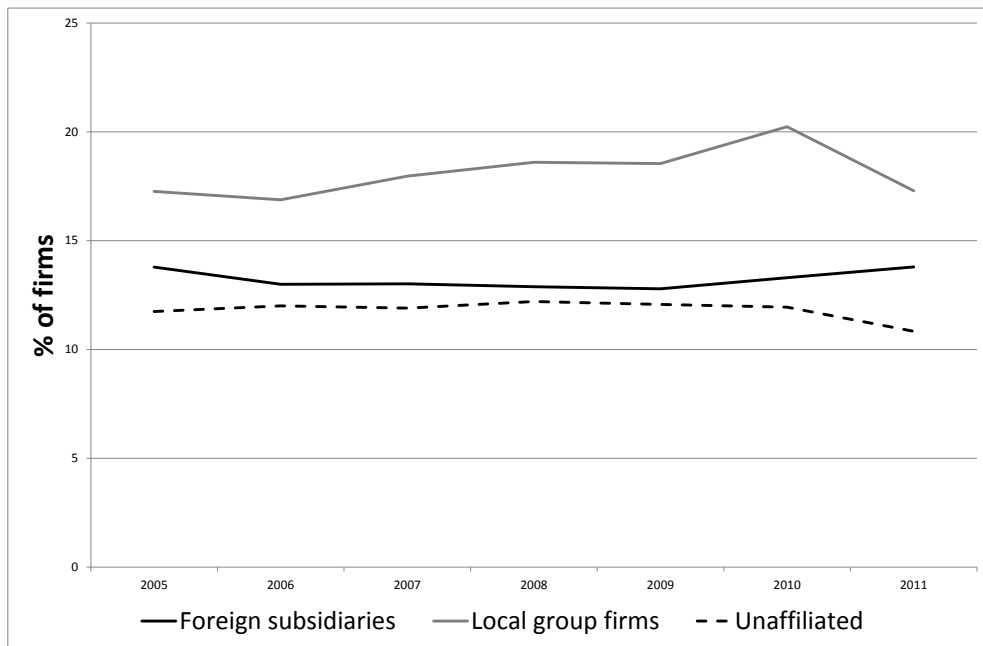
Source: Survey commissioned by Invest in Spain, 2011

Table 5. Overview of the five case studies

Company name	Country of origin	Total employees	R&D employees	Activity in Spain	Subsidiary mandate: evolution of R&D activities	Collaboration with universities: motivations and dynamics
3M	U.S.	650	30	Chemicals, healthcare, office supplies	<ul style="list-style-type: none"> R&D activity initially associated with manufacturing plant of abrasive products for household and industry, oriented to process improvements and adaptation of products to local market (demand driven) Since 2009 increasingly knowledge seeking in new areas like renewable energies and civil infrastructure (supply driven) 	<ul style="list-style-type: none"> Initially oriented to recruiting and corporate social responsibility. Since 2009 more active collaboration in R&D with universities in selected areas.
Atos	France	5.700	200	Technology consulting	<ul style="list-style-type: none"> The company hosts in Madrid its main global R&D center As of 2012 the center was coordinating and or participating in 135 EU projects (out of which 96 EU-funded). 	<ul style="list-style-type: none"> Collaboration in R&D consortia with several Spanish and European universities to access public funding (EU and national). Since 2011 competition of innovative IT projects for students, in partnership with 5 Spanish universities.
HP	U.S.	8.600	450	Computer software and hardware	<ul style="list-style-type: none"> In 2000 manufacturing was offshored to Asia but Spanish subsidiary retained product mandate for large printers, including R&D. The Spanish R&D center has expanded since 2000. Since 2005 the Spanish R&D center also coordinates the work of two other R&D centers that HP acquired in Israel and Minnesota. In 2014 HP announced its decision to locate in Spain its new global unit to develop 3D printers 	<ul style="list-style-type: none"> Since 2003, two major long term partnerships with universities were established to promote joint research and training activities (Chair in Digital Image and Editing at Polytechnic University of Catalonia and Technological Observatory at the University of Leon).
Thyssen Krupp	Germany	5.500	150	Elevators and escalators	<ul style="list-style-type: none"> R&D center for horizontal transportation systems (escalators, moving walks, etc.) is one of the company's three global R&D centers in this area. R&D center for vertical transportation systems (elevators) is one of the eight global R&D centers within this business line. Substantially expanded in 2011 and relocated in a Technology Park by University Rey Juan Carlos. 	<ul style="list-style-type: none"> Initially focused on joint-training activities, internships and recruitment. Also contracting of metrology and quality control services from universities. More recently, raising collaboration in R&D also. Since 2013 annual contest for entrepreneurs in partnership with Rey Juan Carlos university.
Yahoo!	U.S.	110	25	Internet platforms and applications	<ul style="list-style-type: none"> In 2006 Yahoo! established in Spain its first R&D center in Europe (its other global R&D centers are located in the U.S., China, India, Israel and Chile). Decision to locate in Spain was mainly driven by aim to hire leading scientist who wanted to establish the center in the country. 	<ul style="list-style-type: none"> R&D center located within the premises of Pompeu Fabra University in Barcelona. Collaborating in R&D projects with other Spanish and European universities within EU-funded projects

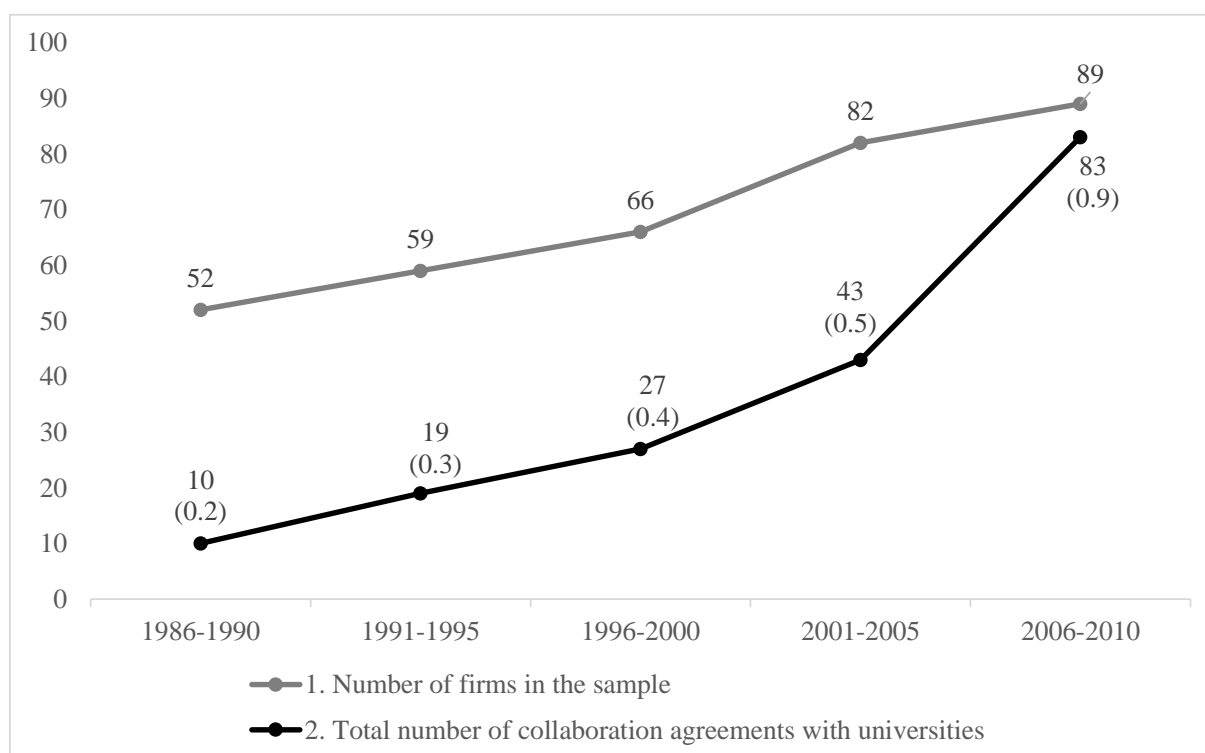
Note: Employment estimates refer to 2011 and only to the firms' operations in Spain.

Sources: Secondary sources (corporate websites, annual reports) and personal interviews with the firms' R&D managers.



Source: Community Innovation Survey Spain, PITEC.

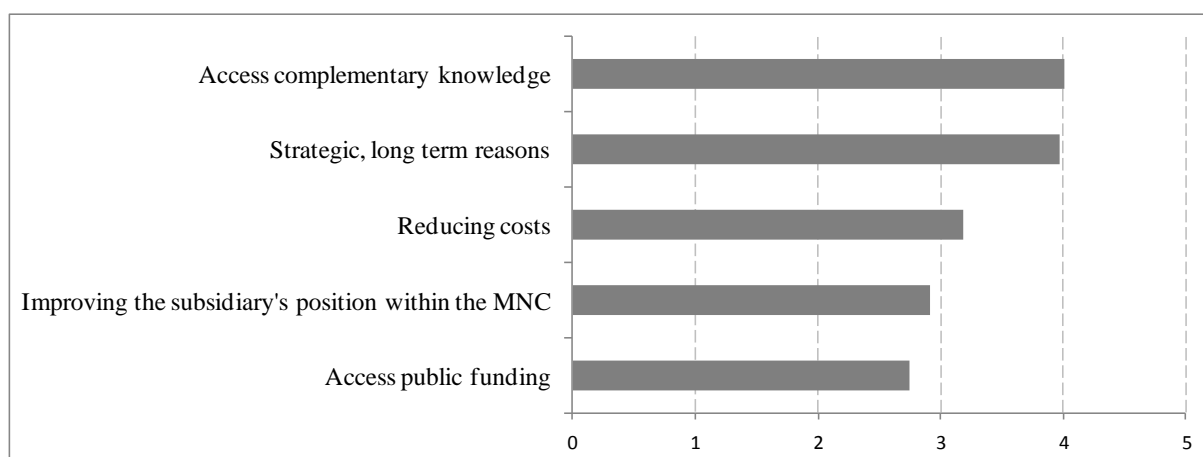
Figure 1. Propensity to collaborate with local universities, by group



Note: Numbers within parenthesis indicate average number of collaboration agreements per firm ($=2 \div 1$).

Source: Survey commissioned by Invest in Spain, 2011

Figure 2. Evolution of the number of collaboration agreements with universities



Note: In a scale from 0 (not important) to 5 (very important)

Source: Survey commissioned by Invest in Spain, 2011

Figure 3. Main reasons for collaborating in innovation with universities