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R&D AND TECHNOLOGICAL INTERNATIONALISATION: EVIDENCE FROM A *RANDOM COEFFICIENT TREATMENT* MODEL

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ABSTRACT: *By considering a sample of Italian manufacturing firms, this paper aims at comparing the R&D performance of foreign (multinational) enterprises with that of home companies. Its methodological innovation consists in adopting a* random coefficient treatment *model, which allows us to: (i) embed this comparison in a "counterfactual" setting; (ii) and calculate the firms' "specific treatment effect". The carrying out of these analyses would not be possible with the use of standard regression tools. The results suggest that the weakness of the (Italian) national R&D production system mainly lies in the "smallness" of its firms: while a home company of large size is able to perform more R&D than a foreign twin, the performance of a home company of small size is worse than that of similar foreign firms. Thus, as for policy implications, we suggest that attracting inward investments should be accompanied by policies aimed at better supporting the growth of home companies.*

JEL classifications: *F23, O30, C21*

Keywords: *MNEs, Internationalisation, R&D, Treatment models*

1. INTRODUCTION

The internationalisation of firms plays a growing and crucial role within the phenomenon of technological and economic globalisation (Narula and Zanfei, 2005). The relevance of internationalisation is twofold: on the one hand, it is a subject studied by economic theory; on the other hand, economic policies consider it an important factor in pursuing their objectives. Our paper focuses mainly on the first aspect, although some policy conclusions are also presented in the final part.

The paper deals with comparing the R&D commitment of foreign and national firms. Indeed, despite the introduction of the circular model of technological innovation, research and development (R&D) remains a fundamental aspect of technological and economic globalisation. It plays a key role in the origin of innovation and in the competitiveness of firms and national economic systems (Porter 1986).

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The literature stresses that there is a difference between the commitment of (foreign) multinational and domestic firms. We may distinguish between two complementary approaches within these studies. First, the commitment of foreign firms can be compared with that of domestic ones by looking at the domestic firms which only operate in their country of origin and those which operate abroad too (namely "domestic multinationals"). Within this approach, a study on Italian firms by Castellani and Zanfei (2006) reveals that, whereas foreign affiliates appear to invest more than national firms as a whole, the relationship reverses when the comparison regards only domestic multinationals. In other words, Italian multinationals invest more in R&D than foreign firms. In the second approach, the affiliates of foreign firms are compared with national firms as a whole (without singling out the domestic multinationals) in relation to two kinds of R&D investment, i.e. intramural and extramural research. Un and Cuervo-Cazura (2008) state that foreign affiliates seem to invest more than national firms when intramural research is considered, but less when extramural research is analysed. Both approaches are investigated in this paper and their predictions are checked by considering a sample of Italian foreign affiliates and domestic firms, although the main econometric exercise performed focuses on the traditional comparison between foreign companies (as a whole) and national companies (as a whole).

The innovative aspect of this paper, compared to previous studies on the subject, is above all methodological, but with remarkable implications also in terms of a better understanding of the economic phenomenon tackled. We apply a *random coefficient treatment* model to the comparison between the R&D performance of national and foreign firms. Compared to the standard econometric practices used in the literature so far – usually, standard regression settings –, this approach has two main advantages: (i) it embeds the comparison in a "counterfactual" setting, thus allowing us to determine what the R&D behaviour of a foreign firm would have been if it had been a national one, and vice versa. As explained later, this choice provides new interesting insights into this analysis (impossible to achieve with previous non-counterfactual approaches). The other advantage is that (ii) our approach allows for the calculation of firms' "specific treatment effect", an aspect that enables us to take into account the firms' heterogeneous response to treatment (which, in our case, corresponds to the event of "being a national rather than a foreign company").

The paper is organised as follows. Section 2 provides a general overview of the issue of firms' R&D commitment and internalisation of production. To clarify the meaning of the tests carried out, this part describes the hypotheses from which we start. Based on these hypotheses, we will derive some predictions, which will be compared with the observations concerning the sample of Italian firms analysed. Section 3 deals with the *random coefficient treatment* model applied. It is the methodological part of the paper. Section 4 presents the dataset, descriptive statistics, and some difference-in-mean tests to be compared with findings from previous studies on this subject. Section 5 describes the results from the *random coefficient treatment* estimation. Lastly, section 6 suggests some policy conclusions.

2. GENERAL OVERVIEW

2.1. Differences in Firms' R&D and Innovation Efforts

The innovative behaviour of firms varies remarkably as some elements change. This variability produces the range of firm characteristics on which market selection acts (Nelson and Winter, 1982). As for the R&D commitment of firms, the innovation theory identifies various elements.

First of all, the industrial sector to which a firm belongs is very important. Firms belonging to different sectors typically show greater or more limited commitment to research. As a consequence, firms participate to varying degrees in the generation of knowledge within an economic system (Scherer, 1982). In relation to this, some patterns have been identified to describe the innovative behaviour of firms, by grouping the numerous sectors making up an economic system into few broader sectors. Firms in each of these sectors display specific features, which can be theoretically explained according to a general taxonomy (Pavitt, 1984). R&D commitment is among the characteristics defining innovative behaviour in Pavitt's taxonomy. In his taxonomy, this commitment is described and explained, not merely registered.

Secondly, firm size is fundamental. It can be measured through various indicators, above all the number of employees, sales or value added, (Griliches, 1986), as well as assets (Scherer, 1992). An influential line of investigation within innovation theory has detected a positive relationship between firm size and commitment to innovative activities, in particular research and development (Schumpeter, 1942).

Said positive relationship might be ascribed to the advantages enjoyed by larger firms when it comes to innovation in general and financial resources for research in particular. First of all, innovative activities have high fixed costs, which can be more easily borne by companies with greater financial resources, a characteristic which tends to be positively associated with size. Moreover, large size is usually linked with greater market power, which allows a firm to better appropriate the economic value of its innovations. In addition, research is an extremely risky form of investment, a fact which favours large firms, able to afford a diversified portfolio of R&D investments. Another aspect regards the profitable scope economies which large firms can attain thanks to their scale economies. Finally, cost reductions deriving from successful research projects produce higher savings for bigger firms, because they affect larger amounts of sales. Nevertheless, size advantage may be partially offset by the disadvantages caused by a heavily bureaucratic structure (Acs and Audretsch, 1988).

The validity of this analysis has often been questioned and tested (see for instance: Cohen and Klepper, 1996; Shefer and Frenkel, 2005). In this article, among other things, we will carry out an experiment to investigate the relationship between firm size and R&D commitment by looking at foreign vs. domestic companies. The results of this experiment have relevant policy implications, as thoroughly explained in the next sections.

In order to describe a firm's innovative behaviour with sufficient precision, its distinctive characteristics must be considered. An anecdotal description of all the characteristics of firms belonging to a big sample would obviously be difficult and of little use. From a theoretical point of view, what is important is that the specific characteristics of a firm's behaviour display cumulative development (Dosi and Nelson, 1994). The fact that the innovative behaviour of firms does not change abruptly ensures that the result of the empirical procedures used to describe their distinctive characteristics retain their validity over a certain period of time.

The innovative behaviour of firms, more specifically their R&D commitment, can be predicted by considering other elements too, which are described in studies regarding the link between research and internationalisation. In particular, it is important to know whether one is considering the affiliate of a foreign firm or a national firm. Within national firms, domestic multinationals can be singled out. Moreover, innovative behaviour can be described by distinguishing between the R&D which firms perform directly and the R&D which they finance in its entirety. These distinctions are relevant not only from an analytical point of view but also for what concerns policy prescriptions, as will be clarified in the conclusions.

2.2. Companies Expanding Abroad

By definition, affiliates of firms having their headquarters abroad belong to multinational enterprises. Within the growing interdependence among actors at the international level, multinational firms make the transfer of technology easier, acting as bridging institutions connecting different national systems of innovation (Nelson, 1993). They do so also thanks to the links that their affiliates establish with national firms, in order to have access to the knowledge and technological assets available in the local markets.

Among others, Cantwell (1989) sheds light on the importance of internationalisation in the production and diffusion of knowledge and technological innovations for multinational enterprises. Technological innovation is connected to internationalisation in two ways. First, innovation fosters the competitiveness and profitability of multinational firms in foreign markets, by enhancing the division of labour within them in relation to knowledge production and use and by allowing the firms to better exploit the assets they already own. This, in turn, improves the efficiency of innovative activities (Caves 1996). Secondly, the fact that multinational enterprises enter foreign markets of scientific and innovative assets favours R&D and innovation. Indeed, it facilitates the exploitation of local resources (as long as they are cheaper than abroad) and the absorption of knowledge produced outside the firm – an essential element of its innovative capability (Cohen and Levinthal, 1989) – by the national innovation system of the country hosting the affiliate. In particular, knowledge absorption can concern research and technology assets of local firms (Cantwell, 2000). This depends, among other elements, on the fact that a portion of the knowledge needed to perform innovative activities is tacit (Blanc and Sierra, 1999); hence, it cannot be gained through standard market transactions. In this regard, it has been found that, although research plays an essential role in innovative activities and competitiveness, R&D is still one of the least internationalised functions of multinational firms – much less, for instance, than production (Patel and Pavitt, 2000). R&D internationalisation tends to be more pronounced in the chemical-pharmaceutical, electronic and automotive sectors. The R&D function in multinationals is partially decentralised from the headquarters to their foreign affiliates (Florida, 1997).

Profitable networks are often set up comprising both the affiliates of a multinational in other countries (Patel and Vega, 1999) and the firms and institutions of the hosting nation (Vaccà and Zanfei, 1995). The usefulness of such networks is cumulative, due to the growth in competencies that a multinational enterprise's R&D unit accumulates over time by establishing long-lasting relationships with users (Steinmueller, 1992) and within the firm's internal network (Dunning, 1993).

2.3. Foreign Versus Domestic Multinationals

Within the whole set of national enterprises, the subset of domestic firms also operating abroad can be singled out. Comparing the affiliates of foreign multinationals with exclusively domestic firms (i.e., those which do not operate abroad) may be somewhat misleading. Indeed, as noted by Castellani and Zanfei (2006), this comparison is not based on homogenous criteria. It is much more appropriate to compare the affiliates of foreign firms (which, by definition, belong to multinationals) with domestic multinational firms, namely national firms controlling production activities abroad. We will describe such a comparison along with the one between foreign and Italian firms. As far as Italy is concerned, Castellani and Zanfei stress the following: first, foreign affiliates invest more in R&D than Italian firms in general; secondly, when the comparison focuses on Italian multinational firms, they are found to perform better than the affiliates of foreign multinationals.

2.4. Performed versus Financed Research

The sources of the technology used by the affiliates of foreign multinationals mainly include internal R&D, knowledge flows originating abroad (i.e. from the headquarters and from affiliates in other countries), and investments in R&D performed outside the firm (Un and Cuervo-Cazura, 2008). Given a certain level of internal R&D investment, the technological knowledge coming from the headquarters and other affiliates can replace extramural R&D investment. When this happens, the affiliates of foreign multinationals tend to invest less in extramural research than domestic firms. This occurrence is particularly important due to its policy implications for the national system of innovation, since the amount of extramural research financed by national firms is, ceteris paribus, equal to or greater than the extramural research financed by the affiliates of foreign firms.

3. THE *RANDOM COEFFICIENT TREATMENT* MODEL

The methodology proposed in this work is innovative because it embeds the typical comparison between R&D performance of foreign and national companies in a *counterfactual* setting. We refer to the wide literature on "program evaluation" presenting the so-called "treatment effects" approach, a class of models that are borrowed from epidemiological studies – where they are used to evaluate the efficacy of new drugs and chemical compounds – and have rapidly become popular also in socio-economic policy evaluation. Given this premise, let us see how this approach can be logically consistent within our setting.

In our context, firms are thought of as "treated" by means of *two* different "drugs", corresponding to *two* different states of *property* and managerial *control*: (i) firms whose property and control are primarily delegated to national subjects (i.e. "national companies"), and (ii) firms whose property and control are primarily delegated to a foreign board (that is, "foreign companies")[1]. Starting from this definition, we define w as an indicator-variable, taking on value "one" for foreign firms and "zero" for national companies.

The target variable, i.e. the quantity over which we want to measure the effect of the "drugs", is the "total (intramural and extramural) company R&D investment". Let us indicate this variable with y.

From a "causal" point of view, we are interested in the estimation of the so-called "treatment effect" of variable w on variable y. The treatment evaluation literature suggests looking at a specific effect, called the Average Treatment Effect (ATE), defined as:

$$\text{ATE} = \text{E}(y_1 - y_0)$$

This population parameter refers to *the same firm at the same time* and it is equal to the difference between the R&D expenditure when the firm is treated (y_1), corresponding in our setting to the case in which the firm is a "foreign" one, and when the firm is untreated (y_0), corresponding to the case in which the firm is a "national" one. It goes without saying that, *for the same firm* and *at the same time*, we can observe just one of the two quantities feeding into the ATE, but not both. For example, we might be able to observe the R&D behaviour of an Italian company, but we cannot know how much R&D it would have performed if it had been under the control and property of – for instance – a German board of directors, and vice versa. In other words, we face a "missing observation" problem, which needs to be overcome to make the estimation of the ATE feasible. Nevertheless, before describing the way in which this problem can be solved econometrically, it is interesting to introduce two additional parameters which are worth estimating and will be particularly important in our exercise. These parameters are known as the Average Treatment Effect on Treated (ATET) and the Average Treatment Effect on Non Treated (ATENT), defined respectively as:

$$\text{ATET} = \text{E}(y_1 - y_0 \mid w = 1)$$

$$\text{ATENT} = \text{E}(y_1 - y_0 \mid w = 0)$$

Plainly, the ATET is the average treatment effect calculated within the subsample of treated units (the foreign companies, in our case), while the ATENT is the average treatment effect calculated within the subsample of untreated units (the national companies, in our case). These two parameters can provide additional information on how the causal relation between w and y actually behaves, and an application of this will be presented in the section on results. For now, let us concentrate on the relation linking all the previous parameters:

$$\text{ATE} = \text{ATET} \cdot \text{P}(w = 1) + \text{ATET} \cdot \text{P}(w = 0) \tag{1}$$

that is, the ATE is a weighted average of the ATET and the ATENT, with $\text{P}(w = 1)$ representing the probability of being a foreign company and $\text{P}(w = 0)$ that of being a national one.

However, another important element is needed to progress in this analysis. Indeed, for each firm, besides the observations on y and w, we (normally) also have access to a certain number of observable covariates, which can be collected in a row vector $\mathbf{x}$. Usually, the $\mathbf{x}$-variables represent various firm characteristics, such as size, sector, costs, financing, innovation, and other types of structural indicators. Under the so-called "conditional mean independence" (CMI) hypothesis, knowledge of the $\mathbf{x}$-variables allows us to consistently estimate all the previous parameters (ATE, ATET, and ATENT).

The CMI hypothesis, introduced for the first time by Rosenbaum and Rubin (1983), states that – conditional on the knowledge of $\mathbf{x}$ – y_1 and y_0 are independent of w. In fact, it can be proven that the problem in identifying these parameters is due exactly to this dependence. Take, for example, the case of the estimation of the ATE. In principle, if y_1 and y_0 were independent of w, a sample comparison of the mean R&D of foreign and national companies, made without taking into account their differential structure as captured by $\mathbf{x}$, would be correct. This is the case of a sample *drawn at random*, in which the knowledge of $\mathbf{x}$ is useless. But, when the sample of treated and untreated units, as is often the case, is *not randomly drawn* but depends on either observable or unobservable firm characteristics, a simple mean comparison is no longer correct. In this case, the knowledge of **x**, i.e. the structural variables that are supposed to drive the non-random assignment to treatment, becomes essential. In order to be correct, the mean comparison needs to be "weighted" by the two groups' differential structure.

Let us take our setting as a suitable example. We expect foreign firms to have specific and distinctive characteristics compared to national enterprises, as the former "decide", at least partially, to become multinationals through a sort of *self-selection* process, i.e. on the basis of some observables or unobservable (to the analyst) characteristics such as size, intrinsic capabilities, propensity to bear risk, capacity to invest, financial structure and incentives, productivity, and so on. In other words, "being a foreign firm" rather than a domestic one is not a completely random occurrence, but it depends on the firm's "endogenous" strategic decision to invest a portion of its productive capacity abroad. In turn, this decision depends on the firm being able to go above a certain threshold in terms of size, availability of financial assets, innovations achieved, productivity and profitability targets, and so on. But, once the factors explaining the decision to become a multinational are suitably taken into account in the estimation phase, the condition for random assignment is restored (except, of course, the case of further unobservable factors). Hence, it becomes clear that the CMI hypothesis leads to consistent estimates of the ATE (as well as the ATET and the ATENT) only in the case of "selection on observable factors", i.e. only when the analyst believes that the non-random nature of the distribution of w is due to observable firm characteristics. If this is not so, the CMI is not enough to consistently estimate causal effects and further hypotheses and methods are needed[2].

It is worth stressing that, under the knowledge of **x**, we can also define the previous parameters "conditional on **x**" as:

$$\mathrm{ATE}(\mathbf{x}) = \mathrm{E}(y_1\text{-}y_0 \mid \mathbf{x}).$$

$$\mathrm{ATET}(\mathbf{x}) = \mathrm{E}(y_1\text{-}y_0 \mid w = 1, \mathbf{x})$$

$$\mathrm{ATENT}(\mathbf{x}) = \mathrm{E}(y_1\text{-}y_0 \mid w = 0, \mathbf{x}).$$

By definition, these quantities are no longer single values, but functions of **x**. Hence, they can be seen as "firm specific average treatment effects", since each firm has a different and specific value of **x**.

Yet, in practical terms, how can we estimate all the previous causal effects of w on y when the selection into sample is non-random and depends only (by assumption) on the observable **x**-variables? Under the CMI hypothesis, we can use either a parametric or a non-parametric estimation strategy. We have adopted the first one, since it is better suited to our context. In this case, we assume a functional form for our target variable, depending on both w and **x**. To better generalise our approach, we propose a treatment model with "observable heterogeneity", which can be estimated via an OLS *random coefficient* regression model (Wooldridge, 2002, pp. 608-614). Hence, we specify two R&D behavioural equations, one for foreign (w = 1) and one for national (w = 0) firms:

$$w = 1: \mathrm{y}_1 = \mu_1 + g_1(\mathbf{x}) + e_1$$

$$w = 1 : y_0 = \mu_0 + g_0(\mathbf{x}) + e_0$$

where μ_1 and μ_0 are constant terms, $g_1(\mathbf{x})$ and $g_0(\mathbf{x})$ are differential R&D reaction functions to **x**, and e_1 and e_0 are unobservable random components, assumed to be uncorrelated with w (that is, ruling out the case of "selection on unobservables"). Given this structure, it is easy to define the "treatment effect" as the difference between the two equations above:

$$y_1 - y_0 = (\mu_1 - \mu_0) + [g_1(\mathbf{x}) - g_0(\mathbf{x})] + (e_1 - e_0)$$

from which the previous parameters can be obtained by simply averaging over it. Nevertheless, to progress in the estimation, we need to work with observable elements. For this purpose, we define the so-called "switching regression" – a relation linking observable with unobservable variables –, which takes on this form:

$$y = wy_1 + (1 - w)y_0$$

By substituting the previous expressions of y_1 and y_0 into this equation, we obtain the following relation:

$$y = \mu_0 + g_0(\mathbf{x}) + w(\mu_1 - \mu_0) + w[g_1(\mathbf{x}) - g_0(\mathbf{x})] + u$$

where $u = e_0 + w(e_1 - e_0)$. Moving towards a parametric form of $g_1(\mathbf{x})$ and $g_0(\mathbf{x})$ by setting $g_1(\mathbf{x}) = \eta_1 + \mathbf{x}\boldsymbol{\beta}_1$ and $g_0(\mathbf{x}) = \eta_0 + \mathbf{x}\boldsymbol{\beta}_0$, we can rearrange the previous equation and obtain, after some simple manipulations, the following "reduced form" *random regression* model:

$$E(y \mid \mathbf{x}, w) = \gamma + \mathbf{x}\boldsymbol{\beta}_0 + w \times \alpha + w \cdot [\mathbf{x} - \boldsymbol{\mu}_\mathbf{x}]\boldsymbol{\delta} \quad (2)$$

where it can be proven that $\gamma = \mu_0 + \eta_0$, $\alpha = ATE$, $\boldsymbol{\delta} = (\boldsymbol{\beta}_1 - \boldsymbol{\beta}_0)$ and $\boldsymbol{\mu}_\mathbf{x} = \mathrm{E}(\mathbf{x})$, the latter being just the sample average of **x**[3]. Equation (2) can be consistently estimated by OLS, and once the OLS estimates of γ, $\boldsymbol{\beta}_0$, α and $\boldsymbol{\delta}$ are obtained, we can determine the various treatment effects by simple transformations of this type:

$$\begin{aligned}
&\widehat{\mathrm{ATE}} = \hat{\alpha} \\
&\widehat{\mathrm{ATE}}(\mathbf{x}) = \hat{\alpha} + (\mathbf{x} - \bar{\mathbf{x}})\hat{\boldsymbol{\delta}} \\
&\widehat{\mathrm{ATET}} = \hat{\alpha} + (1/N^T)\sum_{i=1}^{N} w(\mathbf{x} - \bar{\mathbf{x}})\hat{\boldsymbol{\delta}} \\
&\widehat{\mathrm{ATET}}(\mathbf{x}) = \left[\hat{\alpha} + (\mathbf{x} - \bar{\mathbf{x}})\hat{\boldsymbol{\delta}}\right]_{(w=1)} \\
&\widehat{\mathrm{ATENT}} = \hat{\alpha} + \frac{1}{\sum_{i=1}^{N}(1 - w_i)}\sum_{i=1}^{N}(1 - w_i)(\mathbf{x}_i - \bar{\mathbf{x}})\hat{\boldsymbol{\delta}} \\
&\widehat{\mathrm{ATENT}}(\mathbf{x}_i) = \left[\hat{\alpha} + (\mathbf{x}_i - \bar{\mathbf{x}})\hat{\boldsymbol{\delta}}\right]_{(w=0)}
\end{aligned} \quad (3)$$

Relations (3) are all estimable, since they are functions of pre-estimated and observable (to the analyst) components. The only problem, i.e. how to obtain standard errors for the ATET and the ATENT, can be easily overcome by using bootstrapping[4].

4. DATASET, DESCRIPTIVE STATISTICS AND DIFFERENCE-IN-MEAN TESTS

The dataset used for this analysis comes from the 9th Capitalia/Unicredit 'Survey on Italian manufacturing firms', which presents a large amount of quantitative and qualitative information on the business activities of Italian firms during the 2001-2003 period[5]. This dataset is then merged with accounting data drawn from the AIDA archive, provided by Bureau Van Dijk. The final dataset is a cross-section containing information on 2001, 2002 and 2003, and its sample size is 3,452 companies. The sample covers manufacturing firms with more than 10 employees and it is selected on the basis of a stratified sampling scheme, according to Italian macro-regions, Pavitt's taxonomy, and class of employees[6]. Since the information is available for three years, in order to increase the number of observations (for the sake of precision in the estimation phase), the regression analysis is performed using a longitudinal dataset (i.e. the same firms observed in 2001, 2002 and 2003). In this case, we rely on a three-year panel with 10,356 observations (firm per year). Nevertheless, for the descriptive statistics and the difference-in mean tests, the cross-sectional dataset referring to the 3,452 companies is used, taking the three-year average values of the considered variables as reference. Therefore, results throughout this section refer to averages over 2001, 2002 and 2003.

Table 1
Some Sample Descriptive Statistics

	Frequency	*Share*	*Average size*	*Pavitt taxonomy (shares)*
Number of firms	3452			
Italian	*3176*	*92.00*	334	53, 17, 26, 4
Foreign	*206*	*5.97*	1024	30, 19, 44, 6
N.A.	*70*	*2.03*	1712	40, 20, 29, 12
Number of Italian firms	3176			
MNEs	*223*	*7.02*	700	65, 5, 27, 3
NMNEs	*2906*	*91.50*	254	53, 18, 26, 4
N.A.	*47*	*1.48*	1562	34, 21, 38, 7

Note: Frequency, size and Pavitt taxonomy reported. On the Pavitt taxonomy column, values represent the share of firms belonging to "traditional", "scale-intensive", "specialized-supplier" and "science-based" macro-sectors respectively. MNE: multinational enterprise, NMNE: non-multinational enterprise, N.A.: missing information.

Table 1 sets out some sample descriptive statistics. The number of national (Italian) firms is much higher than that of foreign companies: 3,176 (92%) versus 206 (about 6%). National firms are on average three times smaller than foreign ones. Moreover, while more than 50% of Italian firms operate in traditional sectors, foreign companies are more numerous in Pavitt's specialized-supplier sector (44 %), which means that foreign (multinational) firms are generally larger and more heavily oriented towards high-tech production.

As for national companies, only 223 (7%) are multinational enterprises (MNEs), while 2,906 (91.5%) are non-multinational enterprises (NMNEs). "Size" undoubtedly represents a crucial discriminating factor, since national MNEs are about three times larger than national non-multinational firms (a proportion which mirrors the previous comparison between national and foreign firms). A more surprising aspect is that, in terms of business sector, more national

MNEs operate in traditional sectors (65%) than national NMNEs (having a share of 53% in Pavitt's supplier-dominated sector).

Table 2 shows some difference-in-mean tests to evaluate the differential R&D behaviour of foreign and national companies (both MNEs and NMNEs). We first compare national MNEs and national NMNEs. We find that the former display a much higher level of total and internal R&D spending compared to the latter, while no differences emerge in terms of extramural R&D. Also, foreign firms display a higher level of total and intramural R&D expenditure when compared to Italian NMNEs, although, once again, extramural R&D is not significantly different. Finally, we compare foreign with national MNEs and find that no significant differences emerge in terms of total (internal as well as external) R&D investment. This means that, at least at this stage in the analysis, foreign and national multinationals are indistinguishable, although all three R&D spending indicators are on average higher for foreign firms.

Table 2
Difference-in-mean Tests between Italian and Foreign Firms for a Set of Total, Intra and Extra R&D

	Italian MNEs (N=124)	*Italian NMNEs (N=1106)*	*Difference*	*p-value*
R&D total**	2458	1278	1180	0.071
R&D intra**	2233	1023	1210	0.029
R&D extra	243	257	-14	0.936
	Foreign MNEs (N=107)	*Italian NMNEs (N=1250)*	*Difference*	*p-value*
R&D total***	3735	1278	2457	0.0013
R&D intra***	3365	1023	2341	0.000
R&D extra	397	257	140	0.475
	Foreign MNEs (N=)	*Italian MNEs (N=)*	*Difference*	*p-value*
R&D total	3735	2458	1277	0.173
R&D intra	3364	2233	1132	0.213
R&D extra	397	242	154	0.191

Note: $^{*}=p<0.1$, $^{**}=p<0.05$, $^{***}=p<0.01$. (Variables are expressed in thousands of Euros). MNE, multi-national enterprise; NMNE, non multi-national enterprise.

Let us now focus on a comparison between foreign and national companies. Table 3 reports the difference-in-mean between these two groups over a set of various firm indicators, such as size, R&D and fixed investment capacity, as well as financial, cost, and profitability structure. Furthermore, other variables concerning support to R&D activities, economic production sector, (national) geographic location of the firm, affiliation to a group, and presence of R&D collaborations are also considered. It is quite easy to see that the main differences between national and foreign firms regard size (both in terms of number of employees and total turnover), R&D spending (thus confirming the above findings), investment capacity (national firms mainly focus on increasing the scale of their production), export intensity (exports on total turnover, foreign firms tend to be more export-intensive), and total ICT investment (foreign companies tend to invest more, although ICT intensity is fairly similar). What clearly emerges is the great similarity between the two groups in terms of R&D intensity (total R&D on turnover) and share of internal and external R&D. Furthermore, also the indicators regarding financial structure

Table 3
Difference-in-mean Tests between Italian and Foreign Firms for a Set of R&D, Investment, Cost, Financing and Performance Indicators

Continuous indicators	*Italians (A)*	*Foreigners (B)*	*Difference (C)*	*p-value (D)*	*|C/[(A+B)/2]| (E)*
Turnover***	66761	224854	-158093	0.000	1.084
Employees***	264	852	-587	0.000	1.052
R&D investment**	1258	2847	-1589	0.020	0.774
R&D intensity	0.018	0.016	0.002	0.652	0.118
Investment-intensity**	0.037	0.030	0.007	0.031	0.209
Cash-flow	0.00002	0.00001	0.00001	0.254	0.667
Debt	0.00037	0.00016	0.00021	0.774	0.792
Equity	0.0004	0.0003	0.0001	0.866	0.286
Labour-intensity	0.293	0.186	0.107	0.817	0.447
Capital-intensity	0.001	0.001	0.000	0.846	0.000
Export-intensity***	39.599	48.510	- 8.910	0.000	0.202
ROI	21.331	13.416	7.916	0.132	0.456
ROE	12.966	15.367	- 2.401	0.238	0.169
OPM	0.056	0.055	-0.0005	0.890	0.009
R&D intra (%)	80.514	83.515	- 3.002	0.341	0.037
R&D extra (%)	19.486	16.485	3.001	0.341	0.167
ICT investment***	250	557	-307	0.002	0.761
ICT-intensity	0.004	0.003	0.001	0.587	0.286
Discrete indicators	*Italians (A)*	*Foreigners (B)*	*Difference (C)*	*p-value (D)*	*|C/(A+B)/2| (E)*
R&D subsidy – FIT***	0.092	0.153	- 0.061	0.005	0.498
R&D subsidy - FAR	0.016	0.016	0.001	0.955	0.063
R&D subsidy - other	0.381	0.296	0.085	0.019	0.251
R&D collaborations	0.459	0.455	0.005	0.926	0.011
Group***	0.276	0.772	- 0.496	0.000	0.947
Pavitt – traditional***	0.535	0.295	0.239	0.000	0.576
Pavitt - scale	0.170	0.192	-0.022	0.427	0.122
Pavitt – specialized***	0.257	0.451	-0.194	0.000	0.548
Pavitt - science-based	0.039	0.062	-0.023	0.110	0.455
North-west***	0.345	0.477	-0.131	0.000	0.319
North-east	0.315	0.321	- 0.006	0.853	0.019
Centre	0.181	0.135	0.047	0.101	0.297
South & Islands***	0.158	0.067	0.091	0.001	0.809
Number of foreign firms	206				
Number of Italian firms	3176				
Total number of firms	3382				

Note: The sample has been cut below the 99th percentile of the variable "Employees". * $= p < 0.1$, ** $= p < 0.05$, *** $= p < 0.01$. (Variables in level are expressed in thousands of Euros). ROI: return on investment; ROE: Return on equity; OPM: Operating profit margin; ICT: Information and communication technology; FIT: Fund for

and profitability do not seem to point to any great differences between foreign and national firms.

As for the discrete variables, we can observe that foreign firms receive larger R&D subsidies by means of the FIT policy tool (the Italian Fund for Technological Innovation) than national firms, they generally belong to a group of companies, they operate in Pavitt's specialized-supplier sector more than national firms, and they are more heavily present in the north than in the south of the country. No differences emerge in terms of R&D collaborations with other institutions, since about 46% of both foreign and national firms rely on some kind of R&D project partnership.

Based on these findings, foreign firms do not seem to have any decisive competitive advantage over national ones. With the exception of size, which is clearly a discriminating factor, foreign firms are neither more profitable (in terms of ROI, ROE, and OPM) nor more R&D intensive than national companies. Cost and financial structure is fairly indistinguishable, as is the percentage of intramural and extramural R&D, as seen before. The only competitive advantage of foreign firms regards their export intensity, an element which is offset by the higher fixed capital investment intensity of national firms. Yet, the two groups undoubtedly differ in relation to the sector in which the firms operate: national companies are more concentrated in traditional economic activities, while foreign companies are more high-tech-oriented. As for geographical location, the north of Italy remains the favourite location for foreign multinational companies. This is probably due to their asset-seeking strategies, which lead them to prefer the richer part of the country because of its more qualified assets as well as the potential presence of profitable spillovers.

5. MODEL'S SPECIFICATION AND RESULTS

This section presents the specification (section 5.1) and estimation results (section 5.2) of the model introduced in section 3. We consider the (overall) R&D behaviour of foreign and home companies within a comparison made using the random coefficient model. The aim of this section is to consistently estimate the full set of parameters in (3) and to reach appropriate conclusions. The procedure set out in section 3 starts with an OLS estimation of equation (2), whose parameters are the basis for the estimation of the causal effects in (3).

5.1. Model's Specification

A vast amount of theoretical and empirical literature is available on the determinants of firm R&D behaviour (see, among others, Mansfield, 1964; Nadiri, 1979; Cohen and Levinthal, 1990; David and Hall, 2000). The most popular model of company R&D determination – one comprising most of the main findings from the literature – is that proposed by David, Hall and Toole (2000), hereafter DHT. This model revisits and improves an earlier model of company R&D choice proposed by Howe and McFetridge (1976).

The DHT model describes the optimum level of R&D investment as the point in which the expected marginal rate of return (MRR) and the expected marginal capital costs (MCC) associated with R&D investments are equal. This is a common profit maximisation strategy implemented by firms. The MRR curve derives from sorting R&D projects according to their *internal rate of return*, like in an ordinary investment plan. This curve is a decreasing function of R&D expenditure, since firms will first implement projects with higher internal rates of return and then those with lower rates. The MCC curve, instead, reflects the *opportunity costs* of investments at any level of R&D. This curve has an upward slope due to the assumption that, as soon as the number of projects to be implemented increases, firms have to shift from financing them through retained earnings to financing them by means of equity and/or debt funding (i.e. a shift from internal to external and more costly resources). Both curves depend on a number of variables other than R&D expenditure, which can cause them to move either downwards or upwards. These variables include some proxies of: technological opportunities; state of the demand; appropriability conditions; technological policy instruments; macroeconomic conditions; and external costs of funds (including availability of venture capital).

The choice of control variables to be included in our model aims at best grasping the factors listed by DHT. Our variables are: size (number of employees), financial structure (cash flow, indebtedness, and equity on total assets), R&D competence (R&D intensity), profitability (return on investment, i.e. ROI, and return on equity, i.e. ROE), public support (presence of subsidisation through FIT, FAR[7], and other forms of financing), competitive capacity (export intensity), being part of a group of firms (group) and, finally, a series of dummies, such as Pavitt's sector (as proxy of technological opportunities) and location (four Italian macro-regions). Let us briefly describe the meaning of the selected variables in detail.

Cash flow: this is the "self-financing" (or "internal") component of a firm's "capital structure" (the other components being external resources, such as "debt" and "equity"). It represents a firm's "internal liquidity constraint" and should be seen as the cheapest way to finance (R&D and capital) investments. Since R&D investments are mainly financed through self-retained earnings, introducing such a variable is of great relevance.

Debt: debt financing is a key resource for a firm's R&D and non-R&D investments. In Italy, this is reinforced by the prevalence of SMEs, characterised by a low propensity to rely on financing investments via the stock market.

Investment: fixed capital investment to turnover accounts for the capital intensity of a firm. In sectors oriented towards automation or high-tech manufacturing, this component may complement or substitute the R&D outlay.

Export: this is the share of turnover from exportations over total firm turnover. More internationalised firms are likely to operate under greater competitive pressure, which leads them to implement a diversified portfolio of strategies to attract innovative capacity, so that they can work at the forefront of technological innovation.

R&D intensity. Intramural and extramural R&D intensity is a key variable indicating a firm's relative effort in carrying out, commissioning and acquiring research activities. It is an input variable in the innovation process and, more generally, a measure of a firm's ability to absorb external knowledge. For persistently innovating companies, this variable comprises past experiences in performing R&D and innovation activities. It also represents a defensive strategy enabling a firm to raise "barriers" against imitation and, as such, it approximates quite well the degree of "appropriablity conditions" of the market in which the firm operates.

Size: besides accounting for the different economic scale of firms, this variable can also be seen, within the DHT model, as a proxy for the "state of the demand", since it is strictly collinear with firm turnover. Firm size is an indicator of the strength of a firm on the market and of its ability to support a more expensive and larger portfolio of innovation projects. The amount of resources available to it helps a firm to diversify risk and achieve relatively better R&D performance.

ROI, ROE: return on investment (ROE) and return on equity (ROE) are two measures of company *profitability*. This plays a key role in self-financing future R&D and in measuring company competitiveness, supported by further increasing R&D spending.

Group: this is a dummy variable which takes on value one if the firm belongs to a group of firms and zero otherwise. Belonging to a group can be key in glimpsing possible innovation opportunities and encouraging cross-group sharing of R&D competencies and financing.

FIT, FAR, other financing: these are binary variables indicating whether or not a given firm is supported in its R&D activities through the three most relevant Italian instruments. This is a common "flag", whose coefficient represents the net effect of the policy in question. Referring to the DHT approach, this is our "technological policy tool".

Sector: technological opportunities and other technical aspects are undoubtedly sector-dependent. Including this variable is essential to avoiding potential biases, due to different firm specialisations within our sample.

Region: regional differences are important, especially in countries like Italy characterised by uneven economic development. Moreover, like *Sector*, this variable accounts for the different sample weight of firms located in different Italian regions.

5.2. Model's Results

Table 4 shows the estimation results of equation (2). It goes without saying that the dependent variable is the total R&D expenditure and the comparison is made between foreign and national companies (without any distinction between national MNEs and NMNEs)[8]. Observe that both level and Beta coefficients are considered. Beta coefficients are useful since they are independent of the unit of measurement used for the various regressors, thus providing normalisation and comparability of their magnitude.

Let us comment on the results. The estimation of the Average Treatment Effect (ATE) is by definition the coefficient of the dummy "Treatment" (taking value one for a foreign firm and zero for a national firm), and it is around 81 thousand Euros. This value is significant at 10% but substantially lower than the difference-in-mean estimation reported in table 3, where it is around 1,600 thousand Euros. This great disparity depends on the crucial fact that the difference-in-mean estimator does not take into account any observable characteristics that affect R&D spending other than the different company ownership (foreign or national) considered in our analysis. In other words, when *controlled for* size and for other relevant structural features (i.e. *ceteris paribus*), the difference between the R&D performance of foreign and national firms greatly decreases, although it remains positive and statistically significant. The effects of the other regressors on R&D expenditure are also interesting. As expected, high R&D intensity and large size are the most important predictors of substantial R&D spending. Also, greater export intensity promotes higher R&D expenditure, while the greater the ROE the greater the R&D outlay too. Excluding this variable (the ROE), which can be – at least partially – interpreted as an indicator of R&D self-financing, the other financial features (cash-flow and debt) are globally not significant. Observe the negative significant sign of investment intensity, which may mean that fixed investments are substitutes and not complementary assets in relation to R&D investment[9]. Finally, the FIT supporting policy tool has a strongly significant and positive effect on firm R&D spending.

Table 4
Random Coefficient Regression Analysis

	(Level)	*(Beta)*
Treatment	81.79*	0.028*
	(49.37)	(49.37)
Cash-flow	-101.68	-0.007
	(295.45)	(295.45)
Debt	-25.39	-0.005
	(56.98)	(56.98)
Investment	-583.37***	-0.037***
	(171.20)	(171.20)
Export	0.62**	0.022**
	(0.30)	(0.30)
R&D intensity	13241.80***	0.519***
	(929.63)	(929.63)
Size	1.76***	0.527***
	(0.37)	(0.37)
ROI	-0.47*	-0.017*
	(0.24)	(0.24)
ROE	2.54***	0.045***
	(0.95)	(0.95)
FIT	99.29***	0.051***
	(35.64)	(35.64)
FAR	-90.86*	-0.024*
	(47.32)	(47.32)
Other financing	18.96	0.013
	(19.42)	(19.42)
Group	-49.07***	-0.033***
	(17.20)	(17.20)
N	2390	2390
adj. R^2	0.633	0.633
r2	0.64	0.64
F	37.27***	37.27***

Note: Dependent variable: "total R&D expenditure". Level and Beta coefficients reported. Standard errors in parentheses. The coefficient of "Treatment" is the Average Treatment Effect (ATE). $^{*} = p < 0.1$, $^{**} = p < 0.05$, $^{***} = p < 0.01$. ROI: return on investment; ROE: Return on equity; FIT: Fund for Technological Innovation; FAR: Fund for research facilitation.

Besides the ATE parameter, our analysis allows for the calculation of another two relevant causal parameters: the ATET and the ATENT. Table 5 sets out the point results for the ATE, ATET and ATENT. We can immediately observe that the ATET is equal to -70.57, while the ATENT is equal to 92.65. Of course, the relation existing among these three parameters and expressed by equation (1) is fully satisfied in our empirical application. The standard errors for the ATET and ATENT are obtained via bootstrapping, as analytical formulas are not available for these two parameters. After the bootstrap estimates, we can test the significance of these parameters. We can observe that, while the ATENT is positive and significant, the ATET is negative and non-significant. Nevertheless, we believe that commenting on the signs of these coefficients is crucial, especially because they can provide relevant insights to further our analysis.

Table 5
Estimation of ATE (Average Treatment Effect), ATET (Average Treatment Effect on Treated) and ATENT (Average Treatment Effect on Non Treated)

	Observed coefficient	*Std. Err.*	*P-value*
*ATE**	81.79	49.37	0.098
ATET	-70.57	61.5	0.251
*ATENT**	92.65	54.6	0.090

Note: Standard errors for ATET and ATENT are obtained via bootstrapping.

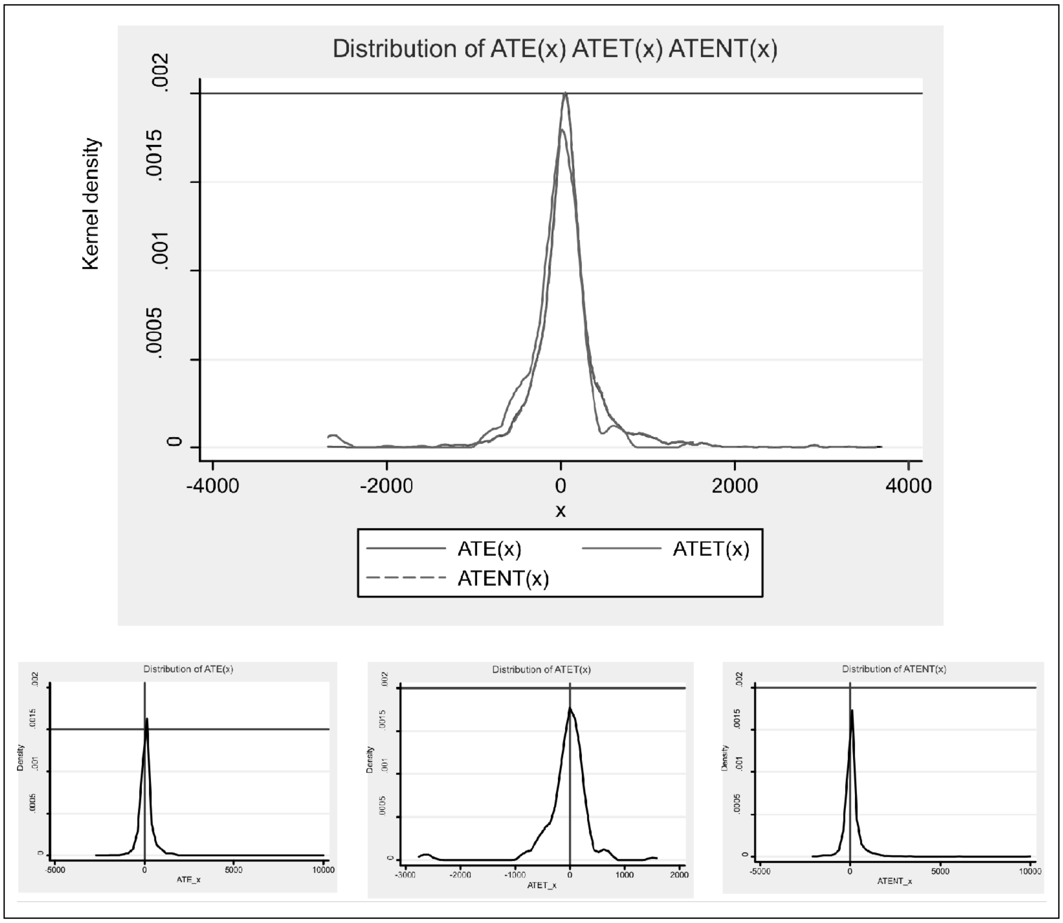
Table 6
Descriptive Statistics for the Distribution of *ATE*(x), *ATET*(x) and *ATENT*(x)

	N. of obs.	*Mean*	*Std. dev.*	*Median*	*Min*	*Max*
ATE(**x**)	2390	81.79	493.23	51.77	-2679	9957
ATET(**x**)	159	-70.57	463.42	-8.08	-2679	1518
ATENT(**x**)	2231	92.65	493.59	56.15	-2059	9957

To better understand this point, it is first necessary to look at the "distribution across firms" of these causal effects. Indeed, although interesting *per se*, the results of the ATE, ATET and ATENT are just based on point-estimates of far more complex, composite and heterogeneous causal phenomena. As suggested in section 3, our random coefficient setting is appropriate to allow for a more in-depth analysis of the effect of "Treatment" on R&D spending, via the estimation of ATE(**x**), ATET(**x**) and ATENT(**x**), that is, via the calculus of firm-specific (idiosyncratic) effects of "being a foreign rather than a national enterprise". More simply put, we estimate not only the single effect of the variable "Treatment" (the w) on "R&D spending" (the y), but the entire distribution of this effect across firms. The results of this analysis are displayed analytically in Table 6 and graphically in Figure 1. Table 6 sets out the main characteristics of the distribution of ATE(**x**), ATET(**x**) and ATENT(**x**) respectively, while figure 1 shows their Kernel density estimates. What emerges from these figures is the existence of long right and left tails, although in a neighbourhood of zero all distributions are fairly "bell-shaped". Hence, the phenomenon we are dealing with displays a significant spread across firms, an aspect which would have been completely ignored in a traditional regression setting.

In the case of the ATET, it is now clearer why the value of its mean is negative: it depends on the presence of a large left (negative) tail compared to a smaller (positive) right tail. The presence of negative signs is thus a "structural event" within this distribution, and its significance and economic interpretation deserve further attention. Indeed, how can we interpret the negative tendency of ATET(**x**) compared to the positive tendency of ATE(**x**) and the even more positive one of ATENT(**x**)? This is an important issue and, given the innovative nature of this approach within the literature, a more detailed analysis is needed. Let us start by looking at the definitions of ATE($\mathbf{x}_i$), ATET($\mathbf{x}_i$) and ATENT($\mathbf{x}_i$), where the subscript "i" now refers to generic company i:

Figure 1: Kernel Density Distribution of ATE(x), ATET(x) and ATENT(x)



$$ATE(\mathbf{x}_i) = E(y_{i,foreign} - y_{i,national} \mid \mathbf{x}_i \,, i{=}overall\ sample)$$

$$ATET(\mathbf{x}_i) = E(y_{i,foreign} - y_{i,national} \mid \mathbf{x}_i \,, i{=}\ foreign)$$

$$ATENT(\mathbf{x}_i) = E(y_{i\,foreign} - y_{i,national} \mid \mathbf{x}_i \,, i{=}\ national)$$

The condition "$\mathbf{x}_i$, $i= k$", with k = *overall sample, foreign, national*, identifies a specific firm "structure". In other words, it has to be interpreted as a "ceteris paribus" condition for the expectation it refers to. The condition "$\mathbf{x}_i$, i=*foreign*" thus means: "given the structure of foreign firms"; similarly, the condition "$\mathbf{x}_i$, i= *national*" means: "given the structure of national firms". This structure depends on the firm indicators contained in the vector **x**.

Based on this premise, we can better understand what a negative ATET means. It means that, given a structure which is the same as that of our sample foreign firms, if a foreign firm changed its status, thus becoming a national one, then its R&D would increase. In other words, the counterfactual situation ("becoming a national firm") would increase its R&D compared to its current status ("being a foreign firm"). Therefore, this result suggests that, given a structure which is the same as that of a foreign firm, a national firm would have a higher level of R&D expenditure.

On the contrary, what does a positive ATENT suggest? It suggests that, given a structure which is the same as that of our sample national firms, if a national firm changed its status, thus becoming a foreign one, then the level of its R&D would increase. Therefore, given a structure which is the same as that of a national firm, a foreign firm would have a higher level of R&D expenditure.

Which are the main discriminating factors characterising the differential structure of foreign and national firms? Column E of table 3 shows the most relevant (control) variables, setting out the results on a normalised index of the difference between foreign and national firms, which takes the following form for generic variable *x*:

$$\left|\frac{(x_{foreign} - x_{national})}{(x_{foreign} + x_{national})/2}\right|$$

By means of this formula, the figures in column E of table 3 can be easily and suitably compared. By looking exclusively at the significant variables, we can immediately notice that the highest value of the index is reached in relation to *size*, expressed both as total Turnover (with a value of 1.084) and number of Employees (1.052), followed by the variable Group, i.e. the characteristic of belonging to a group of firms (0,947), and total ICT-investment (0.761). Other significant variables reach very lower levels of the index. In particular, sector *specialisation* proves to be quite important, but with an index value which is about half that of size, for what concerns both traditional sectors (0.576) and specialized ones (0.548) in Pavitt's taxonomy. This suggests that our previous results mainly depend on the role played by size and, to a lesser extent, on the role played, for instance, by specialisation patterns[10]. Furthermore, since belonging to a group and making larger ICT investments are features typically displayed by bigger firms, we can conclude that – according to our data – size is the most relevant discriminating factor explaining the differential structure of foreign and home companies.

6. CONCLUSIONS

The above findings pave the way for stimulating interpretations and lead to important policy conclusions for Italy. The weakness of Italy's national R&D production system is mainly ascribable to the "smallness" of its firms, a feature which it shares with other European countries[11]. Indeed, given the same "large" size, an Italian company is able to perform more R&D than a foreign twin. However, given the same "small" size, the R&D performance of an Italian firm is worse than that of similar foreign firms. This is the main analytical result of our analysis. It means that, in terms of R&D capacity and from a domestic point of view, "large size" generates comparative advantages, whereas "small size" causes substantial disadvantages (in the case of Italian companies, of course).

From a policy perspective, the role played by "corporate size" should be reconsidered, especially when policymakers are specifically interested in increasing the level of national R&D

outlay. Our work shows that, given the same size, Italian firms start with an R&D disadvantage when compared to foreign ones. Nevertheless, competitiveness increases substantially as soon as Italian companies grow in size. Moreover, beyond a certain threshold, national firms are able to perform even better that foreign ones in relation to R&D capacity.

This "positive" conclusion may lead to relevant "normative" recommendations for Italian industrial policies. Policymakers can adopt two strategies to boost national R&D performance: (i) attract inward investments to enable more multinational foreign firms to set up operations within the national borders, (ii) provide incentives and suitable policies to help smaller home companies grow in size (for instance, by offering incentives for Mergers & Acquisitions, etc.).

In principle, the adoption of either policy does not prevent the existence of the other, and they could, in fact, be used simultaneously. Nevertheless, in situations of public budget constrains, it is sometimes necessary to make a choice. Although it is beyond the scope of this paper to offer definitive advice on the matter, we have shown that both choices can help steer future polices towards increasing Italy's R&D capacity[12].

It is worth stressing that our findings do not necessarily apply to other countries, due to different socio-economic contexts and government policies regulating the operations of MNCs. However, this investigation might prove useful for countries with a similar industrial structure, although only rigorous comparative studies can truly shed light on this relevant issue.

NOTES

1. More precisely, we define a foreign company as one satisfying these two requirements: (i) at least one foreign subject participates (with some shares) in the corporate capital, and (ii) this subject exerts direct control over corporate strategies.
2. In this case, one must turn to the wide class of models for "estimating treatment effects under selection on unobservable factors". In brief, two approaches can be followed: (i) Instrumental-Variables estimation, and (ii) Heckman Selection models. Both approaches require additional hypotheses, which are generally non-testable (see: Angrist, Imbens and Rubin (1996) and Heckman (1997)).
3. In this regression, the CMI hypothesis assumes the following form: $w \perp (e_0, e_1) \mid x$, which means that no endogeneity is present and the OLS estimators are thus consistent.
4. The estimation of (3) is performed using the STATA 11 user-written command "ivtreatreg" (Cerulli, 2012). The tutorial accompanying the command provides a more detailed presentation of the model used in this study with a simple instructional application.
5. This study is part of a three-year research project financed by the Italian Ministry of Education and Research in 2005-2008 on the performance of the Italian productive system. As such, the data period covered by the project, 2001-2003, was an appropriate reference. Nevertheless, project's members were obliged to wait some time before obtaining the permission to publish results. This explains why we were unable to provide a more updated release for the dataset.
6. This survey is representative of Italian manufacturing firms with more than 10 employees. All firms with more than 500 employees are included, while firms with 11-500 employees are selected according to a stratified sampling method based on size, industry and location. This and previous releases of the survey have been used extensively in the literature (see, for instance, Ughetto (2008)).
7. FIT (Fund for Technological Innovation) and FAR (Fund for Research Facilitation) are the two pillars of the Italian system of R&D support.

8. Indeed, as illustrated in table 2, the R&D commitment of foreign MNEs and Italian MNEs is almost indistinguishable, so that it does not make sense to analyse this comparison in greater detail. On the contrary, we focus on the comparison between the whole set of foreign and national companies, since table 2 shows remarkable differences which need to be investigated further.
9. Hall, Lotti and Mairesse (2012) stress that, in order to foster production efficiency, firms may use fixed capital investments (especially in ICT) in place of R&D investments devoted to process innovation. They find a negative relation between these two types of investment.
10. In fact, *size* and production *specialisation* are usually seen as the two key-categories characterising the industrial structure of a country.
11. The European Union, for instance, is engaged in providing suitable and targeted policies to improve the rate of R&D performance and innovation of SMEs, since they are generally thought of as one of the weakest actors within national innovation systems, especially because they are more financially constrained than larger firms.
12. In this regard, Castellani and Zanfei (2006) suggest that "policies aimed at attracting foreign multinationals can be complemented with measures supporting the growth of domestic multinationals" (p. 5). Our analysis suggests generalising this statement to all Italian R&D performers (not only multinationals).

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