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Local cooperation for innovation in ICT—Domestic groups with collaborations for innovation abroad and foreign subsidiaries

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Abstract

On analysing a sample of Information and Communication Technology (ICT) firms, we ask whether domestic business groups that are engaged in international cooperation for innovation are likely to cooperate for innovation in the home market. We compare these companies with other types of ICT firms. The idea behind our inquiry is that domestic groups involved in international cooperation for innovation are exposed to international information, while they are also well embedded in the home economy. We find that these companies as well as foreign subsidiaries are more prone to cooperating for innovation with domestic partners than are other types of ICT companies, even when size and other characteristics of firms that may influence cooperation are taken into consideration. However, domestic groups with international cooperation for innovation show a systematically higher propensity than foreign subsidiaries to cooperate with domestic partners. These results may be useful regarding policies of foreign direct investment promotion and their alternatives.

Key words: internationalisation of R&D; cooperation for innovation; MNEs; domestic business groups; ICT

1. Introduction

Competition to attract R&D-intensive foreign direct investment (FDI) has increased worldwide in recent years since both academics and policy makers believe that foreign multinational enterprises (MNEs) may contribute towards transferring new technology to host countries (Guimón 2011). Both the European Commission and other international institutions have often recommended the adoption of linkage policies since technology transfers seem to be facilitated when foreign subsidiaries are able to build linkages in the host country (Guimón 2011; UNCTAD 2001). One such linkage is found in the form of cooperation for innovation with local partners. It is often believed that foreign subsidiaries that are able to engage in this type of relationship may help domestic companies and local institutions catch up with the rapidly changing technological panorama. In theory, this mechanism may be particularly useful when the host country does not stand at the forefront of technological development since it can contribute towards linking the national innovation system (NIS) to international sources of science and technology. However, foreign MNEs may develop *branch plant syndrome* and become enclaves within a host economy (Phelps 1993). In the literature, branch plant syndrome has been defined as limited local linkages, lack of spillover effects, few opportunities for development, and loss of industrial dynamics all due to the decoupling of foreign subsidiaries from the national economy (see, e.g. Ebersberger and Herstad 2012). Certain MNEs rarely establish technological ties with local firms or with the rest of the NIS (UNCTAD 2001).

A growing body of literature mostly based on the Community Innovation Survey (CIS) of the European Union (EU) has tested whether foreign status influences the willingness of a company to cooperate for innovation (see, e.g. Knell and Srholec 2006; Srholec 2009, 2011; Veugelers and Cassiman 2004). Many of the studies on R&D cooperation fail to distinguish between domestic and international cooperation for innovation although there are exceptions (Cozza et al. 2018; Ebersberger et al. 2011; Holl and Rama 2014). Scholars started by asking whether foreign MNEs are better at cooperating with local partners than domestic firms and, specifically, than affiliated domestic firms (i.e. domestic business groups). However, empirical results remain inconclusive. Since one reason for mixed results could be that foreign MNEs are not a homogeneous group, certain authors have attempted to explain why foreign subsidiaries differ in terms of their propensity to collaborate with local partners by taking into account the geographic origin of the foreign subsidiary, its mandate, or its propensity to recruit expatriates (Dachs et al. 2008; Holl and Rama 2014; Santangelo 2009). In this respect, however, the heterogeneity of domestic firms beyond the mere distinction between affiliated and unaffiliated domestic firms remains an under-researched topic, although there are a few studies that introduce a further distinction between domestic companies and ask whether foreign MNEs are better at cooperating for innovation with local partners than *indigenous* MNEs (Cozza et al. 2018; Ebersberger and Herstad 2012).

Firms may have different types of R&D activities abroad, such as performing own R&D abroad or engaging in international R&D cooperation (Schmiele 2012). Cozza and Zanfei (2016) inquire whether Italian groups with R&D activities abroad are likely to outperform foreign subsidiaries and other types of domestic firms in terms of R&D cooperative activities with external partners and, specifically, with Italian universities. We ask whether domestic business groups (DGs) that perform international cooperation for innovation are likely to cooperate for innovation at home. We compare the domestic collaborations for innovation of these DGs with those of domestic firms that do not cooperate internationally for innovation and with those of foreign subsidiaries. In doing so, the present article further explores the heterogeneity of DGs. The idea behind our inquiry is that DGs involved in international collaborations for innovation are exposed to international information, while they are also well embedded in the home economy.

The inquiry is important since certain situations may clearly limit the potential of foreign subsidiaries in terms of linking the NIS to international sources of science and technology. Although the internationalisation of corporate R&D is undeniable, many MNEs are barely interested in researching in foreign locations and many countries lack the features that appeal to foreign laboratories (Rama 2009). Secondly, foreign MNEs may face high transaction costs that limit their cooperative activities in the host country. Finally, in certain sectors, the nature of key technological actors is rapidly changing and current international sources of new knowledge may now be found primarily in clustered small- and medium-sized enterprises (SMEs), technology-based start-ups, and universities and public research centres rather than in MNEs. In the EU, for instance, this is the case of certain high-tech industries related to Information and Communication Technology (ICT) (Aschhoff et al. 2010). Since many of these new actors are SMEs and institutions, they remain unlikely to establish research facilities abroad. The analyses of the indigenous MNEs as a possible connection between the NIS and international sources of science and technology certainly constitute a step forward. However, they need to be complemented by analyses of other possible channels of the diffusion of international technology. Few peripheral European countries or emerging markets display substantial outward FDI stock in every sector.[1] Most of these countries have, at sector level, either only a handful of indigenous MNEs or no indigenous MNEs at all. In this new international panorama, it makes sense to explore agents other than foreign MNEs and native MNEs that may potentially put the NIS into contact with outside sources of information. Here we ask whether DGs that perform international cooperation for innovation are likely to cooperate for innovation at home.

For our study, the Spanish ICT sector[2] was selected and several considerations justify our choice. One of the most important contributions of previous cross-sectional studies is that of the impact of foreign subsidiary status on local cooperation for innovation changes by sector (Ebersberger et al. 2011; García Sánchez et al. 2016; Guimón and Salazar-Elena 2015). However, sectoral analyses based on CIS-type data, such as that carried out in the present article, are rare. Secondly, ICT currently constitutes one of the cornerstones of the modernisation of economies and societies. The Digital Agenda for Europe is one of the pillars of the Europe 2020 strategy for growth in the EU (Mas et al. 2018). The Framework Programme of the EU especially supports cooperative international R&D in ICT and other high-tech sectors. Information and Communication Technology lies at the root of many key enabling technologies, such as: photonics; micro and nanoelectronics, including semiconductors; and advanced technology manufacturing, such as robotics. Key enabling technologies are closely related to the concept of 'general-purpose technologies' that are likely to rapidly change the face of industry and employment in the EU and elsewhere (Aschhoff et al. 2010). Fostering innovation in these new industries is one of the goals of the European Commission and of most member states of the EU. According to patent analysis, ICT is characterised by recombinant knowledge engaging a variety of knowledge modules, industries, and companies (Antonelli et al. 2010). However, some of these technologies involve very long-term horizons and require active networking among various actors for the development of joint R&D (Aschhoff et al. 2010).

According to patent analysis, technological change in ICT is fast worldwide but Spain has been unable to catch up (Molero and Garcia 2008). For countries that are not at the forefront of technological change, such as Spain, it is essential to identify agents, be they domestic or foreign that may bring state-of-the-art technology not yet available locally. The inquiry regarding a possible role for DGs with international cooperation for innovation is opportune since, in Spain, many domestic ICT companies have recently rapidly internationalised their productive activities and/or their R&D activities (Edwards-Schachter et al. 2013; Fernández-Otheo and Myro 2014; Molero and Rama 2013; Molero et al. 2012). On the other hand, the ICT sector is a key supplier of the automobile industry and other Spanish export industries. The automobile industry is currently witnessing a paradigmatic shift, and its competitiveness depends more than ever on the technological development of ICT. Electronics used to be just one of the many auxiliary industries of the automobile industry, which was basically a mechanical industry, but '*the mechanical machine is being converted into a computer*' due to the increasing importance of electric cars, autonomous cars, new battery technology, and car-sharing services (Ferràs-Hernández et al. 2017: 855). Self-driving systems, navigation and communication systems, and vehicle-sharing platforms are transforming the face of this industry and all heavily depend on the technological development of electronics. Sales of cars that use alternative energies are increasing in several EU countries, such as Sweden, and behind these developments are policies such as tax exemptions and free parking.[3] Other peripheral European countries and emerging economies are currently gaining a foothold in the electronics industry and the analysis of the Spanish experience may prove useful for them.

Are DGs that are engaged in international cooperation for innovation likely to also cooperate for innovation with domestic partners at home? Are they more effective in this respect than foreign MNEs? Does foreign status exert a positive influence on local cooperation for innovation? In order to answer these questions, the remainder of this article is organised as follows. Section 2 discusses the relevant literature and proposes our research questions. Section 3 describes the contextual setting of our research. Section 4 presents the methodology and Section 5 some descriptive statistics. The results and discussion are presented in Section 6. Section 7 offers some conclusions.

2. Literature review and research questions

Firms are increasingly relying on open innovation, which includes a variety of practices meant to capture external knowledge, such as the outsourcing of R&D, cooperation for innovation, and so on. For our analysis, we selected *cooperation for innovation* since this method is well suited for the combination of external knowledge and internal knowledge generated by the firm, and for the ease of

repeated inter-actions of the partners (Dhont-Peltrault and Pfister 2011; Lucena 2011). In ICT, R&D cooperation is considered as a strong tie of knowledge spillovers between companies since it involves reciprocal obligations between partners, long-standing interactions and, often, written agreements (Wang et al. 2017). Although firms combine various types of open innovation arrangements (Holl and Rama 2014), these characteristics of cooperation for innovation may provide the greatest opportunities for transfers of technology between partners.

2.1. Motives for cooperation

Firms cooperate for innovation for a variety of motives, such as accessing new knowledge, accessing new markets, sharing risks, and reducing R&D costs (for a review of the literature on motives, see Edwards-Schachter et al. 2013). Knowledge-oriented motives seem to be predominant in international R&D cooperation (Arvanitis and Bolli 2013); hence there is interest in focusing on a collaborative activity that emphasises the acquisition of knowledge, as we do here. Firms belonging to business groups may be especially motivated to cooperate for innovation since they have greater organisational and technical advantages to access and to profit from external knowledge (Cozza and Zanfei 2016). Most unaffiliated Spanish firms are SMEs, and many of these firms clearly experience difficulties in establishing R&D cooperation (Fernández-Esquinas and Ramos-Vielba 2011). Therefore, we focus on domestic groups.

2.2. The network approach to R&D cooperation

The network approach to the field of innovation and cooperation mainly uses social network theory and the resource-based view of the firm to explain whether cooperative inter-firm agreements are formed (Di Guardo and Harrigan 2012). As stated, a line of research inquires specifically whether ownership can predict the formation of cooperative R&D arrangements (and, specifically, of *local* cooperative R&D arrangements). Building on the transaction cost theory (Williamson 1985), the International Business literature has proposed that foreign subsidiaries may incur a *liability of foreignness*, that is, the social and cultural barriers they have to surmount in a host country (Zaheer 1995). The *liability of foreignness* may represent a difficulty concerning, specifically, the innovation-related activities of foreign subsidiaries abroad; one study attributes the fact that foreign MNEs have their projects cancelled and postponed more frequently than the average German company (Sofka 2006). Foreign subsidiaries may face high transaction costs due to their insufficient social capital in the host country, a crucial ingredient of networking, and joint R&D (Love and Roper 2009; Pittaway et al. 2004; Zaheer 1995). Most scholars believe that these circumstances may put the brakes on their engagement in local innovative networks (see, e.g. Cozza et al. 2018; Schmidt and Sofka 2009).

2.3. The gap between foreign subsidiaries and domestic firms

After reviewing the literature on the respective performance of foreign subsidiaries and domestic firms, Bellak (2004) concludes that one reason for the existence of a technological gap between the two types of companies is that domestic firms usually have a limited geographical range of operations and, hence, insufficient access to the local knowledge-base abroad. This strand of literature proposed that policies promoting the internationalisation of domestic firms may encourage investment in their firm-specific assets. This point of view is supported by evidence: internationalisation and, especially, internationalisation of R&D, help firms to reach international R&D mass and increase their investment in innovation at home (Jaklič et al. 2014; Montresor and Vezzani 2015). International R&D cooperation, another mechanism adopted by firms to develop R&D activities abroad (Schmiele 2012), also positively influences the innovativeness of domestic manufacturing firms and of companies active in knowledge-intensive business services (Fernández Sastre 2012; Rodríguez et al. 2018). According to the aforementioned studies, firms undertaking such R&D activities abroad are more likely to increase their innovative activities at home because they had been previously able to tap into overseas knowledge inputs. The question that remains unanswered in previous studies is whether these domestic firms are likely to undertake their domestic R&D activities with the collaboration of local partners.

2.4. Foreign ownership and local cooperation for innovation

MNEs source technology in a host country for a variety of reasons, such as for the adaption of their products to national tastes and regulations, for access to skilled researchers or for taking advantage of the technological development of the NIS (Rama 2009). Although this may suggest that they would be prone to cooperating with local partners, several circumstances may limit such collaboration. Compared with domestic firms, foreign MNEs are more likely to find the information they need within their own business network (Dachs et al. 2008). Market competition may also limit the cooperative activities of the foreign MNE in the host country. The MNE may fear unintended spillovers of knowledge (Santangelo 2009) or face technologically able local rivals better prepared to engage in local R&D cooperation due to their substantial social capital (García Sánchez et al. 2016; Schmidt and Sofka 2009). As stated, foreign subsidiaries may not be able to build local R&D linkages similar to those of domestic firms since they face higher transaction costs in the host country.

Empirical research has yet to provide a clear answer to this question. A Pan-European study found a positive effect of foreign ownership status on international cooperation for innovation but a negative effect on domestic cooperation (Ebersberger et al. 2011). Another study corroborated this point of view specifically for MNEs active in Italy: these companies are less prone to setting up linkages with local counterparts than with foreign counterparts (Cozza et al. 2018). Similarly, foreign MNEs with interests in Norway are likely to behave as enclaves in the host economy (Ebersberger and Herstad 2012). A study of 12 European countries detected that foreign subsidiaries tend to cooperate for innovation with external partners, especially those located outside the host country (Srholec, 2009). By analysing a sample of more than 28,000 European innovative firms, Srholec (2015) found that foreign ownership tends to be negatively associated with local cooperation for innovation. The discussion suggests that, in foreign subsidiaries, openness to international partners may come at the expense of domestic embeddedness. Certain studies on European countries conclude, moreover, that the risk of *branch plant syndrome* is especially tangible in those countries that are not technology leaders (Ebersberger et al. 2011; Srholec 2009). One reason may be that, in this case, local science holds very little interest for foreign MNEs. However, the empirical evidence regarding this question is conflictive. Other analyses found that foreign subsidiaries active in Spain, which is not a technology leader, tend nevertheless to engage in local cooperation for innovation to a greater extent than do affiliated or unaffiliated domestic firms (García Sánchez et al. 2016; Holl and Rama 2014).

As stated, a few studies have tested whether foreign MNEs are better than indigenous MNEs at cooperating for innovation with local partners. In a sample of Norwegian companies, it was found that foreign MNEs are less prone to establishing local linkages than indigenous MNEs (Ebersberger and Herstad 2012). Those authors conclude that '*one learns more by going abroad, than by having strangers visit*' (p. 290). In addition, they note, indigenous MNEs may be more aware of resources available in the economy and, hence, more willing to engage in local cooperation. Cozza et al. (2018), in a sample of R&D investors active in Italy, note similarly that foreign MNEs are less likely than indigenous MNEs to set up linkages with local counterparts. Compared with foreign MNEs, Italian MNEs also have extensive R&D budgets and connections to cross-border flows of knowledge but, in addition, they enjoy stronger roots in the Italian economy. According to the aforementioned authors, this circumstance provides Italian MNEs with advantages in establishing local linkages. Cozza and Zanfei (2016) find that Italian business groups that have R&D activities abroad outperform both other Italian business groups and foreign subsidiaries in terms of their ability to cooperate for innovation with external partners and, specifically, with Italian universities. Hitherto, the discussion suggests that international openness provides domestic firms with new opportunities to learn from international sources, while at the same time, embeddedness in the home country facilitates their cooperative activities. Nevertheless, in certain cases, a trade-off may exist between international openness and local cooperation for innovation. In his sample of European innovative companies, Srholec (2015) observed that most firms that cooperate abroad also tend to cooperate locally. However, in less advanced European countries, he found that firms may be more interested in international linkages and less interested in domestic linkages due to the weaknesses of the NIS. It remains unclear whether, in those countries, DGs that cooperate for innovation with partners located abroad are likely to cooperate for innovation at home; the question is addressed here.

2.5. Cooperation for innovation in the ICT sector

The literature on organisation provides several analyses on the networking activities of ICT firms, and the national or regional embeddedness of MNEs active in this sector. Information and communication technology firms have pioneered, since the 1980s, the launching of alliances and R&D cooperation agreements with other firms and universities as a way of expanding their own corporate skills (Hagedoorn and Schakenraad 1992; Narula and Santangelo 2009). In this literature, the territorial dimension has been traditionally emphasised as a factor that stimulates local collaboration (see, e.g. Saxenian 1992). Since the 1980s, the geographical concentration of corporate R&D has become a fact in the European ICT industry (Narula and Santangelo 2009; Santangelo 2000). However, not all ICT firms are willing to co-locate, especially if they are technological leaders who may fear information leaks (Narula and Santangelo 2009; Suárez-Villa and Walrod 1997). Furthermore, co-location may go hand in hand with weak embeddedness (Rychen and Zimmermann 2002; Wei et al. 2012), with short-lived embeddedness (Cassiolato et al. 2002), and even with the complete isolation of the ICT foreign company (Arita and McCann 2004; Hendry et al. 1999).

The few cross-sectional studies based on CIS-type data that focus specifically on high-tech sectors suggest that FDI is unlikely to predict local cooperation for innovation. A Pan-European study finds that both in high-tech manufacturing and in knowledge-intensive services, such as those provided by ICT firms, the effect of foreign ownership on the likelihood of local cooperation tends to be either non-existent or negative (Ebersberger et al. 2011). According to another analysis, in the industry of computer and electronics products, foreign MNEs are no better than affiliated Spanish companies at establishing cooperative linkages with Spanish universities; the exception being smaller foreign MNEs (Guimón and Salazar-Elena 2015). A study on the Spanish ICT manufacturing industries notes that foreign subsidiaries are better than unaffiliated domestic firms at cooperating locally for innovation but not necessarily better than DGs (García Sánchez and Rama 2015). Other research results suggest that foreign MNEs active in ICT may avoid local R&D cooperation because they fear involuntary spillovers of knowledge: the most innovative is the most reluctant to cooperate locally for innovation. In a group of industries displaying rapid technological change, ICT included, it was found that foreign subsidiaries are more prone to cooperating locally for innovation than Spanish business groups; however, the advantage held by foreign subsidiaries in this respect disappears in a subsample of highly innovative companies (García Sánchez et al. 2016). By analysing electronics establishments active in Spain, another study observed that non-collaborative foreign subsidiaries invest three times more in R&D per employee than do collaborative foreign subsidiaries (Holl and Rama 2009b). The discussion suggests that foreign MNEs active in ICT may tend to remain isolated in the host economy probably because they fear spillovers of knowledge.

However, a strand of literature dealing with indigenous MNEs based on new exporters of ICT capital, such as Finland, South Korea, and Spain, depicts a different panorama (Paija 2001; Rama and Ferguson 2007; Suárez-Villa and Han 1990; Valdaliso et al. 2011). The empirical evidence, while far from exhaustive, certainly suggests that these companies tend to display networked structures of production. In the home country, they are rarely isolated but rather rely on production subcontracting, joint R&D, and other linkages with myriads of local partners. International comparisons suggest that the social and institutional entourage of the firm plays a role in the prediction of its involvement in cooperative patterns (Love and Roper 2004). The discussion confirms the idea that the *liability of foreignness* applies to MNEs when they operate abroad, not at home.

Therefore, we formulate the following research questions:

RQ1: Are DGs with international collaborations for innovation likely to cooperate for innovation at home?

RQ2: Are foreign subsidiaries likely to cooperate locally for innovation?

RQ2: Do DGs present a higher propensity, in this respect, than do foreign subsidiaries?

3. Context setting

The Spanish ICT sector is rated fifth in the EU in terms of size, after the ICT sectors of Germany, the UK, France, and Italy. In 2015, it generated nearly 368,000 jobs and its turnover amounted to €98,688 M (Muñoz López et al. 2017). The ICT sector plays a substantial role as the supplier of two key Spanish industries. As stated in the Introduction section, ICT is becoming increasingly important in car manufacture, and components already amount to 75% of the value of certain vehicles.[4] Spanish plants are among the most

important users of automation in the EU car industry. In 2017, Spain was the second largest EU producer of cars after Germany[5] and the eighth largest producer worldwide.[6] Spain is also the primary European producer of industrial vehicles.[7] The Spanish ICT subsector that produces components for vehicles, exports 60% of its production. This subsector is also an indirect exporter since 85% of the Spanish production of cars is exported. The ICT sector is also an important supplier of the Spanish machine tool industry, which is the third greatest producer and exporter of machine tools within the EU[8].

In 2015, the inward stock position of FDI in the Spanish ICT industries was €31,583 M and the Spanish outward stock FDI in ICT was €47,261 M. Telefonica, a very large company, occupies central stage in the internationalisation of telecommunication services, while Spanish companies of all sizes participate in the internationalisation of the computing and electronics industries (Esteve and Rodríguez 2014; Rama and Ferguson 2007; Valdaliso et al. 2011).

When engaged in collaborations with partners located abroad, most ICT firms prefer those external to their business group, notably their own associates in the international value chain, such as clients and suppliers (Molero et al. 2012). Most of the international collaborations for innovation involve other European countries. The Framework Programme of the EU has contributed towards incentives for the intra-European R&D collaborations. However, the share of Spanish ICT firms that receive such aid is only ~5% of the total amount.

4. Methodology

4.1. Data

We use data from the Spanish Technological Innovation Panel (PITEC) for the period 2004–13. The PITEC database is a representative subsample of the Spanish Innovation Survey collected by the Spanish National Statistics Institute (INE) which constitutes the Spanish contribution to the European-wide harmonized CIS. As such, it complies with the OECD's Oslo Manual.

The PITEC database provides information on the technological innovation activities of all the principal sectors in the Spanish economy including foreign and domestic companies located in Spain. In our estimation sample, we have excluded non-innovators, since PITEC poses questions regarding innovation cooperation only to firms defined by the questionnaire as 'innovative', that is, companies that have either introduced product and/or process innovations, or have ongoing innovative activities, or have abandoned innovation activities during the survey year and the 2 years prior to the survey. Other CIS-type surveys display the same feature (see, e.g. Cassiman and Veugelers 2002; Srholec 2015).[9]

Cooperative activities are defined as the result of two separate establishments joining forces to share and develop knowledge in order to enhance their innovative performance. These arrangements do not include the acquisition of R&D services via the market or via R&D outsourcing, but do include R&D collaboration. Firms are asked whether they have had cooperative activities for innovation during the survey year and the last 2 years prior to the survey. They are also asked to indicate the type of partner and the location of the partner (domestic or international).

4.2. Model specification

Domestic cooperation for innovation occurs if the expected benefits of cooperation exceed the costs. However, we do not observe the net value to firms of cooperation. This is our latent endogenous variable. We observe only either discrete choices of domestic cooperation or no domestic cooperation for innovation.

Let the decision to establish domestic cooperative activities y_i by firm $i = 1, 2$, be captured by a binary choice model

$$y_i = \begin{cases} 1 \text{ if } y_i^* \geq 0 \\ 0 \text{ otherwise} \end{cases} \quad (1)$$

where the latent variable y_i^*, representing firm i's underlying propensity to engage in domestic cooperation for innovation, is a function of the type of firm c_i and a vector of observable firm specific characteristics x_i. is a random error term.[10]

$$y_i^* = c_i\beta + x_i\delta + \varepsilon_i \quad (2)$$

We define y_i^* as *coop_dex*, which indicates whether the company has cooperated for innovation with external partners located in Spain. 'External' refers to partners external to the business group of the focal firm. The variable is similar to that analysed in most studies on local cooperation for innovation (Holl and Rama 2014; Miotti and Sachwald 2003; Veugelers and Cassiman 2004) and thus does not include intra-group cooperation.

Our key independent variables of interest denote the two different types of firms:

First, the *dgroup_intcoop* variable takes value 1 if the firm belongs to a domestic group that indicates international cooperation for innovation with partners located outside Spain, 0 otherwise. Here we include partners internal and external to the business group and thus intra-group international partnerships since these linkages may involve international transfers of technology. Of the DGs engaged in international cooperation for innovation, 88.1% maintain partnerships with partners external to their business groups; only 11.9% interact exclusively within their business group. According to case studies, the ICT Spanish companies that own subsidiaries abroad are likely to interact with foreign partners through these subsidiaries and not directly through the headquarters located in Spain (Molero and Rama 2013).

Second, *fsub* indicates foreign ownership. The database distinguishes between two different categories of firms: unaffiliated companies and firms belonging to a group. Within the latter, information is provided about the location of the headquarters of the company. If they are located in a foreign country, then the company is classified here as a foreign subsidiary. If not, then the company is classified as a DG. As noted in previous studies, CIS-type data does not allow the correct identification of native MNEs (Cozza et al. 2018; Holl and Rama 2014).[11]

The association of *fsub* and *dgroup_intcoop*, and *coop_dex* are tested first in a sample comprised of all ICT firms, regardless of whether they are unaffiliated or affiliated. The test is then repeated in a subsample of affiliated ICT firms, including both domestic and foreign firms.

4.2.1 Control variables

Leaders and *laggards*. The literature assumes that firms that possess few skills are not considered as attractive partners for networking, given that companies usually engage in such partnerships to gain access to new technology and know-how (Ahuja 2000; Pittaway et al. 2004). Consequently, laggard firms may find fewer opportunities for cooperation for innovation. In addition, technological leadership indicates that the firm enjoys a substantial absorptive capacity (Cohen and Levinthal 1989). Finally, in a number of countries, foreign companies tend to be technological leaders, while domestic firms lag behind. This variable follows Berry (2006) and identifies

firms that are in the top and bottom quartiles, respectively, in terms of the number of R&D employees per total sales in their respective technology sector.[12]

Size. The log of the number of employees is included.

Productivity. High productivity denotes good economic performance and may encourage innovative projects.

New. Trust is a very important ingredient in partnerships but finding reliable external partners and meaningful joint projects may take some time. We include a dummy variable in our estimations that takes the value of 1 if the company was newly created over our study period.

Export status. A dummy variable is included indicating whether or not the firm has sold its goods or services in the international market.

The variables are summarized in Appendix A.1, and Appendix A.2 displays the corresponding correlation matrix.

Finally, estimations also include dummy variables to control for differences among ICT subsectors[13] as well as year dummy variables. We also include regional dummy variables for the main industrial agglomerations (Madrid, Catalonia, Valencia, and the Basque Country). The remaining regions are the reference group. The regional dummy variables are related to the location of the firms' R&D employment. Firms that locate their R&D facilities in the aforementioned agglomerations may be more prone to interacting locally since face-to-face contact may promote trust.

5. Descriptive statistics

Consultancy and programming companies amount to 51% of our ICT sample firms, and producers of electronics and computing products to 26%; the remaining firms are mainly telecommunication service companies.

By the end of the 2004–8 period, the internal R&D expenditure of ICT firms amounted to more than €501 M. Domestic business groups displayed the largest share of the total expenditure (45.2%), followed by foreign subsidiaries (36.3%), and unaffiliated companies (18.4%). Those DGs with international collaboration accounted for 75% of the internal R&D expenditure reported by DGs. Figure 1 depicts the evolution of internal R&D expenditure in our sample firms. During this period, unaffiliated firms were unable to recover the level of their R&D investments previous to the 2008 global crisis. Nevertheless, this apparently downward trend may mask the presence, in our sample, of certain SMEs active in ICT that decided to join forces and constitute DGs in order to acquire critical size (Molero and Rama 2013; Valdaliso et al. 2011). The internal R&D expenditures of foreign subsidiaries experienced a sharp drop in 2008 from which it has since recovered. Domestic business groups with international R&D collaborations showed a different pattern. They sharply increased their internal R&D expenditure at the onset of the economic crisis in 2008 and then reduced their expenditure sharply during the crisis. Since 2012, there has been a recovery of their internal R&D expenditures. Many DGs may have invested in R&D as a strategy to overcome a critical phase of the business cycle. They are certainly important players in the technological arena. DGs without international collaborations for R&D followed a similar trend as unaffiliated firms.

The involvement of ICT firms in domestic and in international cooperation for innovation increased during the 2004–13 period. The share of companies reporting domestic cooperation augmented from 16.2% to 24.5% of the total, while that of companies reporting international R&D collaborations increased from 34.7% to 37.4% of the total. These firms seem to prioritise international collaboration. This confirms the observation of Srholec (2015) regarding the preference of firms for international collaborations for innovation in those European countries that are not technology leaders; this is the case of Spain. During 2004–13, the share of Spanish non-ICT firms that reported domestic cooperative arrangements increased from 20.4 to 26.4% of the total, while the share of those that reported international collaborative arrangements decreased from 31.1 to 29.9%.

Information and Communication Technology firms seem more interested in cooperation for innovation than firms active in other sectors. In the pooled 2004–13 sample, an unreported econometric analysis, whose results are available upon request, revealed that ICT firms are no more likely than the average Spanish firm to cooperate for innovation with domestic partners (size, productivity, technological leadership, and other variables are controlled for). However, ICT firms seem to have become relatively more involved in domestic cooperation for innovation over time: in 2004, they did not differ significantly from the average Spanish firm but in 2013 they displayed a higher probability of local cooperation for innovation. Furthermore, ICT firms display a higher probability than the average Spanish firm of engaging in international cooperation for innovation and this result for 2004–13 is confirmed for both 2004 and 2013. These results corroborate that companies active in high-tech sectors, such as ICT, are more likely to cooperate for innovation than other companies given their higher R&D costs and their greater need to acquire updated technology (Bayona et al. 2001; Miotti and Sachwald 2003; Ebersberger et al. 2011).

6. Results and discussion

Probit estimation results of Equation (2) are shown in Table 1. Column 1 shows the results for all ICT firms. Both *fsub* and *dgroup_intcoop* display positive, statistically significant coefficients. Both types of firms are clearly more likely to participate in local networks of innovators than other ICT companies. Belonging either to a domestic group with international cooperation for innovation or to a foreign MNE clearly increases the statistical probability that an ICT company cooperates for innovation with domestic partners. This occurs even when size, technological leadership, and other characteristics of firms that may influence cooperation for innovation are taken into account. However, DGs that undertake international cooperation for innovation show a higher probability than foreign subsidiaries in this respect. Next to these coefficients, the marginal effects are also shown. One can observe that the marginal effect of the *dgroup_intcoop* dummy variable is about 2.5 times higher than the marginal effect of the *fsub* dummy variable.

In Column 2, the estimation is repeated on a subsample of companies comprised of only ICT firms belonging to a business group, either nationally owned or foreign owned. *dgroup_intcoop* and *fsub* display positive, statistically significant coefficients: DGs with international collaborations for innovation and foreign subsidiaries are better than the remaining ICT business groups at engaging in cooperation for innovation with local partners. However, DGs that collaborate for innovation with partners located abroad again show a higher probability than do foreign subsidiaries. The findings for the two models based on the pooled data for 2004–13 remain unchanged if the models are re-estimated with the 2004 or the 2013 data (results are available upon request).[14]

Leader always displays positive, statistically significant coefficients, while *laggard* tends to show negative, statistically significant

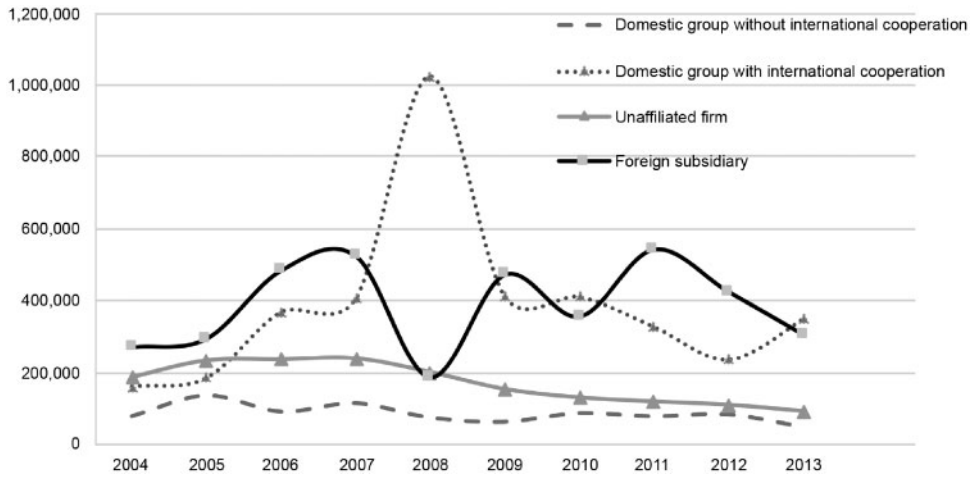

Figure 1. Internal R&D expenditure (in thousands of Euros)

Source: Based on PITEC data

Table 1. Domestic cooperation for innovation with local external partners.

	All ICT firms		Only ICT business groups	
Variables	coop_dex (1)	(dy/dx)	coop_dex (2)	(dy/dx)
dgroup_intcoop	0.917***	0.266***	1.390***	0.424***
	(0.083)		(0.111)	
Fsub	0.422 ***	0.105***	0.846***	0.260***
	(0.093)		(0.119)	
Leader	0.157***	0.033***	0.211 *	0.058*
	(0.065)		(0.127)	
Laggard	−0.309***	−0.058***	−0.161	−0.041
	(0.096)		(0.146)	
Lsize	0.109***	0.023***	0.166 ***	0.044***
	(0.022)		(0.035)	
Lprod	0.107 ***	0.022***	0.134**	0.036**
	(0.035)		(0.057)	
New	0.172 *	0.039	0.082	0.022
	(0.107)		(0.189)	
Export	0.083	0.017	−0.020	−0.005
	(0.059)		(0.104)	
Number of observations	9790		3159	
Log Likelihood	−3608.37		−1353.08	
Pseudo R^2	0.14		0.23	

Standard errors robust to clustering at the firm level are presented in parentheses. ***, **, and * are statistically significant at the 99, 95, and 90% levels. All estimations include unreported regional dummy variables, year dummy variables, and dummy variables for 10 subsectors as well as a constant.

coefficients. *Lsize* and *lprod* always have positive, statistically significant coefficients. The coefficient for newness is also positive but only significant in the sample of all ICT firms. In the reduced sample of only ICT groups, the coefficient loses significance. Exporting activities are not significantly related to engagement in domestic cooperation for innovation. To summarize, greater local cooperation for innovation is associated to two specific types of ICT firms (i.e. DGs engaged in international cooperation for innovation and foreign subsidiaries), a large firm size, technological leadership, and high productivity.

In order to explore this question further, we have divided the sample of DGs with international collaborations into three groups: those engaging in intra-group international collaborations only (*dgroup_intcoop1*), those engaging both in intra-group and extra-group collaborations (*dgroup_intcoop2*), and those engaging in extra-group collaborations only (*dgroup_intcoop3*) (Appendix A.3). The three types of DGs perform better, in terms of domestic cooperation, than other ICT firms (Column 1) or other ICT DGs (Column 2). This suggests that the observed effects of international cooperation are not exclusively driven by within-group technology transfers. Engaging in international collaboration with *external* partners also seems to put DGs in a good position to attract possible partners for innovation at home. However, the evidence presented here is only suggestive in this respect and more research is needed before conclusions may be drawn. The propensity of DGs that cooperate with both intra- and extra-group partners located abroad, and that of those DGs that cooperate exclusively with intra-group partners is higher than the propensity of foreign subsidiaries. The propensity of

DGs that collaborate exclusively with external partners located abroad is similar to that of foreign subsidiaries.[15] Regarding domestic cooperation, our results confirm the validity of exploring the heterogeneity of domestic firms beyond the mere distinction between affiliated and unaffiliated companies.

Our results show a clear pattern whereby DGs engaged in international collaborations for innovation are more prone to engaging in local cooperation for innovation than are foreign subsidiaries. They are more prone to domestic cooperation than the whole set of ICT firms and, specifically, other DGs active in this sector. The resource-based theory of the firm may help in the interpretation of the findings. As noted by Ahuja (2000), the attractiveness of a company to other firms determines whether potential partners may be willing to link with it. According to the aforementioned author, a firm will be the most attractive in the 'linkage market' if it can make assets available that are difficult for the partners to create on their own or obtain from the market. In Ahuja's opinion, the resources available to a company include its social capital, its technical capital, and its commercial capital: the complementary assets needed to commercialise new technology. The DGs with international collaborations for innovation probably have similar social capital to that of other DGs owing to their similar embeddedness in the social milieu although they also enjoy greater technical resources due to their international collaborative experience. Therefore, they may be more able than DGs with no international collaborations for innovation to attract capable partners at home. These two types of DGs differ concerning their propensity to cooperate for innovation probably due to their different levels of attractiveness to local innovators.

A comparison is made of DGs with international collaborations for innovation and foreign subsidiaries. Both types of firms may bring new international technology and this circumstance can make both of them attractive partners for local innovators. However, as noted by previous studies, foreign subsidiaries may encounter more difficulties than DGs to cooperate for innovation with local partners given the *liability of foreignness*. The difficulties of foreign MNEs may also be related to the complex organisation of R&D within the multinational network: transfers of technology to a host country depend on the willingness of the parent company to perform such transfers and on the relative autonomy of the foreign laboratory (Rama, 2009). Foreign MNEs need to balance their internal embeddedness within the multinational network and their external embeddedness in the host country; for innovative activities performed abroad, this task may prove highly complex (Meyer et al. 2011). Most authors take it for granted that subsidiaries are autonomous *vis-à-vis* their headquarters (Sass and Szalavetz 2013). In fact, most subsidiaries lack independence, and this is especially true of peripheral subsidiaries (Bouquet and Birkinshaw 2008). MNEs make the majority of their major technological decisions in their headquarters or in their independent centres of excellence, mostly located in core countries of the Triad (Filippaios et al. 2009). Since Spain plays a very limited role in the geographic strategies of MNEs that operate in the ICT sector of the EU (Fernández-Otheo 2014), the foreign subsidiaries in the sample are likely to display only slight importance in the technological schema of the global company. This circumstance may limit the autonomy and the local embeddedness of these foreign subsidiaries. In contrast, DGs with international collaborations have their headquarters in Spain and, not only their geographic but also their cultural proximity may facilitate decision-making regarding local partnerships for innovation.

Although the foreign subsidiaries of our sample are less likely to cooperate locally for innovation than are DGs with international collaborations for innovation, they are nevertheless more prone than other DGs and unaffiliated ICT companies. This result is unexpected since previous research suggests that ICT multinationals tend to remain isolated in their host countries (Section 2.4). One possible explanation is that familiarity with the local milieu may have increased the willingness of the foreign MNEs in the sample to cooperate for innovation with domestic partners. Castellani and Zanfei (2002), on analysing very large USA and European electronics MNEs, found that the previous experience of these firms with local markets has a positive impact on joint R&D and other local collaborative linkages. Another way to acquire familiarity with the local milieu may consist of outsourcing production from local partners. The subcontracting of production may, in turn, facilitate R&D linkages by reducing transaction costs (Carboni 2012; Love and Roper 2009). In a sample of Spanish electronics manufacturers, it was found that 95% of the firms (domestic and foreign) involved in joint R&D were also engaged in subcontracting production (Holl and Rama 2009a). According to the aforementioned study, joint R&D and other types of networking play a major role in the strategies of foreign MNEs active in three major ICT Spanish agglomerations. The propensity of the foreign subsidiaries of our sample to cooperate locally for innovation (as compared with foreign ICT MNEs active in other host countries) may be explained by the importance of subcontracting arrangements in this Spanish sector. Previous acquaintance, particularly with suppliers, may have contributed towards expanding the social capital of the foreign firms. The PITEC survey does not allow us to explore this idea further since it fails to provide data on the outsourcing of production.

7. Conclusions

We have striven to ascertain whether domestic business groups that cooperate for innovation with partners located abroad are likely to cooperate for innovation at home. We found that they are more likely to cooperate locally than other ICT firms, even when other characteristics of companies are controlled for. Domestic firms with international cooperation for innovation also systematically exhibit a higher propensity to engage in local cooperation for innovation than do foreign subsidiaries. Therefore, our results run counter to the argument of the superiority of foreign subsidiaries as agents of domestic cooperation for innovation. This is a major result since policies of FDI promotion need to balance their costs with those of other, possibly less onerous, policies, to link the NIS to outside sources of information. This is the case of policies meant to encourage domestic firms to cooperate for innovation with partners located abroad. Moreover, in certain host countries, policies to attract foreign MNEs display clear limits since the main factors of success remain elusive to their governments. For instance, it is not within the power of governments to modify the most important reasons why FDI in R&D is drawn to certain countries, such as the existence of a large market. In these cases, policymakers may find it useful to explore alternative methods for the promotion of linkages between the NIS and outside sources of information; one method could consist of the encouragement of cooperation for innovation with partners located abroad. Alternative policies are also desirable when international technological leadership is in the hands of foreign SMEs or foreign institutions, and not of MNEs (Aschhoff et al. 2010). Our results suggest that stimuli to domestic groups willing to engage in international cooperation for innovation may provide a significant tool for policy-makers interested in linking, on the one hand,

domestic innovators and, on the other hand, companies that have direct access to external sources of information. In countries that are not at the forefront of innovation in ICT, this policy may eventually contribute to a greater exposure of the NIS to up-to-date know-how.

Ebersberger and Herstad (2012) have demonstrated that intra-group international cooperation for innovation increases the probability that a native firm cooperates for innovation with domestic partners. Our results suggest that whatever the nature of the partner located abroad (either intra-group partners or partners external to the business group), performing international cooperation increases the likelihood that a domestic group cooperates for innovation at home. However, in terms of domestic cooperation, the largest statistical probability seems to reside in a combination of collaborations with international partners both internal and external to the DG.

As stated, foreign subsidiaries are less willing to cooperate locally for innovation than domestic groups with international collaborations for innovation. Nevertheless, they are more likely than other ICT companies and display a certain degree of embeddedness in the host country. Our results are a clear departure from those of previous studies on other host countries. The propensity of foreign MNEs to cooperate in Spain and not in other host countries may be attributable to the importance of product subcontracting in the Spanish ICT sector. This circumstance may have contributed towards familiarizing the foreign MNEs in the sample with local suppliers. This is a point to be considered in the Spanish case. Policies of FDI promotion probably benefit from parallel stimuli for production subcontracting as a previous step in order to encourage foreign MNEs to cooperate for innovation with domestic partners. To summarize, both DGs that cooperate for innovation abroad and foreign subsidiaries are likely to link the NIS to international sources of up-to-date technology. Policies to attract FDI and policies to promote the R&D internationalisation of domestic firms are compatible. The presence of internationalised domestic firms may attract foreign subsidiaries since these companies may find new knowledge through the international business networks of the host country to be useful (Cantwell and Piscitello 2015). Technologically open industries may present an attractor for FDI in R&D.

However, our analysis presents certain limitations. International bodies (UNCTAD 2001) and most of the literature assume that the cooperation for innovation of a foreign MNE with domestic partners may constitute a step towards the transfer of technology to the national economy. Nevertheless, actual effects have rarely been measured due to the limitations of available data. Veugelers and Cassiman (2004) observe that the CIS data they analysed to study the Belgian case did not allow them to verify whether and to what extent know-how is transferred to the local economy *via* cooperative agreements. Being a CIS-type survey, the PITEC survey that we analyse here displays similar limitations. Consequently, we were unable to verify whether technology was actually transferred through domestic cooperation. At the same time, the cooperation variables are based on self-reported information and therefore tend to include a certain degree of subjectivity. Since our data refers to a sub-sample of innovating firms, the results also need to be interpreted accordingly. Moreover, methods of open innovation other than the international cooperation for innovation studied here need to be explored: for instance, the outsourcing of R&D. This certainly constitutes an important avenue for future research. Further research could also explore the specific product market of the ICT firms in greater detail. We have distinguished 10 different ICT subsectors, but finer distinctions, such as that which takes into account how cutting-edge the product or service of the ICT firms is, could reveal additional interesting insights.

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Notes

1. 'The outward FDI stock is the value of the resident investors' equity in and net loans to enterprises in foreign economies. The inward FDI stock is the value of foreign investors' equity in and net loans to enterprises resident in the reporting economy'. OECD, https://data.oecd.org/fdi/fdi-stocks.htm. November 2018.
2. Includes the electronics industry, software development, and IT services; also involves broadcasting, movie production, and video production.
3. https://ec.europa.eu/eurostat/statisticsexplained/index.php/Passenger_cars_in_the_EU#Overview
4. https://www.interempresas.net/Electronica/Articulos/186740-fabricantes-componentes- electronicos-automocion-reorientan-hacia-vehiculo-electrico.html November 2018.
5. https://www.acea.be/statistics/tag/category/eu-production December 2018.
6. http://www.investinspain.org/invest/es/sectores/automocion/descripcion/index.html Government of Spain, December 2018.
7. http://www.investinspain.org/invest/es/sectores/automocion/descripcion/index.html Government of Spain, December 2018.
8. https://www.afm.es/es/quienes-somos/sector-maquina-herramienta December 2018.
9. As argued in Srholec (2015), the lack of a suitable instrumental variable restricts the possibility of explicitly modelling this selection.
10. Although PITEC has provided annual data since 2004, the survey questions related to the firms' cooperation patterns refer to a 3-year period. Moreover, domestic group status and foreign subsidiary status are nearly time invariant. This prevents a panel data approach from being adopted.
11. Cozza et al. (2018) match CIS-type data with information obtained from an Italian statistical source in order to identify Italian MNEs. Again using CIS-type data, Ebersberger and Herstad (2012) utilize a proxy and define Norwegian multinationals as those domestic firms that maintain innovative collaboration with other branches of the same firm located outside Norway.
12. For a critical point of view on this question, see Montresor and Vezzani (2015).
13. Subsectors are: computer products; electronic and optical products; electrical equipment; other machinery and equipment; other manufacturing activities; repair and installation of machinery and equipment; commerce; telecommunications; programming, consulting and other computer activities; other information and communication services; other services.
14. The probability of cooperation with domestic firms could nevertheless also influence the probability of international cooperation. In unreported robustness checks we have used a

2-year time lag of our dgroup_intcoop variable (available upon request). We end up with a smaller sample, but all estimated coefficients remain noticeably stable.

15. We repeat the test with lagged variables for international cooperation (available upon request). Except in the case of dgroup_intcoop3, which has a positive but not statistically significant coefficient, the other variables denoting international collaborations display positive and statistically significant coefficients.

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Appendix A.1. Description of variables.

Name of variable	Description of variable
coop_dex	Domestic cooperation for innovation: takes value 1 if the firm has collaborated for innovation with local external partners in the previous 2 years
dgroup_intcoop	Domestic group with international cooperation for innovation: takes value 1 if the firm belongs to a business group with headquarters in Spain that reports international cooperation for innovation
fsub	Foreign subsidiary: takes value 1 if the firm is a foreign subsidiary
Leader	Dummy variable taking value 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[a] and year
Laggard	Dummy variable taking value 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[a] and year
lsize	Size of firm: Log of the number of employees
lprod	Productivity: Log of total sales/number of employees
new	New firm: takes value 1 if the firm was newly established during the period of analysis
export	International market: Takes value 1 if the firms sold goods or services in the international market in the previous 2 years

[a]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 A.2. Correlation matrix

Variables	coop_dex	Fsub	dgroup_incoop	Leader	Laggard	Lsize	lprod	export	new
coop_dex	1								
Fsub	0.099	1							
dgroup_incoop	0.297	−0.104	1						
Leaders	0.006	−0.156	0.006	1					
Laggards	−0.096	0.084	−0.118	−0.456	1				
Lsize	0.217	0.346	0.253	−0.323	−0.018	1			
Lprod	0.148	0.172	0.129	−0.266	0.003	0.279	1		
Export	0.119	0.148	0.112	0.020	−0.125	0.255	0.269	1	
New	0.006	−0.062	0.036	0.142	−0.033	−0.207	−0.194	−0.109	1

Appendix A.3. Relation between the type of international cooperation and domestic cooperation

	All ICT firms		Only ICT groups	
Variables	coop_dex (1)	(dy/dx)	coop_dex (2)	(dy/dx)
dgroup_intcoop1	0.806***	0.240***	1.330***	0.477***
(internal only)	(0.223)		(0.224)	
dgroup_intcoop2	1.361***	0.446***	1.907***	0.641***
(internal and external)	(0.102)		(0.129)	
dgroup_intcoop3	0.415***	0.105***	0.854***	0.280***
(external only)	(0.102)		(0.130)	
fsub	0.428***	0.107***	0.855***	0.262***
	(0.093)		(0.119)	
Leaders	0.154**	0.032**	0.195	0.053
	(0.065)		(0.127)	
Laggards	−0.302***	−0.057***	−0.118	−0.030
	(0.096)		(0.144)	
Lsize	0.105***	0.022***	0.153***	0.040***
	(0.022)		(0.035)	
Lprod	0.104***	0.022***	0.127**	0.033*
	(0.036)		(0.062)	
New	0.138	0.031	−0.068	−0.017
	(0.109)		(0.190)	
Export	0.082	0.017	−0.028	−0.007
	(0.060)		(0.106)	
Number of observations	9790		3159	
Log Likelihood	−3549.77		−1288.11	
Pseudo R^2	0.15		0.27	

Standard errors robust to clustering at the firm level are presented in parentheses. ***, ** and * are statistically significant at the 99, 95, and 90% levels. All estimations include unreported regional dummy variables, year dummy variables, and dummy variables for 10 subsectors as well as a constant.