Foreign vs. domestic multinationals in R&D linkage strategies

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This version: September 2019, 10th

Abstract

The aim of this paper is to evaluate the propensity of Multinational Enterprises (MNEs) to set up R&D cooperation and R&D outsourcing. In particular, we suggest that when analysing R&D linkage strategies of firms active in a given market, it is important to distinguish the role played by foreign multinationals (FMN) and by domestic multinationals (DMN) active in that market. We argue that the propensity of DMN and FMN to set up such linkages depends on their specific balance between advantages and challenges of multinationality. On the one hand, MNEs combine the competitive assets originating from their home base and from other locations with learning opportunities and stimuli to innovate stemming from host economy in which they are active. Both FMN and DMN are likely to be characterised by such advantages, which in turn affect their abilities and incentives to set up R&D linkages with both national and international counterparts. On the other hand, dealing with diverse and distant contexts also has a cost, that increases with the degree of unfamiliarity of technical, institutional and competitive conditions characterising such contexts. These costs will reduce the propensity of FMN to create R&D linkages with local counterparts, while they will not penalise DMN, which do not suffer, by definition, any liability of foreignness. This interpretive framework is tested using data on R&D investors active in Italy over the years 2003-2010 and controlling for indicators of firms' internal R&D efforts, internationalisation, age of establishment and regional distribution of R&D activities.

JEL classification: F10, F23, O33

Keywords: Foreign Multinational Enterprises; Domestic Multinational Enterprises, R&D linkage, cooperation, outsourcing

1. Introduction

An extensive literature of innovation scholars has studied the links between internal and external sources of knowledge as drivers of firms' innovation behaviour and performance. In fact, in order to achieve higher innovation capabilities, firms should be able to integrate into their boundaries knowledge coming from a wide range of external sources (e.g. Teece, 2014). From this perspective, an increasing number of studies have explored a variety of connections between firms' intra-muros R&D and external technology sources (e.g. Cassiman & Veugelers, 2006). Such connections include R&D cooperation agreements (see, among others, Belderbos et al., 2004; Cassiman & Veugelers, 2002; Lopez, 2008) and R&D outsourcing (see, among others, Veugelers & Cassiman, 1999, or Bertrand & Mol, 2013). We name the whole set of such external sourcing strategies as "R&D linkages".

Empirical research has also devoted some attention to the role of MNEs in technical linkage creation. However, given that most of these studies rely on CIS-like surveys, they are generally conditioned by two drawbacks of available data. First, while CIS and CIS-like questionnaires do concern R&D activities, they principally aim at catching firms' behaviour and performance in terms of innovation – and much less in terms of R&D. For this reason, such data sources may not be adequate to give account of R&D outsourcing and cooperation. Second, and even more important, CIS data make it possible to distinguish only between domestic and foreign-owned firms, eventually with the information of domestic firms belonging or not to a group. This has contributed to consolidate a conceptual confusion that has long characterised international business studies, which has most often led scholars to more or less implicitly identify MNEs with foreign firms, and foreign presence with linkage creation and technological spillovers. In fact, works that have examined the issue of R&D linkage creation focusing on individual countries (Veugelers & Cassiman, 2004; Knell & Srholec, 2005; Cantwell & Alvarez, 2011; Garcia Sánchez et al., 2016) as well as comparative analyses across EU countries (Srholec, 2009, 2015) have generally been able to single out the role of foreign owned firms as compared to domestic ones. However, they have been generally unable to empirically separate domestic MNEs from the other domestic firms, and to compare these firm categories in terms of the R&D linkages they create locally. Other works have compared economic and innovative performance of domestic owned firms according to their degree of international involvement, and in some cases they have also explored differences in technical cooperation (Castellani & Zanfei, 2007), but they fail to compare these patterns with those of foreign investors in the same country.

Among works assessing the specific contribution of MNEs to R&D linkage creation, Holl & Rama (2014) do account for both the variety of strategies adopted, and for the different propensity of MNEs to set up such linkages, as compared to domestic firms. Their study has the advantage of using an "intermediate" data source represented by the Spanish panel named PITEC that includes a mix of CIS and R&D survey questions, thus allowing to answer questions on R&D linkages (see, among others, García Vega & Huergo, 2011, or García Sánchez et al., 2015 and 2016)[1]. In addition, their paper has the merit of simultaneously considering external R&D outsourcing and innovation cooperation behaviour. Finally, in line with other works, they recognize the peculiarity of foreign subsidiaries in creating technological with domestic

[1] It is worth observing that the dataset does not supply firm level data but only micro level data "anonymized through micro-aggregation". Only innovation active firms were asked questions related to their cooperation behaviour. Thus, their sample is restricted to innovative active firms. These are firms that have introduced new products or new processes or that have ongoing innovative activities or that have abandoned innovative activities during the two years prior to the survey date" (in total, over 41,000 observations for 10,206 private companies).

counterparts. They thus provide an important contribution to understand the key role played by MNEs in characterising intra-industry heterogeneity and linkage creation in particular.

However, like other studies using similar data sources, Holl and Rama disregard the important differences that may exist between Domestic multinationals (DMN) and Foreign multinationals (FMN). Only a few exceptions exist of works that have been able to compare DMN and FMN (Doms & Jensen, 1998; Cozza et al., 2018b), none of them with a focus on both R&D cooperation and R&D outsourcing strategies simultaneously.

This paper aims at filling these gaps in empirical literature by tackling both limitations that have long affected studies on R&D linkage creation. On the one hand, we contribute to extant research by disentangling the role of foreign and domestic MNEs in the development of such linkages. On the other hand, we address the two main linkage strategies simultaneously, to account for their interdependencies.

In order to do so, we use a novel dataset produced by the Italian Bureau of Statistics (ISTAT) to analyse the census of R&D performers in Italy over the 2003-2010 period and test the difference of DMN and FMN against other domestic non-multinational firms. For all categories of firms, we will be able to isolate the subset of their R&D linkages involving local suppliers and partners (i.e. Italian unaffiliated firms and institutions) and foreign suppliers and partners (i.e. foreign unaffiliated firms and institutions).

The remainder of the paper is structured as follows. Section 2 illustrates the interpretive framework underlying our research, connects it to previous literature, and develops our main research questions. Section 3 describes the data sources, the variables used and the empirical strategy. Section 4 illustrates and comments the results obtained with the empirical analysis, and section 5 concludes

2. Interpretive framework and research questions

We argue that the propensity of DMN and FMN to set up R&D linkages depends on their specific balance between advantages and challenges of multinationality. Both categories of firms can in principle benefit from a set of advantages characterising MNEs relative to non-multinational firms, which have long been emphasised in the literature. However, there might be "liabilities of foreignness" characterising the capabilities and incentives of FMN to operate in unfamiliar contexts, which do not penalise DMN in this respect. One thus needs to explore how these sets of advantages and disadvantages combine and impact on R&D linkage creation.

Multinationality advantages and R&D linkage creation

The idea that specific advantages are needed, especially in the form of a "superior technology", in order to compensate the "liabilities" of operating in foreign contexts, dates back to Hymer (1960). Following Hymer's intuition, several scholars have stressed that only the most innovative firms are likely to be able to overcome the costs and risks of operating abroad, and will eventually become MNEs. In addition, once they become MNEs they tend to accumulate additional technological advantages. In fact, they have greater incentives to invest in R&D as they are able to spread the fixed costs of innovation over larger volumes of sales (Mansfield et al., 1979; Petit & Sanna Randaccio, 2000). Moreover, by enlarging the market for new products and processes, internationalisation creates the conditions for a more extensive division of labour among firm-units involved in the generation and use of knowledge (Cantwell, 2001).

This way of theorising MNEs as highly and increasingly innovative institutions has opened up important developments. First, a number of empirical studies have indeed confirmed that MNEs are large R&D spenders and generally carry out more research and innovation activities than non-Multinational firms (Doms & Jensen, 1998; Criscuolo et al., 2010; UNCTAD, 2005; Dachs et al., 2014)[2]. Second, theoretical and empirical works have highlighted the dynamic process through which MNE advantages can be enriched and improved through "asset seeking strategies" (Dunning, 1998; Cantwell & Narula, 2001; Castellani & Zanfei, 2006; Narula, 2014). From this perspective, MNEs will use their superior technology not only to exploit their pre-existing assets in foreign locations, but also to evaluate and filter external knowledge to improve their own competencies. The creation of R&D linkages with indigenous firms and institutions is an essential component of asset seeking and asset augmenting strategies (Le Bas & Sierra, 2002; Cantwell & Mudambi, 2005; Narula & Zanfei, 2005; Rabbiosi & Santangelo, 2013). The superior capability of interpreting and absorbing external knowledge, and the foresight that their own advantages can be enriched through the assimilation of complementary assets, thus constitute a powerful incentive for MNEs to set up linkages with local firms and institutions[3]. A growing literature has documented that MNEs tend to be deeply embedded in multiple locations, enabling them to leverage tangible and intangible resources across national borders (Meyer et al., 2011). Within and across such locations, MNEs thus tend to be involved in complex nexuses of relationships, including bilateral exchanges of knowledge with local counterparts (Le Bas & Sierra, 2002; Cantwell & Mudambi, 2005; Narula & Zanfei, 2005; Rabbiosi & Santangelo, 2013, Castellani et al 2015).

MNEs can be expected to significantly differ in terms of proprietary advantages, which in turn affect their performances and abilities to operate in host country markets (Barłożewski and Trąpczyński 2017); and in terms of the number and variety of locations in which they are active, thus exposing them to different challenges and opportunities (Meyer et al., 2011). The specific combination of advantages, challenges and opportunities associated with internationalisation is likely to impact on the propensity of MNEs to adopt different sourcing strategies.

Whether FMN exhibit greater multinationality advantages than DMN is likely to be mainly an empirical question. In fact, one can hardly have strong priors on how DMN and FMN active in a given country will differ in terms of their ability to mobilise innovation efforts, connect to cross-border knowledge sources and utilise such assets in R&D linkage creation. Along with firm and sector specificities, there might also be important country specific characteristics affecting the propensity of MNEs to set up R&D linkages. As put forward by several scholars (Garcia Sánchez et al., 2015 and 2016), MNEs might be less involved in global innovation networks if they originate from low or intermediate industrialised countries. When comparing DMN and FMN active in such countries, one might thus observe a lower involvement of the former category of MNEs (DMN) in international R&D linkages than is the case of FMN. Also, in countries with

[2] Consistent with this literature, a growing attention has been given by international trade models to intra-industry heterogeneity as a driver of internationalisation, emphasising that firms with better performances will self-select into a greater involvement in trade and FDI activities (see Tybout, 2003; Castellani & Zanfei, 2007; and Wagner, 2011 for extensive reviews).

[3] This emphasis on the dynamic process through which MNEs combine internal and external knowledge assets has clear connections with parallel developments in economics of innovation literature, which has introduced the concept of "absorptive capacity" (Mowery & Rosenberg, 1989; Cohen & Levinthal, 1989, 1990). This concept has in turn heavily influenced research in industrial organisation, which has long emphasised that the decision to set up R&D linkages is affected by the balance between outgoing spillovers, that may reduce the incentives of firms to enter cooperative agreements, and incoming spillovers which will increase the attractiveness of cooperation (De Bondt and Veugelers, 1991; Eaton and Eswaran, 1997). In fact, a number of models have incorporated absorptive capacity as a key variable that can shift this balance in favour of incoming spillovers (Cassiman et al., 2002; Martin, 2002; Amir et al., 2003).

intermediate levels of industrialisation, DMN are likely to benefit from less internal agglomeration economies reflecting a lower geographical concentration of their R&D activities and exhibit a different composition of their R&D budgets or of R&D employees (researchers rather than technicians and other staff, see Cozza et al., 2018a). Such differences in geographical and compositional patterns of R&DS may impact on R&D linkages of MNEs.

Liabilities of multinationality and R&D linkages

As said, the advantages of multinationality are needed to compensate the dis-advantages of operating in unfamiliar contexts, which have been dubbed in the literature as "liabilities of foreignness". The intensity of such liabilities is also likely to impact on R&D linkage creation. Firms doing business abroad will have to deal with unfamiliar environments, giving rise to extra costs and risks that local firms do not face (Hymer, 1960). Zaheer (1995) identified four types of extra-costs that firms have to face when undertaking cross-border operations: costs associated with spatial distance, with unfamiliarity of local contexts, with lack of legitimacy in the host environment and with restrictions from the home country environment.

Unfamiliarity with local contexts, and hence liabilities of foreignness, are bound to increase with distance of foreign firms from home locations; and to diminish with the length and intensity of presence and activity in a given (host) location. Empirical studies confirm that distance factors – particularly institutional diversities - negatively affect the cross-border creation of linkages, by hindering knowledge exchanges (Li et al. 2015), and by diverting partner selection decisions (Hitt et al., 2004, Krammer, 2016). Extant literature does not lead to clear-cut arguments on how firms' length of establishment can affect linkage creation. However, some authors have provided evidence that is broadly consistent with the idea that the degree of experience of local contexts is likely to reduce what Robertson & Gatignon (1998, p.520) refer to as *behavioural uncertainty*. As firms accumulate post-entry experience of local markets, they will improve their ability to accurately assess the performance (outputs) of indigenous counterparts, hence reducing the risk of opportunistic behaviour (Anderson & Gatignon, 1986; Erramilli, 1991; Castellani & Zanfei 2004), and increasing their capacity to adequately perceive the competitive conditions in the local market (Perri et al. 2013). This is likely to determine a shift in the expected balance between incoming and outgoing spillovers and will increase the incentives of MNEs to set up linkages with local firms.

MNEs are likely to differ in terms of their liabilities of foreignness in any given location, reflecting both distance separating them from their home location, and the experience of local contexts they have accumulated after entry. Accordingly, the liability of foreignness will be highest in the case of a new entrant from a (geographically and/or institutionally) distant location; and will be lowest (equal to zero) in the case of domestic owned MNEs dealing with their home contexts. From this perspective, there may be remarkable differences between FMN and DMN in terms of linkage creation.

First, foreign firms will face higher costs when developing linkages with the actors involved in the host location's system of innovation. Getting involved in the host innovation systems requires a lengthy and costly effort to create formal and informal relations with knowledge users and suppliers that are active locally (Lundvall, 1988; Narula, 2003). Becoming familiar with, and integrating into, additional innovation systems might imply high costs —in contrast to the low marginal cost of maintaining its embeddedness in its home location's innovation system as well as in other innovation systems where an FMN has already placed its roots. Such costs may determine strong barriers for FMNs to the creation of local R&D linkages. In other words, there are important inertial forces that may constrain the process of gradual

embeddedness of FMN in a host location's innovation system (Carlsson, 2006; Narula & Zanfei, 2005). An FMN will thus engage in the development of innovation networks with indigenous firms only if it provides access to highly valuable knowledge assets that are not available at a lower cost where the same FMN has already undertaken the effort of getting locally embedded.

Second, even when dealing with locations that are highly attractive in terms of innovation and cutting-edge technology, foreign firms may face difficulties in the search of adequate local partners. It has been observed that in sectors and technological fields wherein the host economy displays Revealed Technology Advantages, FMN may well be willing to undertake asset seeking or asset augmenting strategies, and hence are likely to be interested in interacting with local firms and institutions (Le Bas & Sierra, 2002). However, under such circumstances, leading domestic firms, including DMN, are likely to be better able to secure the most suitable local partners for R&D collaboration. Hence FMN may well run short of valuable partners. Previous empirical studies seem to support this interpretation (Cantwell & Alvarez, 2011; Cantwell & Mudambi, 2011). Quite symmetrically, in sectors where the local economy is lagging behind, FMNs are less likely to be interested in interacting with indigenous firms and institutions; while domestic MNEs might be more willing to set up local networks as to enlarge their competence base and eventually catch up. (Garcia Sánchez et al., 2016; Do Couto e Silva Neto et al., 2013).

Third, FMN's capacity to create linkages with local firms may be limited by organisational constraints. This might be particularly the case when incoming FDIs take the form of acquisitions. Under these circumstances, subsidiaries of FMNs may be forced to rely on the internal network of affiliates to access complementary knowledge assets at the expense of local technology sourcing (Asheim & Herstad, 2005). Especially in the early stages of acquisitions, organisational tensions are likely to be stronger, the attention of FMN units tend to be directed towards corporate resources, and bargaining involves mainly the elite actors in different parts of the multinational group (Currah & Wrigley, 2004). In such early post-acquisition phases, subsidiaries may find it more convenient and less costly to access valuable knowledge from the parent company or from other affiliates belonging to the same multinational group, rather than exploiting external networks locally (Phelps & Fuller, 2000; Mudambi & Navarra, 2004).

Fourth and finally, foreignness implies lower Headquarter proximity. As opposed to the case FMN, affiliates of DMN are co-located with Headquarters in the same country. In other words, DMN are located where one can expect to find the "brain of the polyp" (Archibugi and Michie 1995). This is likely to facilitate exchanges of knowledge of national affiliates of DMN with their parent companies. Since a large component of technology is tacit, its transfer requires the mobility of researchers whose cost increases with distance (Agrawal et al., 2006; Ebersberger et al., 2011). Moreover, the functioning of informal mechanisms of knowledge transmission is certainly favoured by a commonality of language, jargon, and habits which typically characterise affiliates located within the same country (Buckley & Carter, 2004). Altogether, the costs of accessing valuable knowledge available at the headquarter level are much higher in the case of affiliates of an MNE based in a foreign country (FMN) than in the case of domestic affiliates of an MNE, which are located in the same country. Hence the incentive of FMN to exchange knowledge with local firms and institutions will be lower as compared with DMN.

For all these reasons, we believe that is worth comparing DMN and FMN in their R&D linking strategies, yielding the following Research Question: *To what extent do FMN and DMN differ in terms of the various types of R&D linkage creation?*

3. Data and methodology

The Italian business R&D survey (RS1)

As mentioned in the introduction, the majority of works on R&D linkage creation have relied on the Community Innovation Surveys (CIS), conducted in several EU countries, as data source. Although CIS and CIS-like questionnaires do concern R&D activities, they principally aim at catching firms' behaviour and performance in terms of innovation – and much less in terms of R&D. For this reason, such data sources may not be adequate to give account of R&D outsourcing and cooperation.

For instance, the question on innovation expenditures in the CIS includes a sub-question on extra-muros R&D that can be used as a measure of R&D outsourcing but can be hardly utilised to make inference on the intensity and variety of R&D linkages. As a consequence, this source is not adequate to explain the overall behaviour of R&D performers in their strategic choice of which R&D linkages to use. On the other side, for confidentiality reasons the use of a more appropriated source (that is the R&D surveys) has been very limited, with some notable exceptions (e.g. Veugelers, 1997; Teirlinck & Spithoven, 2013; Cozza & Zanfei, 2016; Cozza et al., 2018a and 2018b). In addition, an "intermediate" data source is represented by the Spanish panel named PITEC that includes a mix of CIS and R&D survey questions, thus allowing to answer questions on R&D linkages (see, among others, García Vega & Huergo, 2011, or García Sánchez et al., 2015 and 2016).

The main data source for the analysis carried out in this paper is a novel dataset that aims at overcoming the drawbacks of prevailing data-sources utilised so far, namely the *RS1 dataset* based on the Italian business R&D survey. This survey has been conducted yearly since 1963 by the National Bureau of Statistics (ISTAT), in accordance with the OECD Frascati Manual (2015) guidelines, and it constitutes the basis for the official statistics on business R&D in Italy. It follows a census approach, thus targeting all the potential R&D performers active in the country. This means that all firms "signalling themselves" for different reasons (being large, being active in high-tech sectors, having performed R&D in the past, having applied for R&D tax incentives, etc.) are asked to compile the RS1 questionnaire. Over the past decade, about 20,000 firms per year have been receiving the questionnaire, with response rates ranging constantly between 60% and 70%. Questionnaires are compiled at the firm-level, not at the group-level: if several firms belonging to the same business group perform R&D, they individually respond to the RS1 questionnaire.

The data collected with the RS1 survey cover several aspects of R&D activities, providing a comprehensive and detailed account of the innovative behaviour of firms. The main information is total intra-muros R&D expenditures, but firms also provide details on the number and main occupation of R&D employees (e.g. researchers, technicians and other staff); on the location of their intra-muros R&D expenditures in the country (Italian regions where firms' R&D is actually conducted); and on several other characteristics such as their size, expressed in terms of total employees, their capital expenditures or their principal sector of economic activity. As far as multinationality is concerned, the peculiarities of the RS1 survey should be underlined: in the first place, the possibility of distinguishing among firm categories according to their (foreign or domestic) ownership and their belonging to a group rather than being independent companies (see below for details); in the second place, the availability of the amount of R&D (if any) undertaken by each firm's subsidiaries abroad (in literature, a variable usually referred to as "outward R&D" or "captive R&D offshoring"). In addition to these characteristics RS1 survey is particularly suitable to our purpose as it also provides measures

of technological linkage creation trough which we can distinguish measures of R&D outsourcing and R&D cooperation activities, both with respect to local and foreign counterparts.:

- The amount of extra-muros R&D expenditure, which we consider the measure of R&D outsourcing;
- A dichotomic variable on whether the respondent firm is involved in R&D cooperation activities.

In both cases of R&D outsourcing and cooperation variables, respondents are also asked to distinguish among different types of counterparts: that is, whether they contract out R&D or cooperate in R&D with Italian or foreign counterparts, and whether these are firms or other types of institutions (e.g. public research organisations or universities). In this paper, we single out:

- Contractual relations set up by each firm with Italian unaffiliated companies and institutions, which we name "local counterparts";
- And those set up by each firm with foreign unaffiliated companies and institutions, which we name "foreign counterparts".

The dataset

As described above, the RS1 survey is meant for statistical purposes. However, the survey has been recently used to set-up a novel dataset for analysis, which includes all firms active in Italy which have responded to the RS1 survey at least once over the 2001-2010 period, for a total of 39,152 observations corresponding to 13,675 firms (see Bonaccorsi & Perani, 2014, for further details). All the variables mentioned above are included in this novel dataset, with the only exception of "outward R&D" that is reported for the 2003-2010 period. Given the focus of this paper on multinationality, we will then use this sub-set of firms responding at least once between 2003 and 2010, for a total of 27,276 observations corresponding to 7,547 firms.

As we have recalled earlier, the RS1 survey directly provides *inter alia* information on group belonging of respondents and on the national/foreign ownership of the mother company. Matching such information with an external database (Aida, produced by *Bureau van Dijk*), we identify four typologies of firms to be used in our analysis:

- Firms belonging to domestic non-multinational groups (IGP),
- Firms belonging to domestic owned multinational groups (DMN),
- Firms belonging to foreign owned multinational groups (FMN),
- All other unaffiliated firms (NGP) that we use as baseline category in our estimations.

The availability of data on these categories of firms marks a fundamental departure from previous empirical analyses of the role of MNEs in technological linkage creation. In fact, as mentioned already in the introduction, due to data limitations, empirical studies have been generally unable to separate simultaneously foreign MNEs from domestic MNEs, and from the other domestic firms, and to compare these firm categories in terms of the technological linkages they create locally. The availability of data allowing to distinguish DMN from FMN is of central importance for the present analysis that aims to disentangle multinationality from foreignness factors affecting linkage creation. The micro matching has also allowed to gather additional information regarding firm "age", in terms of the number of years from establishment.

Definition of variables

The following variables available in the dataset will be used to test our research question on whether a diversity exists between FMN and DMN in setting-up R&D linkages:

- **Typology of firms.** As reported above, a flag about firm typology (IGP, DMN or FMN) will be tested against the baseline typology represented by all other unaffiliated firms (NGP)[4].

- The **Internal R&D efforts** of firms, measured first in terms of total Intra-muros R&D expenditures (*intraR&D*); we are also able to disentangle internal R&D human capital distinguishing between the share of researchers on total R&D employees (*research_x*) and the share of technicians on total R&D employees (*tech_x*);

- The degree of **Internationalisation** of firms, measured by the share of outward R&D on the total amount of R&D (*outwardR&D*). According to the literature giving importance to the determinants of R&D internationalization from a firm level perspective (e.g. Cozza et al., 2018a), this variable can be relevant also when considering the choice of channel to get new knowledge. Having higher amount of R&D abroad reveals the ability of the firm to deal with different actors and contexts, that is also relative to the ability of connecting different types of technological knowledge. Therefore, we expect this variable will be positive related to the choice of foreign partners, but a positive role can be expected also for the establishment of domestic linkages.

- The **Regional distribution of R&D,** measured by the share of Italian regions[5] in which they perform R&D (*regions*). This indicator can be considered an indirect control for the degree of experience of local contexts and of technological environments in particular, as R&D establishments are typically a way to set up technological windows and create opportunities for the development of knowledge intensive relationships with third parties. More precisely, it is a measure of how R&D activities are geographically spread throughout the country, reflecting firms' ability to monitor, and eventually gain access to, external knowledge assets that are diffused in the territory. Thus, the expectation here is that a higher share of regions should positively affect R&D linkages with domestic counterparts. In the case of FMNs active in Italy, controlling for regional distribution of their activities should help measure to what extent they have placed roots in the local technological environment, hence reducing their liability of foreignness. A higher share of regions should thus increase their propensity to create technical linkages with domestic counterparts and reduce their disadvantage relative to DMNs in this respect.

Table 1 summarises all the variables mentioned as they appear in the econometric analysis, while in table 2 descriptive statistics, divided according to firms' typology are reported.

[4]In the case of FMN data do not allow to separate foreign firms that are the result of Greenfield FDIs from those deriving from mergers and/or acquisitions. Admittedly, this is a limitation of the present analysis as it may be the case that acquired firms follow specific patterns of linkage creation. See *inter alia* Cefis (2010) who shows that firms involved in M&A tend to primarily focus on full integration of their knowledge bases, hence substituting R&D outsourcing with higher internal R&D efforts. However, the impact of acquisitions on linkage creation is also likely to be mediated by the age of firms (Asheim & Herstad, 2005). We will partially take this factor into account as we control for the age of observed firms (number of years from establishment).

[5] It is meant here that all firms, also those not belonging to a group, can have plants or laboratories distributed across Italy where they perform R&D.

Table 1 – Variable definition

Variable name and description	Source
Dependent variables	
Outdom: dummy variable equal to 1 if the firm outsourced R&D services to an unaffiliated partner in Italy	**Istat-RS1**
Outfor: dummy variable equal to 1 if the firm outsourced R&D services to an unaffiliated partner in another country	**Istat-RS1**
Coopdom: dummy variable equal to 1 if the firm had an R&D cooperation agreement with an unaffiliated partner in Italy	**Istat-RS1**
Coopfor: dummy variable equal to 1 if the firm had an R&D cooperation agreement with an unaffiliated partner in another country	**Istat-RS1**
Controls for firm typology	
IGP: dummy for "firm belonging to domestic non-multinational groups"	**Istat-RS1 / Bureau Van Dijk-Aida**
DMN: dummy for "firm in an Italian multinational group"	**Istat-RS1 / Bureau Van Dijk-Aida**
FMN: dummy for "subsidiary of a foreign multinational group"	**Istat-RS1 / Bureau Van Dijk-Aida**
NGP: dummy for "unaffiliated firm" (baseline category)	**Istat-RS1 / Bureau Van Dijk-Aida**
Other controls	
IntraR&D: (Natural Log of) Intra-muros R&D expenditure	**Istat-RS1**
Empln: (Natural Log of) number of firm employees, in Full Time Equivalent (proxy for firm size) and squared (**Empln_sq**)	**Istat-RS1**
Age: (Natural Log of) number of years from firm establishment	**Istat-RS1 / Bureau Van Dijk-Aida**
Intcc: Capital expenditures dummy for "Expenditure for machinery, equipment and software"	**Istat-RS1**
Main explanatory variables	
OutwardR&D: the amount of R&D (if any) undertaken by each firm's subsidiaries abroad	**Istat-RS1**
Research_x: share of researchers on total R&D employees	**Istat-RS1**
Tech_x: share of technicians on total R&D employees	**Istat-RS1**
Regions: share of Italian regions where Intra-muros R&D is undertaken	**Istat-RS1**

Table 2 – Descriptive statistics

NGP						**IGP**				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Empl	16,216	95.6949	736.3695	1	60603	4,168	268.125	1265.414	0.833333	26471
IntraR&D	16,216	643.3944	4281.956	1	330049	4,168	2843.437	18643.99	2	430449
Research_x	16,216	3.03224	15.557	0	756	4,168	10.30691	60.35877	0	1218
Tech_x	16,216	4.437815	25.1649	0	2620.2	4,168	11.34587	54.68218	0	1356
outwardR&D	16,216	110.9201	3536.429	0	410755	4,168	835.4631	17601.54	0	656019
intcc	16,216	0.359953	0.480001	0	1	4,168	0.363244	0.480992	0	1
FMN						**DMN**				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Empl	2,429	630.7837	1163811	1	11004	4,463	829.6388	3479.232	1	60480
IntraR&D	2,429	6481.481	27527.96	3	486786	4,463	5123.384	23507.63	1	779778
Research_x	2,429	23.09218	83.51501	0	1053	4,463	16.27004	69.5287	0	1322.8
Tech_x	2,429	22.17011	75.91033	0	1239	4,463	26.15862	157.1097	0	6559
outwardR&D	2,429	708.1836	3532134	0	55123	4,463	1349.752	9346.041	0	155296
intcc	2,429	0.531906	0.499084	0	1	4,463	0.490253	0.499961	0	1

As a first illustration, Table 2 shows that there exists a clear hierarchy across firm categories. Italian and foreign owned MNEs (DMN and FMN) are characterised by the largest size, the highest R&D expenditures (both intra- and extra-muros) and the highest number of researchers, while non-MNEs (IGP and NGP) are the smallest and worst R&D performers. On average, MNEs are between six and nine times as large as NGP firms, and this ratio is even higher when looking at intra-muros R&D expenditures. A similar hierarchy, albeit more limited, emerges when looking at the gap between MNEs and IGP firms; however, in terms of total extra-muros R&D expenditures, IGP firms show a higher average than FMN. Italian MNEs (DMN) exhibit the highest R&D extra-muros expenditure per firm, hence signalling a particularly high involvement in this form of contractual relationship.

These simple statistics provide a very preliminary evidence of two facts. On the one hand, MNEs do exhibit remarkable premia in terms of linkage creation as compared to non-MNEs, in line with their larger size, greater R&D budgets and higher productivity. This appears to roughly suggest that MNEs can be potentially better than domestic firms at R&D linkage creation. As anticipated earlier, this might reflect their higher capacity to generate valuable knowledge that can be exploited locally, and to absorb and utilise local knowledge. Moreover, these premia might reveal the availability of superior organisational competencies stemming from their experience of knowledge flows within and across firm boundaries. The next section will further test these premia and the underlying factors using econometric techniques.

Estimation methodology

As recalled earlier, our sample is made up of 27,276 observations and 7,547 firms over the years 2003-2010. Among them 391 are subsidiaries of foreign firms (FMN), 741 are domestic multinational (DMN), 1,186 are firms belonging to a purely domestic group (IGP) and 5,229 are

independent domestic firms (NGP). Following Holl and Rama (2014) we have built four dependent variables: ***Outdom, Outfor, Coopdom*** and ***Coopfor*** (see table 1).

Our aim is that of uncovering possible different patterns between DMN and FMN, and also between them and non-multinational firms. Through a MV probit regression we can take into consideration the possibility that simultaneously different technology sourcing strategies are chosen by the firm: therefore, they may have a certain degree of interdependence. When equations are positively correlated it means that the strategies are also complementary. In the same way as Holl and Rama (2014), the aim of the estimation is that of testing the choice of a particular channel of technology sourcing conditional on the choice of any other technological sourcing channel.

The estimated equation is the following

$$Y_m = \alpha + \beta_m + \upsilon_m \quad \forall m = 1,2,3,4$$

where Y_m corresponds to one of the channels of strategy sourcing that is equal 1 if the firm source technology through channel m, otherwise is equal 0. The errors u_m are considered to be distributed through a normal MV distribution.

β_m are our variables of interest that in our specific case are three dummy variable: FMN, that indicates whether the firm is the subsidiary of a MNE; DMN, that instead indicates whether the firm is a domestic multinationals and IGP, which stands for a domestic firm that is part of group of firms.

4. Empirical results

Main econometric results are reported in tables 3 and 4. In table 3, we report the basic model, including all standard controls plus the comparison of firm typologies. Results show that main control variables (firm size, intra-muros R&D expenditures and the dummy for capital expenditures) are all positively and significantly associated with all four dependent variables, as expected. Looking at firm typologies, we find that DMN have always a premium as compared to non-MNEs, regardless of the dependent variables. On the contrary, being FMN gives an advantage only when outsourcing R&D to foreign counterparts. Also for R&D cooperation with foreign partners, DMN have an advantage, although the significance of the coefficient is very low. Overall, this finding is broadly consistent with previous research: small and medium sized firms – which are the bulk of non-MNEs monitored in the RS1 survey – encounter greater obstacles to access external knowledge due to their limited absorptive capacity (Belderbos et al., 2004). Both firm size and intra-muros R&D expenditures are expected to have a substantial and significant impact on the creation of technical linkages with counterparts in general. This result appears to confirm the important role played by firms' ability to generate valuable technology that can be exploited locally, as well as their capacity to absorb local knowledge. This is consistent with a view of MNEs as characterised by a superior technology that should place them in a better position in terms of technical linkages as compared with non-MNEs.

However, this finding holds in the case of FMN only when foreign partners are considered and only in the case of R&D outsourcing. FMNs are less prone to local linkage creation than DMN, and even exhibit a disadvantage as compared to IGP firms in terms of local R&D cooperation. For FMNs, in other words, the liability of foreignness appears to more than compensate the advantages of multinationality. This result might confirm that R&D linkage creation is the result

of a balance between advantages of multinationality and disadvantages of foreignness. FMN will suffer a liability of foreignness as compared to domestic owned firms when they operate in the Italian research environment; and this will determine a relative disadvantage in terms of local linkage creation. However, FMN will face no such disadvantage relative to Italian firms when they operate elsewhere. In particular when dealing with R&D outsourcing to other markets, FMN will be in a better position than Italian firms, as they can rely on their own world-wide network of subsidiaries as bridge-heads for the development of transnational linkages (Zanfei, 2000; Castellani & Zanfei, 2006).

Table 3

VARIABLES	(1) outfor	(2) outdom	(3) coopdom	(4) coopfor
Age	-0.0321	-0.0193	-0.00242	-0.0938**
	(0.0436)	(0.0292)	(0.0273)	(0.0418)
Empln	-0.177***	-0.184***	-0.302***	-0.285***
	(0.0611)	(0.0364)	(0.0368)	(0.0482)
Empln_sq	0.0160**	0.0219***	0.0366***	0.0342***
	(0.00650)	(0.00399)	(0.00408)	(0.00507)
IntraR&D	0.201***	0.0607***	0.115***	0.169***
	(0.0229)	(0.0129)	(0.0120)	(0.0181)
Intcc	0.293***	0.283***	0.324***	0.235***
	(0.0427)	(0.0256)	(0.0237)	(0.0341)
DMN	0.192***	0.140***	0.131***	0.125**
	(0.0612)	(0.0410)	(0.0380)	(0.0556)
FMN	0.208***	-0.0691	-0.0470	0.0578
	(0.0785)	(0.0564)	(0.0507)	(0.0650)
IGP	0.0810	0.0365	0.0641*	-0.0107
	(0.0635)	(0.0365)	(0.0343)	(0.0519)
atrho2k	0.400***			
	(0.0207)			
atrho3k	0.198***	0.501***		
	(0.0178)	(0.0154)		
atrho4k	0.345***	0.202***	0.587***	
	(0.0264)	(0.0196)	(0.0213)	
Log-likelihood	-37589.6			
Constant	-2.583***	-0.734***	-0.777***	-1.741***
	(0.247)	(0.159)	(0.151)	(0.206)
Observations	27,276	27,276	27,276	27,276

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0:

chi2(6) = 4878.3 Prob > chi2 = 0.0000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All regressions include sector and year dummies

In the model presented in table 4, we add all the main explanatory variables, that is: the fact of having foreign subsidiaries performing R&D; the "quality" of R&D undertaken, proxied by the share of researchers vs. the share of technicians over total R&D employees; and finally the share of Italian region where each firm's R&D is undertaken. Not surprisingly, all these variables absorb a large share of explanation, but with some difference among them. Outward R&D is particularly relevant when looking at both R&D linkages with foreign partners. In theoretical terms, this finding suggests that the propensity of MNEs to undertake foreign R&D strategies (both outsourcing and cooperation) reflects their ability to coordinate knowledge exchanges across organisational units and countries.

Concerning the "quality" of R&D, the share of researchers on total R&D employees is always positive and significant, while the share of technicians is always not significant. Having a larger share of researchers is also particularly relevant for both R&D cooperation strategies. This might be explained as a higher signal of absorptive capacity (Cohen & Levinthal, 1989 and 1990): firms with more researchers are expected to better absorb knowledge generated by external partners, especially in cases of lower commitment strategies (cooperation agreements), less legally binding than outsourcing contracts.

Finally, also performing intra-muros R&D in a larger number of regions is always positive and significant, but coefficients are higher in the cases of "domestic strategies", that is for both R&D outsourcing and R&D cooperation with Italian partners. This result confirms the idea that more embeddedness in the Italian territory, via a widespread performance of R&D, leads to higher probability of undertaking R&D linkages with other partners resident in the same territory. In other words, the decision to set up R&D labs in different regions can be expected to increase firms' acquaintance with the technological environment in which they are active, thus reducing uncertainty and paving the way to exchanges of knowledge.

We then look at the differences across firm typologies after the introduction of these explanatory variables. They have in fact an effect on the premia related to the fact of being a DMN or an FMN. As compared to results in table 3, the premium of being DMN disappears when looking at foreign R&D cooperation; the coefficient and the significance of being DMN for foreign R&D outsourcing are strongly reduced; only the R&D linkages with local counterparts remain unaltered. This might mean that while DMN do maintain a higher propensity to set up Linkages with local firms and institutions, it was not the fact of being a DMN per se to yield an advantage in foreign R&D linking strategies. It is rather a matter of being (among DMN) a firm undertaking R&D also abroad and having large shares of researchers at home and a widespread R&D activity again at home.

On the other side, for FMN the only positive and significant strategy is that of foreign R&D outsourcing, while being FMN gives no advantage for all other strategies. It might be suggested that FMN in Italy do not contribute a lot in increasing local R&D, as they do not significantly outsource R&D in the host country (that is a positive outcome expected when attracting foreign firms), but they keep on using their foreign R&D network (eventually that of the home country, but this point cannot be controlled for with these data). One may venture suggesting that these results might have to do with the fact that these FMN are located in a country where private R&D efforts are limited and declining over time (see Cozza & Zanfei, 2014): hence they are likely

to be relatively marginal players in international R&D networks with a low involvement in R&D cooperation agreements.

Overall, based on these findings, we can suggest that it is not to be taken for granted that multinationals are better at R&D linkage creation: while both DMN and FMN benefit from the advantages of multinationality, this is not enough to promote the creation of technical linkages with local firms and institutions. An extra cost must be sustained to place roots in local contexts that not all MNEs are able to undertake, and this is a particularly challenging effort in the case of FMN. It might be suggested that FMN in Italy do not contribute a lot in increasing local R&D, as they do not significantly outsource R&D in the host country (that is a positive outcome expected when attracting foreign firms), but they keep on using their foreign R&D networks (possibly resorting, inter alia, to their home country knowledge base, but this point cannot be controlled for with these data). Instead, Italian DMN are confirmed to be first of all the "best R&D performers" among Italian firms, with a strong relative power in relation to other (smaller?) Italian R&D performers; but they do not seem to be particularly active in foreign R&D linking strategies.

Table 4

VARIABLES	(1) outfor	(2) outdom	(3) coopdom	(4) coopfor
Age	-0.0416	-0.0211	-0.00259	-0.0979**
	(0.0438)	(0.0293)	(0.0272)	(0.0421)
Empln	-0.114*	-0.110***	-0.215***	-0.198***
	(0.0632)	(0.0377)	(0.0370)	(0.0488)
Empln_sq	0.00934	0.0132***	0.0267***	0.0253***
	(0.00683)	(0.00419)	(0.00412)	(0.00518)
IntraR&D	0.190***	0.0552***	0.118***	0.169***
	(0.0229)	(0.0130)	(0.0121)	(0.0178)
Intcc	0.264***	0.261***	0.292***	0.187***
	(0.0433)	(0.0259)	(0.0239)	(0.0346)
OutwardR&D	1.737***	0.680**	0.393	1.032***
	(0.303)	(0.267)	(0.290)	(0.265)
Research_x	0.204**	0.282***	0.466***	0.706***
	(0.0936)	(0.0582)	(0.0521)	(0.0778)
Tech_x	-0.131	-0.0335	-0.0102	0.0943
	(0.0884)	(0.0516)	(0.0472)	(0.0757)
Regions	1.311**	2.361***	2.031***	1.237***
	(0.612)	(0.494)	(0.511)	(0.474)
DMN	0.121*	0.120***	0.112***	0.0791
	(0.0622)	(0.0413)	(0.0381)	(0.0565)
FMN	0.194**	-0.0891	-0.0853*	0.00642
	(0.0788)	(0.0566)	(0.0505)	(0.0649)
IGP	0.0746	0.0305	0.0572*	-0.0229
	(0.0636)	(0.0367)	(0.0342)	(0.0520)
atrho2k	0.395***			
	(0.0206)			

atrho3k	0.190***	0.492***		
	(0.0177)	(0.0153)		
atrho4k	0.338***	0.186***	0.572***	
	(0.0266)	(0.0195)	(0.0215)	
Log-likelihood	-37244.5			
Constant	-2.698***	-1.010***	-1.172***	-2.239***
	(0.256)	(0.165)	(0.159)	(0.222)
Observations	27,276	27,276	27,276	27,276

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: chi2(6) = 4632.76
Prob > chi2 = 0.0000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All regressions include sector and year dummies

In table 5 we show the results relative to simple probit estimations that take into consideration the choice of multiple channels, but without considering them as interdependent. This empirical exercise can be considered a sort of robustness check in order to understand whether when choosing multiple channels, the same types of firms confirm the hierarchy previously identified. In column 1 and 2 we consider two opposite situations: in column 1 the dependent variable (dummy_all) is built as a dummy variable that is equal to 1 if a firm displays all types of linkages at the same time. Instead, Column 2 refers to the situation in which a firm has no linkage at all (dummy_no): the variable is built as a dummy equal to 1 when the firm does not show any sourcing behaviour neither for cooperation nor for outsourcing. In the first case it is clearly visible that foreign multinationals are those that with higher probability will engage in all types of sourcing strategies rather than domestic multinationals and domestic firms. These firms, being embedded in both networks, internal and external to the firm, will be able to deal with multiple channels of sourcing strategies. In the second case instead, we find a negative and significant coefficient for domestic multinational and local firms, while foreign multinationals still maintain a positive coefficient. This stands for the fact that more locally oriented firms will not chose to stay in isolation because their knowledge "*completeness*" will be negatively affected as they will not dispose of an adequate level of technological capabilities within their boundaries. In columns 3 and 4 we take into consideration, again, two opposite situations: in the first we refer to firms having simultaneously Italian partners (dummy_it)[6] or foreign partners (dummy_for), regardless of the linkage strategy adopted. Results confirm domestic multinational mainly choose national counterparts while foreign multinationals mainly choose foreign counterparts (including those based in their own country of origin, and foreign partners they are likely to be considered more reliable or endowed with better knowledge assets than Italian ones).

[6] In building this variable we do not impose the restrictions that the firm may eventually have also foreign/Italian partners.

Table 5 – Multiple strategies

VARIABLES	(1) dummy_all	(2) dummy_no	(3) dummy_it	(4) dummy_for
Age	-0.00472	0.00554	-0.0412	-0.0335
	(0.0651)	(0.0268)	(0.0320)	(0.0622)
Empln	-0.135*	0.259***	-0.106***	-0.110
	(0.0816)	(0.0378)	(0.0406)	(0.0792)
Empln_sq	0.00823	-0.0318***	0.0134***	0.00766
	(0.00850)	(0.00428)	(0.00440)	(0.00863)
IntraR&D	0.251***	-0.117***	0.0710***	0.237***
	(0.0343)	(0.0118)	(0.0143)	(0.0328)
Intcc	0.239***	-0.316***	0.269***	0.238***
	(0.0697)	(0.0236)	(0.0282)	(0.0636)
OutwardR&D	1.455***	-0.854***	0.519*	1.637***
	(0.306)	(0.254)	(0.289)	(0.295)
Research_x	0.169	-0.487***	0.277***	0.217*
	(0.128)	(0.0515)	(0.0632)	(0.115)
Tech_x	-0.213	0.000295	-0.0790	-0.171
	(0.132)	(0.0453)	(0.0575)	(0.119)
Regions	1.172	-3.053***	2.279***	0.793
	(0.823)	(0.594)	(0.518)	(0.817)
DMN	0.104	-0.107***	0.148***	0.0715
	(0.0939)	(0.0376)	(0.0440)	(0.0875)
FMN	0.257**	0.124**	-0.0168	0.219**
	(0.115)	(0.0503)	(0.0600)	(0.105)
IGP	-0.0382	-0.0737**	-0.00331	-0.0107
	(0.104)	(0.0331)	(0.0409)	(0.0947)
Constant	-3.294***	0.884***	-1.301***	-3.241***
	(0.336)	(0.149)	(0.185)	(0.336)
Observations	27,276	27,276	27,276	27,276

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All regressions include sector and year dummies

5. Conclusions

This paper has addressed the issue of whether and to what extent foreign MNEs active in a given country differ from domestic owned MNEs in terms of R&D linkages with both local and foreign counterparts. Using firm level data on R&D outsourcing and R&D cooperation of firms active in Italy , we have shown that it is not to be taken for granted that multinationals are better at R&D linkage creation: while both DMN and FMN benefit from the advantages of multinationality, it is mainly firms that invest in high level and quality of R&D, and have a long

and geographically diffused presence of R&D labs on the territory that exhibit the best performances in terms of local linkage creation. An extra cost must be sustained to place roots in local contexts that not all MNEs are able to undertake, and this is a particularly challenging effort in the case of FMN, which deal with some degree of liability of foreignness that DMN do not suffer. FMN do not seem to contribute so much in increasing local R&D, as they do not significantly outsource R&D to Italian counterparts (that is a positive outcome expected when attracting foreign firms). In fact, they appear to mainly use their foreign R&D networks to convey and exploit valuable knowledge. Instead, Italian DMN do perform higher and better R&D than other Italian firms, they set up R&D linkages with local counterparts, but they do not seem to be particularly active in foreign R&D linking strategies. This finding, combined with the relatively low and lowering profile of FMN active in this country, induces concern on the actual involvement of the Italian economy in global knowledge networks.

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