Are multinationals better at creating technical linkages with local firms?

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Abstract Keywords: Absorptive capacity; R&D, technical linkages; Multinationals

JEL: F10; F23; O33

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Abstract
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1. Introduction
An extensive literature has developed the idea that multinational enterprises (MNEs) possess extra-advantages compared to other firms in their home and host markets. The idea draws back to Hymer (1960), and has been subsumed in both international business studies and international trade literature (Dunning 1977, Cantwell 1989, Helpman et al. 2004, Girma et al. 2004, Criscuolo et al. 2010, Guadalupe et al. 2012, Piening et al. 2016). This way of theorizing MNEs as peculiar institutions endowed with ex-ante advantages is associated with two other topical views that have prevailed in the literature. On the one hand, given their superior technology, MNEs are likely to generate spillovers to host economies (Branstetter 2006, Meyer & Sinani 2009, Girma et al. 2014). On the other hand, MNEs can be expected to use their own knowledge assets as a basis for further learning, thus giving rise to "asset seeking", "technology sourcing" and "asset augmenting" strategies (Dunning & Narula 1995, Le Bas & Sierra 2002, Narula & Zanfei 2005, Griffith et al. 2006, Rabbiosi & Santangelo 2013). Important efforts have been made to explain and empirically test under which circumstances MNEs create knowledge flows in either direction (from MNEs to local contexts or vice-versa). It is also widely accepted that such knowledge flows largely rely on linkages with local firms and institutions, which are a fundamental channel for both the generation of externalities, and for the exchange and absorption of new ideas. The case of technical linkages - i.e. alliances and contractual agreements involving R&D collaboration and/or R&D outsourcing - is

particularly relevant, as they involve non trivial exchanges of technology and hence represent fundamental vehicles for (bilateral) knowledge spillovers between MNEs and local counterparts.

However, the ability of MNEs to develop linkages of this kind cannot be taken for granted. In other words, while the fact that MNEs are better at R&D and innovation is well documented, this does not necessarily imply they are also more prone than other firms at developing technical linkages with *local* counterparts. For instance, are MNEs better at creating on-site technological relationships than companies that are not internationalised at all, but may have greater abilities to place their roots in the local economy? In a similar vein, one may venture wondering whether foreign owned MNEs in a given market are in a better or worse position in the creation of technical linkages, as compared to domestic owned MNEs.

Differences in the ability and propensity to create technical linkages with local counterparts reflect the nature of institutions involved: their ability to invest in R&D and in innovative activities; their exposure to, and ability to coordinate activities in, different technological contexts; and their experience of local contexts. We suggest that MNEs are characterised by a specific mix of advantages and disadvantages in this respect. On the one hand, they are generally characterised by higher capacities to carry out and manage R&D activities, and to govern knowledge flows stemming from different and geographically dispersed sources. These features of MNEs will translate into higher absorptive capacity and greater economies of common governance. On the other hand, MNEs need time and resources to get acquainted with the specific norms, codes of conduct and competitive conditions characterising the different and geographically dispersed context in which they are active. Thus MNEs are generally not as well rooted in any individual host economy as indigenous companies are. In other words, MNEs may be characterised by a relative disadvantage compared to domestic firms, in terms of their experience of local contexts. This might well limit the ability of MNEs to interact with indigenous actors, effectively organise economic transactions with them, and ultimately put a brake on technical linkages with local firms and institutions. From this perspective, MNEs are likely to differ from one another in terms of their combination of advantages and disadvantages, hence determining heterogeneous patterns of linkage creation.

Severe data limitations have by and large constrained the evaluation of how firms differ in linkage creation. In particular, there has been virtually no previous study empirically assessing how MNEs compare with other firms in terms of knowledge exchanges and technical cooperation. Analysing whether and under which circumstances MNEs are in the position of setting up technical linkages with local counterparts is key to the design of appropriate policies for the attraction of inward FDIs, and for structural policies to favour the internationalisation of domestic companies.

This paper contributes to fill in a gap in the theoretical and empirical literature, and compares the propensity of different categories of firms to set up technical linkages, with a specific focus on Italy. Using a novel dataset produced by the Italian Bureau of Statistics (ISTAT) we are able to evaluate how firms differ in their involvement in two typologies of technical linkages: R&D subcontracting and R&D cooperation agreements. An important distinction we are enabled to make is between different categories of firms undertaking linkage creation decisions: national independent companies, firms belonging to domestic groups with no foreign activities, firms belonging to domestic owned multinational groups, and companies belonging to foreign owned

multinational groups. Moreover, for all categories of firms, we will be able to isolate the subset of their linkages involving local counterparts (i.e. Italian firms and institutions).

We will show that, even controlling for firms' absorptive capacity and for their experience of local contexts, multinationality is associated with a higher propensity to linkage creation in general. Moreover domestic owned MNEs are more prone to R&D contracting out, while foreign MNEs are better at developing R&D cooperation with external parties. Finally, we will highlight that foreign MNEs active in Italy are much less prone to set up linkages with *local* counterparts, than with foreign ones.

The remainder of the paper is structured as follows. Section 2 briefly recalls the main streams of background literature. Section 3 sketches the analytical framework that will be used to discuss the role of MNEs in technical linkage creation. Section 4 describes the data sources and the variables we will use in the empirical analysis. Section 5 illustrates the empirical strategy and results. Section 6 concludes.

2. Background literature

To examine the comparative advantages of MNEs in linkage creation, one may refer to at least three streams of literature.

A first line of research highlights the role of firm specific advantages in the creation of technical linkages. On the one hand, collaborative ventures and other contractual agreements can be seen as a key strategy to exploit distinctive, *ex-ante* advantages in a foreign market. On the other hand, MNEs can be expected to set up linkages to gain access to external knowledge assets and competencies that are missing (*ex-post* advantage creation).

These views of linkage creation strategies have their theoretical foundation in literature on ownership advantages, which was first developed by Hymer (1960). The original idea was that MNEs are characterised by a "superior technology" that allows them to overcome the "liability of foreignness", i.e. the costs and risks of cross-border operations. This superior technology consists of a bundle of largely immaterial resources, including R&D, technical skills, managerial practices (Dunning 1977, Cantwell 1989, Caves 1996), and of organisational competencies and routines for the effective governance of complex cross-border transactions (economies of common governance) (Dunning 1993). This way of theorising MNEs as institutions endowed with extraordinary capacity to innovate and organise cross-border activities helps justify the early phases of multinational expansion in post World War II (Vernon 1966, Kindleberger 1969, Stopford & Wells 1972). In more general terms, international operations aimed at extracting value from pre-existing advantages of MNEs have been dubbed in the literature as "asset exploiting" strategies (Dunning 1993). From this perspective, linkages with local firms can complement FDIs as market penetration strategies. In fact, while MNEs generally consider wholly owned subsidiaries, alliances, joint ventures, and licensing agreements with local firms as alternative entry modes (Agarwal & Ramaswami 1992), once they have entered a market, they may well resort to linkages in order to reinforce their ability to explore market opportunities, adapt and exploit their proprietary technology in the host country (Castellani & Zanfei 2004).

Other developments in this stream of literature have emphasised the dynamic nature of the process through which MNEs develop and enrich their competitive advantages over time, as a

result of their experience of, and access to, foreign markets and local sources of knowledge (Dunning 1998, Cantwell & Narula 2001, Narula 2014). The emphasis has thus moved from traditional "asset exploiting" cross-border activities, based on the adaptation of the advantages that MNEs are already endowed with, towards "asset seeking" and "asset augmenting" strategies, aimed at gaining access to complementary, ex-post advantages. Even more than in the case of asset exploiting, technology sourcing implies that MNEs learn from local contexts and adopt a reciprocity approach in their exchanges with local counterparts. Therefore the creation of technical linkages with indigenous firms and institutions is an essential component of asset seeking and asset augmenting strategies (Cantwell & Mudambi 2005, Castellani & Zanfei 2006, Griffith et al. 2006, Jindra et al. 2009, Puga & Trefler 2010, Rabbiosi & Santangelo 2013). There are connections here with the extensive literature on multinational embeddedness, which emphasises that the nature and intensity of relationships with local counterparts affects the innovative performance of MNEs (Andersson et al. 2002, Jindra et al. 2009, Piening et al. 2016).

A second and related strand of literature has developed the idea that internal R&D is a fundamental source of the ability to absorb, select and use external knowledge. Economics of innovation has long emphasized the links between internal and external knowledge that reflect the systemic nature of technical change (Mowery & Rosenberg 1989, Cohen & Levinthal 1989, 1990). This point has been incorporated also in industrial organization approaches in general. The latter models have traditionally emphasized a dual role of spillovers: outgoing spillovers may reduce the incentives of firms to enter cooperative agreements while incoming spillovers increase the attractiveness of cooperation (De Bondt & Veugelers 1991; Kesteloot & Veugelers 1995; Eaton & Eswaran 1997). More recent IO models take into account that firms can attempt to manage spillovers, trying to minimize outgoing spillovers while at the same time maximizing incoming spillovers (Cassiman et al. 2002; Martin 2002; Amir et al. 2003). Firms can increase the effectiveness of incoming spillovers by investing in "absorptive capacity". Empirical research has generally recognized that firms significantly differ in their access to external knowledge due to their level of "absorptive capacity", which in turn is most often identified in terms of some measure of internal R&D efforts[1] (Arora & Gambardella 1990, Veugelers 1997, Piga & Vivarelli 2004, Cassiman & Veugelers 2006, Belderbos et al. 2014, Spithoven & Teirlinck 2015).

Concepts borrowed from absorptive capacity literature have also contaminated the international business literature and theorizing on the advantages of multinationality. The idea is that in each location, the MNE absorbs and adapts its Ownership advantages in response to the Location advantages available, and through linkages with co-located firms adapts as well to the Ownership advantages of these unaffiliated firms (Narula & Santangelo 2012).

A third stream of studies has emphasised that FDIs may produce important effects on host economies to the extent that MNEs create linkages with local firms. MNEs can generate positive externalities by expanding the demand for local inputs, hence making it possible for suppliers to exploit economies of scales (Hirschmann 1958, Rodriguez-Clare 1996, Smarzynska Javorcik 2004);

[1] Since the seminal contributions of Cohen and Levinthal, Absorptive Capacity has been measured in different ways. By reviewing these methods, Duchek (2013) recalls that input-oriented proxies of AC are all concerning the amount of R&D expenditure, of R&D human capital and of R&D expertise. Similar proxies will be used in the empirical section of this paper.

by voluntarily and involuntarily transferring valuable knowledge that will eventually be incorporated in the goods produced locally (Dunning 1958, Mansfield and Romeo 1980, Jenkins 2005); and by affecting the demand and supply of human capital in the host economy (ILO 1981, Fosfury et al 2001). These contributions have paved the way to a very prolific literature wherein linkages with local firms are considered a key channel for the generation of externalities accruing to the host economy. A number of studies - discussed, *inter alia*, in Irsova & Havranek (2013), Gorodnichenko et al. (2014), and Castellani et al. (2015) - have investigated under which circumstances the creation of linkages outbalances the negative externalities that may well be associated with multinational presence, such as market stealing and the subtraction of natural resources and human capital. Factors affecting linkage creation and knowledge spillovers include: the ability of local firms to absorb and utilise foreign knowledge (Cantwell 1989); the variety of inputs produced locally relative to the demand expressed by foreign companies (Rodriguez-Clare 1996); the R&D intensity of foreign subsidiaries and their ability to transfer valuable knowledge (Castellani & Zanfei 2006); the mandate assigned to foreign subsidiaries in the organisation of the investing MNE (Santangelo 2009); the role of market competition in easing or inhibiting linkage creation and, hence local spillovers (Perri et al. 2013).

3. Analytical framework and hypotheses

The joint consideration of the three lines of research we have briefly recalled leads us to argue that the answer to our research questions (Are MNEs better at linkage creation? How are they placed at setting up linkages with local counterparts in particular?) depends on a fundamental trade off. On the one hand, MNEs are more prone to get involved in technical linkages because they are likely to have greater "absorptive capacity", and benefit from higher "economies of common governance", as compared to domestic firms. On the other hand, MNEs face substantial costs to comply with technical, institutional and competitive conditions that are largely unfamiliar and location specific.. Altogether these costs will reduce the propensity of MNEs to create technical linkages with local counterparts.

On the positive side of this trade-off, one should first consider how MNEs are positioned in terms of the R&D efforts they are able to carry out. As recalled earlier, R&D is indeed the most commonly used measure of absorptive capacity (Duchek 2013). Cohen & Levinthal (1989) themselves identify R&D activities as a repository of firms' ability to identify, assimilate, and exploit knowledge from the environment. Arora & Gambardella (1990) argue that R&D expenditures reflect the ability to evaluate the quality of external knowledge assets. Kim (1997) observes that R&D efforts also allow firms to employ external experts who are aware of technological developments in emerging fields. Gao et al. (2008) use the ratio of R&D personnel over total employees as an indicator of the quality of human capital that can positively affect the capacity to absorb external knowledge. Veugelers (1997) and Schmidt (2010) use more direct measures of the quality of R&D personnel, such as the share of researchers with a doctoral degree, and find that they positively affect the propensity of firms to set up technical collaborations.

These developments in empirical research can be combined with the extensive literature highlighting that MNEs are large R&D spenders and they generally carry out more research

activities abroad than local firms in the foreign countries in which they are active (UNCTAD 2005, Dachs et al. 2014). A key implication is that MNEs are likely to have a relative advantage in terms of absorptive capacity that will facilitate them in setting up technical linkages.
This line of argument leads us to:

Hypothesis 1: Subsidiaries of MNEs can be expected to possess a greater absorptive capacity as compared to purely domestic firms, and this will positively affect their propensity to the creation of technical linkages.

A second fundamental driver of linkage creation in the case of MNEs is their superior capacity to exploit what Dunning (1993) called *economies of common governance*, that is the ability to combine firms' proprietary resources with complementary assets. These economies partly derive from size, diversification, economies of scope and specialisation which are more frequent when firms organise themselves into complex groups rather than in the case of independent companies. However, Dunning suggested that part of such advantages "specifically arises because of multinationality". In his words, the economic benefits related to multinationality include the "ability to take advantage of geographic differences in factor endowments, government interventions, markets" as well as the ability to reduce risks or to "learn from societal differences in organisational and managerial processes and systems". We argue that these advantages are likely to be associated with the geographic spread of internal and external networks through which MNEs organise their cross-border generation and absorption of knowledge (Zanfei 2000, Castellani & Zanfei 2006). MNEs will thus benefit from the fact that each of their units have access to geographically dispersed knowledge assets of other units, via internal networks of subsidiaries belonging to the multinational group. By the same token, individual units of a MNE have access to a wide set of knowledge bases via external networks, i.e. through inter-firm cooperation and technical alliances developed by each individual node of the internal network. In a similar vein, Narula (2014, page 6) observes that advantages of common governance "are capabilities for the creation and coordination of efficient internal hierarchies and markets within MNEs that span a complex diversity of locations". One may further emphasise that these economies also encompass the ability of MNEs to exploit the complementarity between internal and external networks (Castellani & Zanfei 2004). In fact, MNEs may well rely on internal networks of subsidiaries as bridge-heads to exchange key assets (including knowledge) across firm boundaries, through the creation of external linkages in different sectors and locations.
Hence, hypothesis 2 can be formulated as follows:

Hypothesis 2: The geographic spread of MNEs will generate economies of common governance that favour linkage creation.

On the negative side of the trade-off, one needs to consider that MNEs face substantial costs in their efforts to accumulate an adequate experience of local contexts. Of course this corresponds to a disadvantage in comparison with domestic firms. While it is widely acknowledged that FDIs allow greater proximity to local contexts, relative to exports, licensing and arms length (Brainard

1997), foreign affiliates are most likely to have a lower knowledge of the characteristics of markets in which they are active, as compared to domestic firms. This is generally the case of MNEs in the early stages of their presence in a foreign country. Extant literature has suggested that MNEs with a limited experience of local contexts will face a high "behavioural uncertainty" with negative effects on linkage creation (Castellani & Zanfei 2004). As suggested by Robertson & Gatignon (1998, p. 520), internal (or behavioural) uncertainty concerns the difficulty of observing and measuring the adherence of contracting parties to the contractual arrangements. This kind of uncertainty is conducive to opportunistic behavior, in the absence of control mechanisms. The inexperienced firm might not be in a position to assess accurately the performance (outputs) of economic agents active in foreign markets, and be induced to limit interactions with local counterparts. Behavioural uncertainty will also reduce the ability of MNEs to adequately perceive the competitive conditions in the local market. This is likely to determine a shift in the expected balance between incoming and outgoing spillovers and will further reduce the incentives of MNEs to set up linkages with local firms (Perri et al. 2013)

The negative effect of uncertainty on linkage creation is likely to be higher the greater the cultural (and geographic) distance between MNEs' HQs, local firms and local institutions, as this will create barriers to the transfer of complex, tacit knowledge (Dow & Karunaratna 2006, Castellani et al. 2013).

From this perspective, MNEs may attempt to reduce uncertainty by accumulating experience of individual markets. This is a costly and time consuming process that will eventually imply the set up of local subsidiaries, their acquaintance with context specific institutional and competitive conditions, and the creation of mutual trust with local counterparts. To the extent that MNEs succeed in this effort, they will eventually increase their propensity to set up linkages with local firms and institutions. In the case of *technical* linkages, MNEs' decisions will be particularly affected by their acquaintance with the *technological environment* in which they are active. This specific type of acquaintance (technological experience) is likely to reflect the efforts of MNEs to establish R&D activities locally. MNEs will thus significantly differ from one another in terms of their experience of local contexts and technological environments, and hence exhibit remarkably different patterns of local linkage creation.

Therefore we submit the following hypothesis:

Hypothesis 3: Local linkage creation is positively affected by the experience of local contexts accumulated. Foreign firms will differ from one another in this respect and will generally be in a worse position as compared to domestic firms.

The propensity of MNEs to set up technical linkages is also limited by coordination and communication costs. By extending their global reach, firms will increase their ability to transmit, and gain access to, knowledge across national borders, but they will also face higher coordination costs (Teece 1977). Moreover, the international technology transfer is likely to be limited by the "bandwidth" of knowledge flows that MNE units can set up and manage (Narula 2014). Although being generally considered to be more efficient than independent firms in expropriating the opportunities of cross-border markets for knowledge, MNEs may not able to "exploit the benefits

of multinationality". That is, they may end up being "simply a multi-locational collection of free-standing establishments held together by common ownership" (Narula 2014).
One might venture arguing that coordination costs as well as bandwidth limitations are likely to be a function of the number of nodes characterising multinational networks. In fact, expanding multinational networks *per se* can be expected to increase the organisational burden without necessarily improving the exploratory capacity of the firm. Also the geographical spread of foreign subsidiaries might indeed be associated with coordination and communication costs. However, we expect that these disadvantages of geographic spread be at least partially compensated by the advantages of utilising knowledge in different application contexts, and by the higher probability to gain access to geographically dispersed sources of new ideas and competencies. Hence "diseconomies of common governance", and hence lower incentives to set up linkages, are likely to be associated with the mere *extension* of the number of subsidiaries (and less so with the *variety* of locations).
Therefore, we introduce the following hypothesis:

Hypothesis 4: The number of foreign subsidiaries is likely to increase the diseconomies of common governance, hence reducing the propensity of MNEs to set up technical linkages.

To evaluate the relative propensity of MNEs to set up technical linkages one thus needs to tackle both sides of the examined trade-off, and test the four hypotheses we have discussed.

4. Data and variable definition

The Italian business R&D survey (RS1)

The main data source for the analysis conducted in this paper is the novel dataset based on the Italian business R&D survey (RS1). This survey is conducted yearly by the National Bureau of Statistics (ISTAT), in accordance with the OECD Frascati Manual (2002) guidelines. It follows a census approach, thus targeting all the potential R&D performers active in the country. 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. Among these data, the ones used in this paper refer to the amount of intra-muros R&D expenditures; to the number and main occupation of employees (e.g. researchers vs. total R&D employees); to the location of their intra-muros R&D expenditures in the country (Italian regions where firms' R&D is actually conducted).
The RS1 survey also provides measures of technical linkage creation, such as the amount of extra-muros R&D expenditure and the (dichotomy) variable on R&D cooperation. We shall use our Extra-muros R&D and R&D cooperation indicators as dependent variables in all the econometric exercises in section 5. Each individual firm monitored in the RS1 dataset can also be distinguished according to several other characteristics which we will use as control variables: its size, expressed in terms of total employees; its capital expenditure; its principal (3 digit) sector of activity; and the (NUTS2) region in which it is located in Italy. A key issue in the present analysis will consist in controlling for specific firm categories according to their (foreign or domestic) ownership; their belonging to a group rather than being independent companies.

In the case of R&D contracting out and of R&D cooperation, the survey allows to distinguish different types of counterparts. For the purposes of this paper we single out contractual relations set up by each firm with "local counterparts", i.e. with Italian companies and institutions. The RS1 survey over the 2001-2010 period includes all firms active in Italy which have responded to the R&D survey at least once over the period, for a total of 39,152 observations corresponding to 13,675 firms (see Bonaccorsi & Perani 2014, for further details on the panel).

Data matching and definition of variables

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. Such pieces of information allow defining three firm categories: firms not belonging to a group (NGP), firms belonging to a domestic owned group (TIGP, which stands for Total Italian Group firms) and subsidiaries of foreign firms (FOR). For the purposes of this paper, a matching has been performed with an external database (Aida, produced by *Bureau van Dijk*), to further distinguish among TIGP firms those that are domestic MNEs (ITM) and those that belong to national groups but are not MNEs (IGP). The former are those TIGP firms that, according to *Aida*, control at least one subsidiary abroad; the latter are those which control only domestic subsidiaries.

The micro matching has also allowed to gather additional information for all firms (whenever possible) regarding: firm "age" in terms of the number of years from establishment; firm productivity (Labour productivity and Approximate Total Factor Productivity, ATFP, as calculated by Head & Ries 2003); number of foreign countries of activity and of foreign subsidiaries controlled (only for ITM and FOR).

The final outcome of this merge is a dataset comprising 34,630 observations corresponding to 11,586 firms. As illustrated in figure 1, NGP firms represent about 60% of total observations, FOR hold a minor and diminishing share in the sample, which has halved from slightly more than 10% at the beginning of the decade to less than 6% in 2010, while IGP and ITM almost equally split the remaining share of observed data. This trend is revealing of the changing composition of R&D performers in Italy, which appears to be characterised by a large majority of SMEs with low R&D budgets, and by a diminishing role played by relatively larger R&D spenders as in the case of foreign owned multinationals. Further evidence on such a decrease in the weight of foreign multinationals as R&D performers in Italy can be found in Cozza & Zanfei (2014).

Figure 1 about here

For all firm categories, the data allow us to identify three distinctive characteristics which we expect to have an impact on the creation of technical linkages with local counterparts:

- The **Internal R&D efforts** of firms, measured both in terms of "quantity" (total Intra-muros R&D expenditure) and in terms of its "quality". Our measure of R&D quality is represented by the share of researchers on total R&D employees. We consider these measures as indicators of firms' *absorptive capacity*. It is intended here that firms' ability to absorb knowledge from external counterparts is higher the more they spend in R&D. Moreover, it is suggested that the composition of R&D personnel also matters. In fact, while firms'

innovative performance may well be the result of a combination of researchers with other technical and administrative personnel that support the activities of researchers, it is mainly the latter that are most likely to have the skills needed to interpret, evaluate and eventually absorb external knowledge.

- The **Regional distribution of R&D,** measured both by the number of Italian regions[2] in which they perform R&D (ITregions), and by a dummy (Top5Regions) taking value one if the observed firm is present in at least one of the top 5 Italian regions (Lombardia, Piemonte, Lazio, Emilia-Romagna, Veneto, where altogether the 75% of Italian business R&D is performed). These indicators can be considered as indirect controls 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, we consider *ITregions* a measure of how geographically spread R&D activities are throughout the country, reflecting firms' ability to monitor, and eventually gain access to, external knowledge assets that are diffused in the territory. *Top5regions* is more likely to identify firm's capability to locate their R&D where higher level knowledge is concentrated (Cantwell & Iammarino 2003). We expect this indicator to be more correlated with quality, rather than with the intensity of technical linkages. Moreover, while the top regions are likely to be characterised by greater technological stimuli and opportunities, competition may well be fiercer in those regions, thus making it riskier for firms to set up linkages in those areas.
- The degree of **Internationalisation** of firms, measured by two indexes: the Network Spread index (*NSi*, see Ietto-Gillies 1998) which corresponds to the number of foreign countries where each single firm operates, divided by the total number of countries where all firms in this sample operate; and the Internationalisation index (*Ii*) which measures the share of foreign subsidiaries on total firm subsidiaries (including domestic ones). We deem these indicators should capture the effects of MNE specific economies (and diseconomies) of common governance, which should affect linkage creation. *Ii* is a measure of the extension of internal networks of MNEs, while *NSi* proxies the variety of foreign contexts in which MNEs are active. On the one hand, higher *Ii* and *NSi* should be correlated with greater opportunities to explore and gain access to transnational sources of knowledge, which in turn can be circulated throughout the multinational group and eventually transferred to external parties. On the other hand, the degree of internationalisation of firms, and particularly the extension of multinational networks, might be associated with higher coordination and communication costs, which could reduce the effectiveness of (knowledge) transactions (see section 3 for a discussion of this point). Depending on which of the two effects prevails, one might expect to obtain a different impact in terms of linkage creation.

[2] 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 summarises all the variables mentioned as they appear in the econometric analysis (see next section).

Table 1 about here

As a first illustration, Table 2 shows that there exists a clear hierarchy across firm categories. Italian and foreign owned MNEs (ITM and FOR) are characterised by the largest size, the highest R&D (total and per firm) expenditure and the top productivity, while Italian firms not belonging to groups (NGP) are the smallest and worst R&D performers, and Italian firms belonging to non multinational groups (IGP) exhibit intermediate values. MNEs are between eight and nine times as large as NGP firms and more than twice the size of IGP companies. Their R&D expenditure is between nine and ten times as high as in the case of NGPs, and more than twice the R&D budget of IGPs.

A similar hierarchy emerges when one observes the average intensity of the two indicators of linkage creation, namely extra-muros R&D expenditure and the percentage of firms involved in R&D cooperation. The propensity to set up technical linkages in the case of MNEs is about twice as high as the one observed for NGP firms, and approximately 60% higher than in the case of IGP firms, with the highest premia in the case of R&D contracting out. Italian MNEs appear to have the highest propensity to extra-muros R&D, while foreign MNEs are the most prone to set up R&D cooperation agreements.

Table 2 about here

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, in line with their larger size, greater R&D budgets and higher productivity. This appears to roughly confirm that MNEs are better at linkage creation, and this might reflect their higher capacity to absorb and utilise external knowledge, as well as superior organisational competencies stemming from their experience of knowledge flows within and across firm boundaries on a global scale. On the other hand, there may be differences between Italian and foreign owned multinationals (ITM and FOR), with the former exhibiting a higher propensity to R&D contracting out, and the latter being better at R&D cooperation. Section 5 below will further test these premia and the underlying factors using econometric techniques.

5. Testing the relative propensity of MNEs to set up technical linkages

We have run regressions to test differences in the propensity of firms to create technical linkages in the Italian industry, conditional on a number of controls. Data allow us to evaluate whether and to what extent MNEs are in a better position to create such linkages in comparison with other firm categories, and to differentiate linkage creation in general from the creation of linkages with local counterparts. See table 1 for variable definitions and tables 2 and 3 for descriptive statistics. Given the richness of available data, we are thus able to tackle both of the research questions discussed earlier: first, whether MNEs are better at developing technological relationships with external

parties, whatever their nature and nationality; second, whether MNEs are also better at setting up linkages with local counterparts in particular. As the creation of technical relationships with *local* counterparts is a key vehicle for knowledge transfer and absorption, answering these questions is crucial to understanding both firm competitiveness *and* local development.

Our empirical strategy will be as follows. As a first, preliminary step, we will introduce a rudimentary proxy of "economies of common governance", by controlling for (multinational) group belonging as a differentiating factor in linkage creation. Second, we will take absorptive capacity into account, using different measures of the quantity and quality of internal R&D efforts. Third, we will introduce proxies of regional distribution of R&D activities to capture the experience of local contexts in which firms are active. Fourth, we will control for the degree and geographic spread of internationalization of MNEs, to evaluate the impact of multinational-specific economies (and diseconomies) of common governance on linkage creation processes. Fifth, we will further control for non-observable aspects of contextual experience by restricting our tests to the subset of linkages with *local* firms, which we expect should be more affected by the extent to which firms are rooted in a specific socio-economic context. All of these levels of analysis will be conducted for both measures of technical linkage creation adopted in this paper, i.e. Extra-muros R&D and R&D cooperation.

Table 3 about here

Let us then start with the overall yearly value of Extra-muros R&D expenditure (in natural logarithm) as a dependent variable. This captures the amount of research activity contracted out by firms to other companies, including both local and global counterparts. We employ pooled OLS with heteroscedasticity-consistent standard errors to produce estimates with firms not belonging to a group – which we identified as NGP in section 4 – as baseline category. In column (1) of table 4 we show how multinational and non multinational firms compare in terms of R&D contracting out, controlling only for usual measures of size, age, firm level capital expenditure, sector and time dummies. Baseline NGP firms clearly appear to have the lowest propensity to resort to extra-muros R&D. This finding is broadly consistent with previous research: Small and medium sized firms – which are the bulk of independent firms monitored in the RS1 survey – encounter greater obstacles to access external knowledge due to their limited absorptive capacity (Belderbos et al. 2004). By contrast, what immediately turns out from Table 4 is that MNEs exhibit the highest propensity to resort to extra-muros R&D. In fact MNEs' premium is not only much higher as compared to independent firms, but it is significantly higher than in the case of firms belonging to non multinational groups (IGP), thus confirming in more rigorous terms the hierarchy we had observed in section 4, table 2. The top category is represented by domestic owned MNEs (ITM), with a propensity to R&D contracting out that is 41.9% higher than the baseline category, while the premium is 26.4% in the case of subsidiaries of foreign MNEs (FOR), and only 9.5% in the case of firms belonging to non multinational groups. Thus while group belonging is *per se* an important differentiating factor, it is the multinational nature of groups that appears to be the most important discriminating factor. We suggest that this already captures, at least partially, the role

played by what we have identified as "economies of common governance" that is associated with group belonging, and even more so with multinational groups.
To better isolate the effects of multinationality on R&D contracting out, one needs to control for other important determinants of technical linkages with external parties, including firms' absorptive capacity and the experience of local context.

Table 4 about here

As highlighted in column (2) our proxies of "absorptive capacity" - i.e. intra-muros R&D expenditure, as a measure of the intensity of research efforts, and the share of researchers in R&D personnel, as an indicator of quality of such efforts - explain an important part of these premia. This largely confirms hypothesis 1 discussed in section 3. In fact the difference in the propensity to contracting out R&D shrinks by about one third in the case of ITM and by slightly less than 60% in the case of FOR[3]. Nevertheless, there remains a remarkable difference between MNEs and the baseline category in terms of R&D contracting out. The hierarchy between ITM (30.0% higher propensity), FOR (11.3% higher propensity) and IGP (6.4% higher propensity) also persists after these controls for absorptive capacity. One needs to observe however that the premium in the case of FOR has diminished dramatically, and the difference between this category of MNEs and Italian firms belonging to non multinational groups (IGP) is not significant any more. Thus, R&D budgets being equal, it does not really make a difference to be part of a foreign group or being part of an Italian non multinational group in terms of linkage creation.
It thus appears that introducing additional proxies of internal R&D efforts does capture some aspects of heterogeneity, helps identify R&D expenditures and quality as key aspects of internal absorptive capacity, and improves the fit of estimates (as confirmed by the R-squared values in the tables)[4].
In column (3) we introduce a further control for a key factor that can be expected to differentiate firms' propensity to contracting out R&D to local parties, namely the regional distribution of R&D activities of the examined companies, as indirect controls for firms' experience of local contexts. As anticipated in section 4, *ITregions* reflect firms' ability to monitor, and eventually gain access to, external knowledge assets that are diffused in the territory; while *Top5regions* is more likely to identify firm's capability to locate their R&D where higher level knowledge is concentrated. Results in column (3) show that while *ITregions* has an important positive and significant impact on extra-muros R&D, *Top5regions* has the opposite effect. In other words, firms that are most involved in R&D contracting out do have an extensive coverage of the territory in terms of R&D

[3] As a robustness check, we ran separate regressions using alternatively controls for R&D expenditure and for the share of researchers on total R&D employees and obtained very similar results and significance levels.
[4] As a further robustness check, a separate set of regressions has been performed controlling also for different indicators of firms' productivity, to account for efficiency seeking strategies that are not captured by R&D efforts. While we are aware that the introduction of such controls may raise non trivial endogeneity problems, we deem they could help isolate the effects of R&D investment and technological accumulation leading to greater levels of absorptive capacity, from other strategies undertaken by firms aiming primarily to reduce production costs (including the reduction of personnel, shrinking idle times, and lowering maintenance of equipment). These regressions did not yield significantly different results.

establishments, but they do not locate their R&D in higher ranking regions. A possible explanation of this finding is twofold. On the one hand, it might reveal that the quality of research being contracted out is not very high, at least on average. In fact, firms with no R&D establishments in top regions are not exposed to a technological environment that is highly conducive to innovation, and may not gain access to the results of cutting-edge research. As a partial support to this statement one may mention the fact that it is firms with R&D activities in top regions that have the highest intra-muros R&D, and this applies when considering both the average R&D levels, and the highest percentiles of R&D expenditure (Table 5). The concentration of best R&D performers in top regions is confirmed for all categories of firms, and is more pronounced in the case of MNEs, and of foreign owned MNEs in particular. This is likely to imply that the quality of extra-muros R&D will also be different across firm typologies[5].

Table 5 about here

On the other hand, the negative sign of *Top5regions* could signal that firms that place their R&D labs in these areas are not inclined to set up linkages because they fear that the balance between incoming and outgoing spillovers may be negative (due to higher risks of information leakages and to the co-location of the best and most competitive R&D performers) (Santangelo 2009, Perri et al 2013).

Nevertheless, the introduction of regional controls does not significantly change the size of premia observed for the three categories of firms, hence leaving the hierarchy unmodified. Thus, after controlling for absorptive capacity, the additional control for the regional spread/concentration of R&D, does not seem to further explain diversities in linkage creation. Hypothesis 3 on the role of experience of local contexts is not confirmed in the light of this set of results. We shall come back to this issue with a test focused on linkages with local firms (infra).

Once again group belonging and, even more so, multinational group belonging appears to play an important differentiating role, even after this set of controls. This applies particularly to the case of domestic owned, Italian MNEs, which exhibit the highest premia in terms of R&D contracting out; but also and remarkably applies in the case of foreign owned MNEs, which maintain a 12% higher propensity to extra-muros R&D relative to the baseline (once again, the comparison between FOR and IGP reveals no significant differences).

Consistent with the view suggested in section 3, one might argue that the persistence of such premia, after controls for absorptive capacity and regional distribution of technological activities, might have to do with the more specific advantages of multinationality, and particularly with what we have identified as "economies of common governance". In other words, the higher propensity of MNEs to set up technical linkages might well reflect their superior ability to coordinate transactions (including knowledge exchanges) across organisational units and countries.

To better evaluate the impact of such advantages associated with multinationality, we ran regressions on the subsample of foreign and domestic MNEs and expressly control for their degree

[5] We have run separate regressions for each category of firms which seem to support this view. In fact Top5regions has a positive impact on extra-muros R&D in the case of foreign multinationals, which exhibit the highest R&D expenditure per employee and control the largest share of R&D in these regions.

of internationalisation (Ii) and for the geographic spread of their transnational networks (NSi). The former is a measure of the extension of internal networks of MNEs, while the latter captures the variety of foreign contexts in which MNEs are active. Column 4 of Table 4 illustrates the impact of this set of controls in the case of FOR and ITM. The baseline category is here represented by all non multinational firms active in Italy, i.e. the sum of NGP and IGP firms. Interestingly enough, it is the variety of contexts that impacts positively on R&D contracting out, while the extension of the network has a negative, albeit much lower, effect on these linkages. One might interpret this as evidence of the fact that expanding the number of markets increases coordination costs more than it generates knowledge transfer opportunities within the MNE network, whereas the variety of contexts seems to be associated with greater learning opportunities. This is in line with hypotheses 2 and 4 discussed in section 3.
The introduction of this set of controls reduces the premium observed for domestic owned MNEs (ITM), and the gap between FOR and ITM has shrunk by 4-5 percentage points to less than 15%. This might reveal that foreign owned MNEs can benefit from greater economies of common governance, reflecting more variegated networks to rely upon as a source of knowledge flows and of organizational advantages, as compared to the average Italian MNEs.

Up to now we have tested differences in the propensity of MNEs to R&D contracting out in general. Let us now focus on R&D contracting out with *local parties*. This will enable us to further highlight how multinationality advantages combine with firms' experience of local contexts. By introducing this level of analysis, a more convincing test of hypothesis 3 will thus be conducted. Table 6 illustrates the differences across firm categories in this respect. A fundamental result emerges here: different from the case of linkages with external parties in general, foreign owned multinationals exhibit no significant advantage in terms of linkage creation with local parties. Domestic owned MNEs do maintain a substantial premium as compared to independent firms. As expected, the size of premia drop by more than one third when controls for the intensity and quality of R&D efforts are introduced, thus confirming that absorptive capacity does play a key role as a differentiating factor, also when linkages with local firms are considered. Controls for regional presence and for the degree of internationalisation have a much lower impact, as their introduction further reduces the observed premia by a mere 3%. We interpret the different role of ITM firms (in comparison with FOR) as revealing of the different mix of advantages and disadvantages of multinationality in terms of linkage creation. Domestic owned MNEs appear to have all the advantages in terms of linkage creation, and none of the disadvantages. Much like FOR, Italian MNEs are characterized by extensive R&D budgets ensuring high absorptive capacity, and have accumulated capacities to coordinate cross-border knowledge flows (economies of common governance). Differently from FOR, they are by definition well rooted in the local context, that is their home economy. Hence they face no additional costs in terms of experience of local contexts; they encounter no barriers in terms of cultural and institutional distance; and have historically contributed to shaping the technological context in which they develop their linkages with other local counterparts.

Table 6 about here

In order to better explore the propensity to set up technical linkages of the different categories of firms under observation, we also focused on technological cooperation. We replicate here the same procedure we have followed in the case of R&D contracting out, and first consider R&D collaborations with all firms and institutions, i.e. with both local and global partners (table 7). In this case the dependent variable is a dummy that takes value one in case the observed firm participates in an R&D agreement with third parties (zero otherwise). Pooled logit estimates with robust standard errors referring to cooperation with all partners (including both Italian and foreign counterparts) are shown in table 7[6]. There are important similarities and differences with respect to the results we obtained when we examined extra-muros R&D. Here too, firms belonging to multinational groups, taken as a whole, exhibit higher propensity to cooperate than other firms. This result is confirmed with usual controls for size, age, capital intensity, sector and time dummies (Table 7, column 1). Premia are reduced but the hierarchy persists when controlling for different measures of internal R&D efforts (column 2), and after introducing regional controls (column 3). The introduction of internationalisation controls further reduces the observed premia, thus revealing an important role played by multinational spread as a differentiating factor (column 4).

What is remarkably new is that ranking of MNEs is different. In this case, FOR are characterized by a higher premium than ITM. As shown in column 4 of table 7, after all controls, the propensity to set up R&D collaborations observed in the case of FOR is not only higher than for the baseline category (NGP and IGP), but also higher than the one observed for domestic owned MNEs.

Table 7 about here

While the dummy nature of the cooperation variable does not allow to fully capture the relevance and intensity of R&D cooperation as a strategy to access external knowledge, these results are very much consistent with the view we have suggested: firms belonging to an international group are likely to have extra advantages in terms of their ability to explore, evaluate, assimilate and utilize external knowledge. However the extra-premium that we observed in the case of domestic owned MNEs cannot be observed here, and this might reflect a different balance between advantages and disadvantages of multinationality in this case. In terms of the interpretive framework developed in section 3, one may suggest that foreign MNEs are likely to experience much greater advantages in terms of their ability to mobilize knowledge through their own networks, and benefit from more effective organisational capabilities and economies of common governance, as compared to firms based in Italy, including domestic owned MNEs. Having controlled for both absorptive capacity and regional presence of firms, this extra-premium observed in the case of foreign subsidiaries might thus reveal that FOR are better than domestic MNEs in terms of their ability to organise and govern knowledge flows, and these assets are particularly important in the case of R&D cooperation. This seems to confirm that cooperation is

[6] Regressions testing for marginal effects have been conducted, yielding analogous results.

more demanding in terms of organizational and technical skills, generally speaking it requires that greater resources and commitment are devoted than in the case of R&D contracting out[7].

Table 8 about here

However, the advantage we have observed in the case of FOR in terms of R&D cooperation in general does not hold when collaborations with *local partners* are considered, as shown in Table 8. Much similar to the results we have illustrated with reference to extra-muros R&D, FOR exhibit no premia, while domestic owned multinationals continue to outperform the baseline category of firms in this case too. Given the size of premia shown by FOR when cooperation in general is considered, our finding in the case of linkages with local partners highlights the importance of the relative lack of experience of local contexts in the case of foreign MNEs, as a key hindering factor for R&D cooperation.

6. Conclusion

In this paper we showed that MNEs active in Italy are more prone to technical linkage creation in comparison with other firms. Moreover, we found that domestic MNEs and foreign owned MNEs exhibit distinctive ways to set up technical linkages, the former having a greater propensity to R&D contracting out, while the latter are better at developing R&D cooperation with external parties.

An additional finding of this paper is that foreign owned MNEs appear to be much less prone to set up technical linkages with *local* parties, than with foreign counterparts. This suggests that foreign multinationals have on average accumulated a lower experience of the Italian context as compared to domestic firms. This drawback appears to outbalance the advantages associated with multinationality, in terms of higher absorptive capacity and greater economies of common governance, in this case.

These findings have important implications for policies of FDI attraction and promotion. In fact, as suggested by an extensive literature, linkage creation can represent fundamental vehicles for technological spillovers and knowledge exchanges between MNEs and local counterparts. Hence they represent a key mechanism through which international production affects economic growth. Our paper highlights that a country can benefit from the presence of both domestic owned MNES and foreign owned MNEs, at least in terms of linkage creation. This is especially true of those (foreign and domestic) MNEs that exhibit high R&D efforts, in terms of both expenditure and composition of personnel involved in R&D activities, and geographically diversified networks of affiliates. As a consequence, structural policies should not only be aimed at attracting inward FDIs

[7] These findings do not contradict the ones obtained by Cozza & Zanfei (2015), who examined technical cooperation of Italian firms with local firms and universities. While that paper was not focused primarily on the comparison between foreign and domestic owned multinationals, it did contain some evidence on a limited subsample of Italian MNEs which have R&D activities abroad (while all Italian MNEs, including those that only have production or commercialisation facilities and no R&D activities abroad, are included in regressions presented in the present paper). As suggested by the authors, this subsample represents the very top of the iceberg of the rather circumscribed number of Italian outward investors, that is characterised by very high technological and economic performances. Not surprisingly, Cozza & Zanfei (2015) find that these firms exhibit a very high propensity to develop also technical linkages with external parties, with a premium that is even greater than the one that foreign owned multinationals have relative to other domestic firms.

and at promoting the internationalisation of domestic firms *per se*. They should pay a particular attention to, and create favourable conditions for, the R&D intensity and network spread of (foreign and domestic) multinational activities.

Moreover, this paper suggests that domestic MNEs are better embedded in the Italian economy and more prone to set up linkages with *local* counterparts than foreign owned MNEs. However, this should not lead us to the conclusion that supporting domestic MNEs is enough or even better than attracting foreign R&D investors. In fact, our evidence shows that foreign owned MNEs active in Italy have more extensive and variegated international networks, and are more prone to set up technical linkages with foreign counterparts. As a consequence, foreign MNEs can be expected to get in touch with a larger variety of knowledge sources. Thus, while their technical linkages with Italian counterparts are proportionally less than in the case of domestic firms, the amount and quality of knowledge exchanged though these linkages might well be higher.

Moreover, we showed that it is foreign MNEs that are better equipped for the development of relatively more strategic and commitment intensive linkages, taking the form of R&D cooperation. This might constitute a further indicator of the quality of knowledge transmission in the case of foreign MNEs. In fact R&D alliances are more likely to be vehicles for the transmission and exchange of high quality knowledge, than is the case of R&D contracting out.

These considerations, combined with the available evidence on the evolution of multinational presence in Italy, entail a rather pessimistic view of the on-going trends of innovation and growth in this country. In fact, we have shown that while MNEs exhibit the best performances in terms of R&D and productivity, and are better at linkage creation, they also represent a diminishing share of the population of R&D spenders in Italy over the past decade. This is particularly the case of foreign owned MNEs, whose share of total observations in our dataset has dramatically diminished from 11% to slightly more than 5% in 2001-2010. One would be led to conclude that, if this trend were to continue, the oligopolistic core of the Italian economy is bound to get weaker and weaker. What is even more worrisome in the light of the examined evidence is that the shrinking number of MNEs in Italy corresponds to an overall lower creation of technical linkages between firms. As it is FOR that are particularly losing weight in the Italian economy in general and in R&D activities in particular, our findings also suggest that technical connections with other foreign counterparts will also diminish. This is likely to reduce the extent and quality of knowledge exchanges and transmission, thus putting a brake on one of the key mechanisms for innovation diffusion and generation throughout the Italian economy.

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FIGURES AND TABLES

Figure 1 –Distribution of observations in the final dataset, by typology of firm

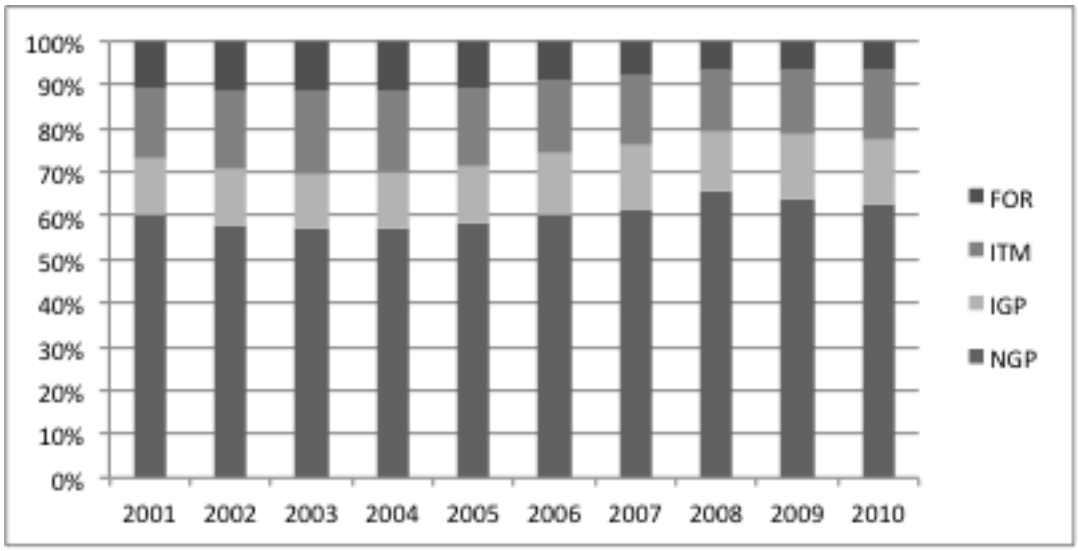

Table 1 – Variable definition

Variable name and description	Source
Dependent variables	
Extln-tot: (Natural Log of) Extra-muros R&D expenditure	**Istat-RS1**
Extln-loc: (Natural Log of) Extra-muros R&D expenditure contracted out ***to Italian counterparts***[8]	**Istat-RS1**
Coop-tot: (dummy for) R&D Cooperation[9]	**Istat-RS1**
Coop-loc: (dummy for) R&D Cooperation ***with Italian counterparts***	**Istat-RS1**
Measures of internal R&D efforts	
Intln: (Natural Log of) Intra-muros R&D expenditure	**Istat-RS1**
Quality: ratio of researchers on R&D employees	**Istat-RS1**
Measures of regional diffusion of R&D activities	
Itregions: number of Italian regions where Intra-muros R&D is undertaken	**Istat-RS1**
Top5regions: (dummy for) Presence of R&D activities in top5 Italian regions (Lombardia, Piemonte, Lazio, Emilia-Romagna, Veneto)	**Istat-RS1**
Controls for firm typologies	
NGP: dummy for ''firm not in a group''	**Istat-RS1**
IGP: dummy for ''firm in an Italian non-multinational group''	**Istat-RS1 / Bureau Van Dijk-Aida**
ITM: dummy for ''firm in an Italian multinational group''	**Istat-RS1 / Bureau Van Dijk-Aida**
FOR: dummy for ''subsidiary of a foreign group''	**Istat-RS1**
Internationalisation[10] controls	
NSi: ratio of countries where the firm has subsidiaries on total countries where firms in the sample have subsidiaries	**Bureau Van Dijk-Aida**
Ii: ratio of foreign subsidiaries on total (including domestic)subsidiaries of MNEs	**Bureau Van Dijk-Aida**
Other controls	
Empln: (natural log of) number of firm employees Full Time Equivalent	**Istat-RS1**
Age: number of years from firm establishment	**Bureau Van Dijk-Aida**
Sector: Hi-tech, medium-hi-tech, medium–low-tech, Low-tech, KIS, L(ess)KIS, Other	**Istat-RS1**
Intcc: Capital expenditures dummy for "Expenditure for machinery, equipment and software"	**Istat-RS1**
Labour Productivity (Value added per employee) and (Approximate) Total Factor Productivity[11]	**Bureau Van Dijk-Aida**

[8] Italian counterparts can be: private firms not belonging to the same group of the respondent, public organisations or universities.

[9] In the text we use "R&D cooperation" and "technical cooperation" as synonyms.

[10] Both countries and subsidiaries are limited to 'downstream' ones. That is: all foreign countries where the Italian R&D performer has activities, and its related foreign subsidiaries. In the case of Italian firms belonging to another domestic multinational or to a foreign multinational group, these ratios *exclude* foreign countries and subsidiaries controlled by the mother company directly or by sister companies.

Time dummies	**Istat-RS1**

Table 2 – Size, R&D and performance indicators by typology of firms active in Italy (average values 2001-2010)

	NGP	IGP	ITM	FOR
Number of firms[12]	8,770	2,279	1,509	864
Size (Average number of firm employees)	87.90	245.30	837.42	656.56
Average Intra-muros R&D expenditure per firm (in thousand euro)	592.04	2,588.27	5,380.03	6,706.96
Labour Productivity (in thousand euro, average 2008-2010)	71.12	70.43	81.76	91.92
Average Extra-muros R&D expenditure per firm (in thousand euro)	90.64	704.17	1311.43	992.29
Share of firms involved in R&D Cooperation	28%	38%	45%	50%

Table 3 – Descriptive statistics

	N	Min	Max	Mean	Std. Dev
NGP	34,855	0	1	0.615	0.486
IGP	34,855	0	1	0.148	0.355
ITM	34,855	0	1	0.151	0.358
FOR	34,855	0	1	0.086	0.280
LN of employees	34,852	0	11.042	4.028	1.591
Capital expenditure	34,855	0	1	0.411	0.492
Age	34,855	5	159	31.134	16.445
LN of Intra-muros R&D	34,855	0	13.567	5.820	1.510
Quality	34,855	0	1	0.324	0.305
IT regions	34,855	1	17	1.145	0.617
Top 5 regions	34,855	0	1	0.762	0.426
NSi	34,855	0	0.389	0.006	0.023
Ii	34,855	0	1	0.052	0.156
LN of Extra-muros R&D (Total)	34,855	0	13.394	1.120	2.184
LN of Extra-muros R&D (Local)	34,855	0	12.997	0.918	1.927
Cooperation (Total)	34,855	0	1	0.341	0.474
Cooperation (Local)	34,855	0	1	0.301	0.459

[11] Labour productivity has been calculated as value added per worker; ATFP has been calculated as value added per worker net of the contribution of capital per worker, with an elasticity of 1/3 (see Head and Ries, 2003).
[12] Including duplications for those firms which have switched typology over the 10 years period.

Table 4 – The propensity to *Total* extra-muros R&D (R&D spending contracted out to both foreign and local counterparts). OLS regressions with robust standard errors / dependent variable: LN Extra-muros R&D *Total*.

	1	2	3	4
VARIABLES	Ln Extra-muros R&D Total	Ln Extra-muros R&D Total	Ln Extra-muros R&D Total	Ln Extra-muros R&D Total
IGP	0.095***	0.064**	0.074**	
	(0.033)	(0.033)	(0.033)	
ITM	0.419***	0.300***	0.301***	0.284***
	(0.042)	(0.041)	(0.041)	(0.065)
FOR	0.264***	0.113**	0.127**	0.144***
	(0.055)	(0.055)	(0.054)	(0.054)
Ln Intra-muros R&D		0.335***	0.305***	0.285***
		(0.013)	(0.013)	(0.013)
Quality		0.542***	0.489***	0.441***
		(0.038)	(0.038)	(0.038)
IT regions			0.337***	0.320***
			(0.032)	(0.032)
Top 5 regions			-0.144***	-0.136***
			(0.026)	(0.026)
NSi				10.415***
				(1.034)
Ii				-1.002***
				(0.134)
Constant	-0.379***	-1.428***	-1.452***	-1.213***
	(0.080)	(0.092)	(0.094)	(0.093)
Implied differences				
ITM – IGP	0.324***	0.236***	0.227***	
ITM – FOR	0.155**	0.187***	0.174***	0.140*
FOR – IGP	0.169***	0.049	0.053	
Number of observations	34,852	34,852	34,852	34,852
R^2	0.101	0.131	0.140	0.149

Size, age, sector, capital expenditure controls and time dummies included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5 – Average and Maximum of R&D intra-muros (in LN), per firm typology

Average LN R&D intra-muros	**NGP**	**IGP**	**ITM**	**FOR**
Firms not performing R&D in any of top 5 regions	5.122	5.758	6.742	6.903
Firms performing R&D in at least one of top 5 regions	5,431	5.898	6.995	7.005
Max LN R&D intra-muros	**NGP**	**IGP**	**ITM**	**FOR**
Firms not performing R&D in any of top 5 regions	12.653	11.381	12.980	11.463
Firms performing R&D in at least one of top 5 regions	12.707	11.716	13.567	13.096

Table 6 – The propensity to *Local* extra-muros R&D (R&D spending contracted out to local counterparts only). OLS regressions with robust standard errors / dependent variable: LN Extra-muros R&D *Local*.

	1	2	3	4
VARIABLES	Ln Extra-muros R&D Local	Ln Extra-muros R&D Local	Ln Extra-muros R&D Local	Ln Extra-muros R&D Local
IGP	-0.050*	-0.072*	-0.064**	
	(0.029)	(0.029)	(0.029)	
ITM	0.266***	0.176***	0.177***	0.171***
	(0.037)	(0.037)	(0.037)	(0.058)
FOR	-0.037	-0.153***	-0.141***	-0.102**
	(0.047)	(0.047)	(0.046)	(0.046)
Ln Intra-muros R&D		0.249***	0.223***	0.209***
		(0.011)	(0.011)	(0.011)
Quality		0.436***	0.395***	0.366***
		(0.035)	(0.035)	(0.035)
IT regions			0.292***	0.283***
			(0.030)	(0.030)
Top 5 regions			-0.079***	-0.073***
			(0.024)	(0.024)
NSi				6.322***
				(0.962)
Ii				-0.523***
				(0.121)
Constant	-0.042	-0.831***	-0.878***	-0.729***
	(0.072)	(0.083)	(0.085)	(0.084)
Implied differences				
ITM – IGP	0.316***	0.248***	0.241***	
ITM – FOR	0.013	0.329***	0.318***	0.273***
FOR – IGP	0.303***	-0.081	-0.077	
Number of observations	34,852	34,852	34,852	34,852
R^2	0.073	0.095	0.102	0.106

Size, age, sector, capital expenditure controls and time dummies included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7 – The propensity to R&D cooperation (with both foreign and local counterparts). LOGIT regressions with robust standard errors / dependent variable: Cooperation *Total*.

	1	2	3	4
VARIABLES	Cooperation Total	Cooperation Total	Cooperation Total	Cooperation Total
IGP	0.278***	0.259***	0.262***	
	(0.035)	(0.035)	(0.035)	
ITM	0.487***	0.386***	0.390***	0.314***
	(0.037)	(0.038)	(0.038)	(0.055)
FOR	0.586***	0.444***	0.455***	0.379***
	(0.045)	(0.047)	(0.047)	(0.046)
Ln Intra-muros R&D		0.248***	0.236***	0.235***
		(0.012)	(0.012)	(0.012)
Quality		0.908***	0.851***	0.843***
		(0.041)	(0.041)	(0.041)
IT regions			0.242***	0.237***
			(0.030)	(0.030)
Top 5 regions			-0.343***	-0.343***
			(0.029)	(0.028)
NSi				1.830***
				(0.692)
Ii				-0.187*
				(0.113)
Constant	-2.009***	-2.950***	-2.865***	-2.837***
	(0.075)	(0.086)	(0.089)	(0.090)
Number of observations	34,852	34,852	34,852	34,852
Pseudo R^2	0.070	0.090	0.095	0.094
Log pseudolikelihood	-20,818.659	-20,356.807	-20,237.867	-20,260.541

Size, age, sector, capital expenditure controls and time dummies included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 8 – The propensity to R&D cooperation *with local counterparts*. LOGIT regressions with robust standard errors / dependent variable: Cooperation *Local*.

	1	2	3	4
VARIABLES	Cooperation Local	Cooperation Local	Cooperation Local	Cooperation Local
IGP	0.055	0.031	0.035	
	(0.036)	(0.038)	(0.037)	
ITM	0.327***	0.226***	0.230***	0.096*
	(0.038)	(0.039)	(0.039)	(0.056)
FOR	0.055	-0.111**	-0.100**	-0.117**
	(0.047)	(0.049)	(0.049)	(0.048)
Ln Intra-muros R&D		0.240***	0.223***	0.217***
		(0.012)	(0.012)	(0.012)
Quality		0.876***	0.819***	0.807***
		(0.041)	(0.041)	(0.041)
IT regions			0.268***	0.265***
			(0.029)	(0.029)
Top 5 regions			-0.318***	-0.316***
			(0.029)	(0.029)
NSi				3.203***
				(0.711)
Ii				0.061
				(0.114)
Constant	-2.090***	-2.992***	-2.920***	-2.855***
	(0.077)	(0.087)	(0.090)	(0.091)
Number of observations	34,852	34,852	34,852	34,852
Pseudo R^2	0.056	0.076	0.082	0.082
Log pseudolikelihood	-20,121.211	-19,698.854	-19,576.434	-19,564.543

Size, age, sector, capital expenditure controls and time dummies included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1