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Research Paper

Business Group Affiliation and R&D

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ABSTRACT This paper analyzes whether belonging to a business group enhances firms' propensity for and intensity of R&D based on the greater opportunities to finance and co-ordinate R&D strategies and internalize knowledge spillovers. Compared with the existing literature, this paper has the following novelties: (a) it examines how the organization and diversification of business groups influence the R&D investment of affiliated firms; (b) it analyzes the role of R&D spillovers among affiliated firms; and (c) it distinguishes between propensity for and intensity of R&D. We find that less diversified groups are more likely to centralize R&D, while in more diversified groups firms are more likely to be autonomous. We find that controlled companies are more likely to benefit from knowledge spillovers than firms at the head of the group. Finally, we find that R&D autonomy is significantly associated with both a higher propensity for and intensity of R&D in controlled companies.

KEY WORDS: Business groups, R&D investment, knowledge spillovers, diversification, R&D management

JEL Classification: L2, M1, O32

1. Introduction

The aim of this paper is to investigate the relation between the firm's organization and R&D activity. In particular, we compare the propensity for and intensity of R&D between stand-alone firms and firms that belong to a business group. Our study is original compared to the existing literature in this area in: (a) examining how the internal characteristics of business groups influence the R&D investment of affiliated firms; (b) analyzing the role of R&D spillovers among affiliated firms; and (c) distinguishing between R&D propensity, i.e. the decision to engage in R&D activity, and R&D intensity, i.e. the amount of R&D investment.

R&D investment is one of the main inputs to the innovation process and one of the main predictors of firms' innovative capacity (Frenz and Ietto-Gillies, 2009). Firms engaging in R&D are more likely to both introduce innovations and develop radical innovations (Godoe, 2000; Raymond and St-Pierre, 2010); for this reason, R&D expenditure is the most common variable used in empirical studies to proxy for the firm's innovative efforts. Empirical surveys

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of firms' innovative activity demonstrate that not all firms invest in R&D, especially small firms (Ortega-Argilés *et al.*, 2009).

There can be little incentive to invest in R&D if fully appropriating or adopting its results is likely to be problematic. The presence of positive spillovers from R&D, though beneficial at the macroeconomic level, reduces the incentive for firms to invest in this activity (Bernstein and Nadiri, 1988). The presence and intensity of knowledge spillovers depend on structural factors, such as the sector's technological environment and the intensity of competition, but also on the firm's internal organization, such as the degree of diversification. One way to control a portfolio of diversified businesses is to create a business group. A business group is a set of legally independent companies owned by the same person/persons (Almeida and Wolfenzon, 2006). Business groups are widespread in both emerging economies where they are supposed to substitute for the deficiency of market institutions (Khanna and Rivkin, 2001; Khanna and Yafeh, 2005), and in developed countries where this organizational structure can enable superior static and dynamic efficiencies to that achievable by stand-alone firms (Cainelli and Iacobucci, 2011; Hamelin, 2011).

One of the reasons for the large presence of business groups in advanced economies might be their ability to increase firms' propensity to engage in R&D in order to enhance their innovation capabilities and economic productivity (Blanchard *et al.*, 2005). These benefits stem from two features of business groups that potentially can influence the R&D propensity of member firms. The first is the greater possibility to internalize the positive spillovers resulting from R&D investment (Cefis *et al.*, 2009). The second is the presence of an internal capital market that facilitates the financing of R&D projects; it can be expected to mitigate the asymmetry of information between R&D actors (e.g. affiliated firms) and providers of funds (e.g. the head of the group).

In this context, there is a recent empirical literature investigating the relation between business group affiliation, R&D investment and innovative performance (Filatotchev *et al.*, 2003; Mahmood and Mitchell, 2004; Blanchard *et al.*, 2005; Cefis *et al.*, 2009; Belenzon and Berkovitz, 2010). The common hypotheses of these works are that group affiliation is expected to increase both the R&D investment of member firms and their innovation performance. The empirical evidence seems to confirm these hypotheses.

In contrast to the previous literature, in this paper we consider not only the intensity of but also the propensity for R&D because investment in R&D often involves fixed costs; as a consequence, there may be a threshold below which the firm would receive no benefits from R&D activity. We also explore whether belonging to a group might facilitate affiliated firms to go beyond this threshold level.

So far, empirical work assumes the presence of cooperative relations among affiliated companies but does not consider the internal organization of the business group explicitly. This is a major research gap, given that business groups show great variation in relation to the number of companies, their size and degree of diversification, and the internal mechanisms adopted to co-ordinate and control affiliated firms—from highly centralized structures mimicking a divisional organization to highly autonomous structures in which there are no significant operational links among member firms (Cainelli and Iacobucci, 2011). For this reason, when looking at the innovative performance of firms, what matters is not only belonging to a group "per se", but also the internal characteristics of the business group.

In this paper, we focus on R&D rather than innovation for two reasons: on the one hand, it is easier to define and measure R&D investment than innovation; on the other hand, R&D

investment is more directly linked to the explanatory factors, i.e. internal capital markets and knowledge spillovers. R&D can also be considered a good indicator of the innovative efforts of firms (Nieto and Quevedo, 2005). We distinguish between R&D propensity and intensity. By R&D propensity, we mean whether a firm invests or not in R&D; by intensity we mean the amount of R&D expenditure. Most of the empirical literature on R&D in business groups refers only to R&D intensity (Filatotchev *et al*., 2003; Cefis *et al*., 2009).

We analyze how R&D management is organized within business groups according to the degree of diversification of the group and how this influences the propensity for and intensity of R&D. We find that the degree of diversification determines the way in which R&D is organized: centralized/autonomous. In particular, we find that less-diversified groups are more likely to centralize R&D, and highly diversified groups are more likely to allow affiliated firms more autonomy over R&D investment. Moreover, we find that knowledge spillovers are more likely to benefit controlled companies, rather than companies at the head of the group. We also find that R&D autonomy among controlled firms is significantly associated with higher R&D propensity and intensity, despite the fact that knowledge spillovers could induce free riding behavior.

The paper is organized as follows. Section 2 reviews the relevant literature and proposes the hypotheses to be tested. Section 3 presents the data used in the paper and the method of analysis. Section 4 presents and discusses the empirical results. Section 5 draws the main conclusions and discusses possible extensions to this study.

2. Related Literature and Research Hypotheses

Several empirical works investigate how the organization of firms in business groups influences the innovative efforts of member firms. By business group, we mean a set of legally independent companies controlled by the same person or persons through ownership ties. The vertex of the group can be an individual or a group of people, often members of the same family (Almeida and Wolfenzon, 2006). Interest in studying business groups has grown, as a result of increased awareness of their widespread presence and economic importance in both emerging and developed countries. In the present study, we define business groups based on ownership and control ties. This is not to deny the importance of other forms of relations among firms which are not based on ownership ties; rather, this definition allows clearer and more objective delimitation of the group boundaries, and also is suited to the aims of this study. The notion of control, resulting from ownership ties, is central to consideration of the appropriability of R&D results and the functioning of an internal capital market, both of which we consider are key to explaining the relation between group affiliation and R&D investment. A recent literature (see Figure 1) has investigated the influence of business group on affiliated firms' investment in R&D to increase their innovation performance. The common hypothesis in this literature is that group affiliation enhances the innovation performance of member firms. Firms affiliated to business groups are supposed to have easier access to the resources required for innovation—such as capital, technological knowledge, trained people, etc.—thanks to the close relations with other member companies, and centralized management of these resources. Also, affiliated firms are likely to have a greater incentive to invest in R&D because the knowledge spillovers resulting from their innovative efforts can be internalized within the group. Overall, these empirical studies confirm the hypothesis that group affiliation enhances the innovation performance of member firms.

Paper	Theory / Main hypothesis	Unit of analysis / data	Country / years	Dependent variables	Independent Variables	Main results
(Filatotchev et al., 2003)	Resource sharing / Belonging to a group favor R&D activity Position within the group influence R&D activity	Firm level / 2002 manufacturing firms	Italy / 1992–94	R& Dexpenses / employees	Group dummy Position within the group (head or controlled)	1) Belonging to a group is positively associated with R&D intensity 2) Higher positioning within the group's hierarchy is associated with higher R&D intensity
(Blanchard et al., 2005)	Knowledge externalities / Explaining the effects of on a firm's productive efficiency of the R&D conducted in other affiliates	Firm level and group level / 3100 firm affiliates	France / 1994–98	Value added	Firm R&D Group R&D	1) Within group R&D has an impact on the productivity of affiliates 2) R&D of other affiliates is more profitable to firms not doing R&D than to those having their own R&D
(Chang et al., 2006)	Resource sharing Groups as substitutes for weak market institutions / Business groups contribute to affiliate firms' innovation contingent on a country institutional environment	Firm level and group level / Sample from the largest 500 firms	Korea Taiwan / 1991–99	US patents	Group dummy Group diversification	1) Affiliation benefited firm innovation in Korea, but did not do so in Taiwan 2) the benefit of business group affiliation for firm innovativeness is contingent on a country's institutional environment 3) diversification at the group level negatively affected affiliate firms' innovation performance in Taiwan, where capital markets were more developed than they were in Korea.
(Cefis et al., 2009)	Knowledge externalities / Coordination of strategies (groups) favor the internalization of the effects of product and process innovations	Firm level / 3696 Italian firms with a positive R&D budget	Italy / 1992	R&D expenses on product and process innovation	Group dummy	1) firms that belong to a group invest significantly more into aggregate R&D than independent firms. 2) the R&D portfolio of firms that belong to a group is more intensive in product R&D.
(Belenzon and Berkovitz 2010)	Internal capital market Knowledge spillovers between group members / Positive relation between group affiliation and innovation	Firm level / 11645 firm of which 5683 are affiliated	Europe / 1995–2004	EPO and US patents	Group dummy Group diversification Industry dependence on external finance Research similarity index of affiliated firms	1) group affiliates patent more than standalones or affiliates of small groups 2) group–innovation relation is stronger in industries that rely more on external finance and in groups with more-diversified capital sources 3) affiliates of the same group tend to have different research focus and are unlikely to cite each other's patents.
(Hsieh et al., 2010)	Resource sharing Internal capital market / Belonging to a group enhance firm's innovation performance	Firm level and group level / 4170 firms of which 715 belonging to a group	Taiwan / 2001–2003	Granted patent applications	Group dummy Group diversification Ownership Industry dependence on external finance	1) Business groups foster innovation of affiliated firms 2) Group-innovation relation is stronger in industries that rely more on external finance 3) group diversification is positively related to firm innovativeness 4) family ties results in a better innovative performance of affiliated companies

Figure 1. Papers on the relation between group affiliation and firm innovation

This performance is measured in different ways. Some papers consider input to the innovation process, in terms of R&D expenses (Filatotchev *et al.*, 2003; Cefis *et al.*, 2009). Others consider the output of the process, measured by patents granted (Chang *et al.*, 2006; Belenzon and Berkovitz, 2010; Hsieh *et al.*, 2010). Blanchard *et al.* (2005) analyze whether and to what extent the productivity (value added) of the affiliated firm depends on the R&D activities of other companies in the same group. We focus on firms' R&D rather than their innovative output because this latter depends not only on the innovative effort (R&D) but also the efficiency of the innovation process. We consider innovative outputs only when analyzing knowledge spillovers.

The decision to invest in R&D is motivated by the possibility to profit from its results. R&D investment is one of the riskiest forms of investment and firms usually find it difficult to raise external funds to finance it. In addition to the difficulties involved in predicting the likelihood of achieving positive results, most R&D expenses involve intangible assets that cannot be used as collateral to obtain external financing. The affiliation of a firm to a business group can have a positive influence on the financing of R&D projects and the appropriability of their results. Thus, we propose the following hypotheses.

H_{1a}: Firms belonging to a business group are expected to exhibit a higher propensity for R&D (i.e. investment in R&D activity) than stand-alone firms.

H_{1b}: Firms belonging to a business group are expected to exhibit higher R&D intensity (i.e. higher level of R&D spending) than stand-alone firms.

Most studies consider belonging to a group as a sufficient condition for the presence of a coordinated R&D strategy and internalization of knowledge spillovers among affiliated companies (Filatotchev *et al.*, 2003; Cefis *et al.*, 2009). As Hsieh *et al.* (2010) note, one of the limitations of empirical work on the relation between group affiliation and firm innovation performance is that it does not consider the characteristics and internal organization of business groups. An important characteristic is the degree of their diversification. We suggest that the degree of diversification influences the organization of R&D within a group. In particular, we expect that in less-diversified groups, R&D is more likely to be centralized to exploit scale and scope economies. Also, the existence in less-diversified groups of synergies and a common knowledge base are likely to make it easier for the group's top management to understand the innovation processes of affiliated firms, thus making centralization more effective.[1]

In contrast, in diversified groups, it is more likely that affiliated firms will have autonomy over their R&D spending. This is because the higher the level of diversification, the greater the effort that is required to manage and control various product categories, and the higher the probability that the scope of activities will go beyond managerial competencies and capabilities (Baysinger and Hoskisson, 1989; Hitt *et al.*, 1996).

Thus we propose the following hypothesis:

H_2: Low (high) diversified groups are more likely to show a low (high) degree of independence in R&D management.

[1] We thank an anonymous referee for suggesting this point.

Some authors (Blanchard *et al.*, 2005; Cefis *et al.*, 2009; Belenzon and Berkovitz, 2010) examine the presence of knowledge spillovers among firms that belong to groups. Specifically, Blanchard *et al.* (2005) find that the productivity of affiliated firms depends on the R&D efforts of other companies in the same group, thus indicating the presence of positive knowledge spillovers from R&D activity among affiliated companies. On the other hand, Belenzon and Berkovitz (2010) find very low frequency of within-group patent citations which leads them to conclude that knowledge spillovers are of little relevance in business groups. However, their study considers groups whose firms often operate in unrelated technology areas (Belenzon and Berkovitz 2010: 520).

We analyze the relations between degree of diversification, position of the firm in the group and the presence of knowledge spillovers. As is well known, the detection and measurement of knowledge spillovers are controversial and troublesome. It might be remembered that spillovers should not involve pecuniary transactions (Breschi and Lissoni, 2001a, 2001b, 2009). For this reason, we take a conservative approach and consider those affiliated firms that did not invest in R&D during the period but nevertheless introduced significant innovations.

Moreover, the theoretical and empirical literature is not conclusive about the relation between diversification and knowledge spillovers. On the one hand, in low diversified groups, the R&D of affiliated companies is more likely to generate positive externalities for the other firms in the group. On the other hand, a high level of diversification could reduce potential synergies among affiliated companies in the sharing of knowledge spillovers from R&D. In fact, according to the agency view of the firm, diversification is seen as the result of managerial discretion related to empire building and risk reduction, rather than to gains from exploiting production and knowledge synergies (Amihud and Lev, 1981). However, according to the resource-based view, diversification can be seen as a strategy for exploiting positive knowledge spillovers and transferring different technologies across product lines (Teece, 1980, 1982). Our database (described in Section 3 below) includes a representative sample of Italian firms, and since the Italian situation is characterized by a predominance of family-owned firms and lack of separation between ownership and control (Barca and Becht, 2001), we argue that the resource-based view should be more relevant than the agency view. Thus, we expect a positive relationship between degree of diversification and presence of knowledge spillovers. We test the following proposition:

H_{3a}: There is a positive relation between the degree of diversification of the business group and the presence of knowledge spillovers in affiliated firms that did not invest in R&D.

Moreover, we expect that controlled firms are more likely to benefit from knowledge spillovers than business group heads. This is because the head of the business group has an interest in knowledge being transferred to its controlled companies because its ownership share allows the business group head to appropriate part of the profits of controlled companies. However, if the flow of knowledge is from controlled companies to the head of the business group, the affiliated companies do not obtain the same benefits.

We empirically test the following proposition:

H_{3b}: Among affiliated companies that did not invest in R&D, controlled companies are more likely to benefit from knowledge spillovers than the head of the business group.

Autonomy to conduct R&D activities in business groups should increase the R&D intensity of controlled companies. Affiliated companies are granted R&D autonomy as an incentive to engage in this activity. This mechanism is similar to what Aghion and Tirole (1997) propose when examining the effect of delegating authority in organizations. We expect that the degree of autonomy in the management of R&D activity should positively affect both the propensity for controlled companies to engage in R&D, and the intensity of their R&D. This result may be counterbalanced by other forces. The presence of positive spillovers, whose benefits mainly involve controlled companies (H_{3b}), could reduce their incentive to invest in R&D.[2] Overall, we expect that free riding behavior should be mitigated among firms belonging to the same group. This leads us to hypothesize that the first effect (autonomy in R&D decisions) will prevail over the problems arising from R&D spillovers (free riding). As a result, we propose that:

H_{4a}: The degree of independence in R&D management is expected to increase the R&D propensity of controlled companies.

H_{4b}: The degree of independence in R&D management is expected to increase the R&D intensity of controlled companies.

3. Data and Methodology

To test our hypotheses, we use secondary data derived from the Capitalia survey. The survey includes over 4,000 firms, stratified by firm size (number of employees) and geographical area, and is representative of the universe of Italian manufacturing firms with more than 10 employees. We use the IX survey, which collected data referring to the 3-year period 2001–2003. The survey data are enriched by balance sheet and income statement data for the same period. Since balance sheet data and income statement data were not available for all respondents, the number of observations in our empirical analysis dropped to around 3,200.[3]

3.1 Dependent Variables

We use four dependent variables:

(a) R&D propensity is a dummy variable for R&D expenses in the period 2001–2003, used to test the hypotheses about the likelihood to engage in R&D;
(b) R&D intensity measured as the ratio between R&D expenses and number of employees in 2003;
(c) degree of independence enjoyed by affiliated firms in R&D and other key management functions; and
(d) indicator for knowledge spillovers.

[2] Also, when the controlled companies have autonomy to decide their R&D effort, the ex-post requirement to share its results diminishes managerial incentives to invest in R&D (Brusco and Panunzi, 2005). In business groups, this problem may be exacerbated by potential conflicts between controlling owners and minority shareholders in the controlled companies that invest in R&D because these latter will not benefit from the sharing of R&D results.

[3] The Capitalia survey is one of the most important surveys of Italian manufacturing firms and has been used frequently by researchers to investigate Italian firms' behavior and performance (Filatotchev *et al.*, 2003; Piga and Vivarelli, 2004; Bianco and Nicodano, 2006; Angelini and Generale, 2008).

In the Capitalia survey firms were asked whether, in the period 2001–2003, they had invested in R&D, and if so, the amount of the investment. From this information, we constructed the first two dependent variables. R&D intensity is measured as the ratio between R&D expenses and some size variables. The most commonly used variables are employees and sales; to enable comparison with other studies, we chose employees (Vivarelli *et al.*, 1996; Filatotchev *et al.*, 2003; Piga and Vivarelli, 2004; Lhuillery, 2011; Lhuillery and Pfister, 2011).

The third dependent variable is the degree of independence of R&D management. The Capitalia data-set provides four different multinomial variables for level of autonomy of affiliated firms, referring to the four key management functions of finance, administration, marketing, and R&D. These variables equal 1 if management of the function is centralized, 2 if management is partially independent and 3 if it is completely independent. Because of the importance of this issue for the aim of our paper, we use two different variables to capture the degree of independence in the management of R&D. First, we use the multinomial variable "R&D independence" as a measure of the degree of independence enjoyed by affiliated companies. Second, the high correlation among the variables representing the key management functions (Table 1) suggests that governance of R&D is part of a more general decision about the internal organization of the business group. Therefore, as a robustness check, we perform a principal component analysis in order to obtain a synthetic measure of the degree of independence of affiliated firms (Table 2). Table 2 shows that the first component can be considered a satisfactory measure since it captures about 78 per cent of the total variance; also, we use this first component (which we label "Autonomy") as a proxy for degree of independence in R&D management.

In line with the approach described in Section 2, we investigate the presence of knowledge spillovers based on firms that introduced innovations in the period considered but did not invest in R&D. In relation to R&D expenses, the Capitalia survey provides information on both internal R&D expenditure and external R&D acquired from universities, research centers and other firms by pecuniary transactions that cannot be considered knowledge spillovers (Breschi and Lissoni, 2001a, 2009). However, also firms investing in R&D can take advantage of knowledge spillovers. In considering firms that introduced innovations without investing in R&D, we are aware that we are applying a restrictive criterion but it is reassuring that we are considering the presence of knowledge spillovers.

Table 1. Correlation matrix about the degree of independence of key management functions in business groups

	R&D autonomy	Financial autonomy	Administrative autonomy	Commercial autonomy
R&D autonomy	1			
Financial autonomy	0.6619	1		
Administrative autonomy	0.6056	0.8173	1	
Commercial autonomy	0.8044	0.6851	0.6419	1

Source: Elaboration on Capitalia data-set.

Table 2. Extracting the measure representing the degree of autonomy of business groups

	Principal component analysis[a]			
	First component	Second component	Third component	Fourth component
R&D autonomy	0.4929			
Financial autonomy	0.5101			
Administrative autonomy	0.4936			
Commercial autonomy	0.5032			
Eigenvalue	3.1111	0.5223	0.1959	0.1706
Proportion of variance explained	0.7778	0.1306	0.0490	0.0426
No. of observations	976	976	976	976

Source: Elaboration on Capitalia data-set.
[a] First component unrotated.

3.2 Independent Variables

To test whether firms in groups show greater R&D propensity/intensity compared to standalone firms, we use a dummy variable that is equal to 1 if the firm belongs to a group and 0 otherwise. In the case of firms belonging to a group, the Capitalia survey asks about their position within the group: head of the group, intermediate (i.e. controlled by a company and controlling other companies) and bottom of the group (i.e. not controlling other companies). In the empirical estimates, we take account of position within the group by separating the head of the group from the controlled companies (including intermediate and bottom of the group firms).[4]

Companies belonging to groups were asked whether the group was mono-sector or diversified. Based on this information, we construct a dummy variable that is equal to 0 if the group is mono-sector (which we associate with low degree of diversification) and 1 if it is diversified. We acknowledge that this is a subjective and rough measure of diversification; however, we think that it is appropriate for our purposes. Also, several studies demonstrate that subjective measures of diversification produce similar results to quantitative indicators in relation to assessing the degree of diversification of firms (Chatterjee and Blocher, 1992; Hoskisson *et al.*, 1993).

We control for other variables that potentially might affect the probability of engagement in R&D. We control for the firm's industry since this is expected to influence the propensity to invest in R&D. Technological opportunities vary across industries, which has a crucial influence on the results that the firm can expect from its innovative efforts (Jaffe, 1986; Klevorick *et al.*, 1995). To take account of industry effects on R&D propensity, we use Pavitt's (1984) taxonomy which distinguishes between four macro sectors: scale intensive, supplier dominated, science based and specialized supplier. We take supplier dominated as the reference sector.

[4] The Capitalia survey considers only manufacturing firms. It follows, then, that the heads of groups as well as the firms belonging to the groups are all manufacturing companies and not financial holdings.

We consider firm size in relation to sales since size is expected to show a positive relationship with R&D spending. Given the potential endogeneity between R&D spending and sales, we lag sales at the beginning of the period.

Given the information asymmetries in financial markets, availability of internal funds should increase the probability to invest in R&D. Therefore, we control for firms' past performance measured as return on investment (ROI) and leverage (financial debt/equity), in both cases referring to 2001. In the case of ROI we expect a positive sign, since it can be considered a proxy for internal generation of funds and expected profitability of investment. In the case of leverage, we expect a negative relation with R&D investment.

Another internal characteristic that is expected to have a positive impact on the firm's innovation efforts is absorptive capacity, i.e. the ability to identify, assimilate and apply know-how generated outside the firm (Cohen and Levinthal, 1990; Zahra and George, 2002). The firm's absorptive capacity depends on human capital and previous R&D efforts. The latter generates a path-dependent process in which firms that invested in the past are expected to put more effort into innovation in the present, which, in turn, will stimulate greater innovation efforts in the future. Absorptive capacity is not easily defined or measured (Flatten *et al.*, 2011). We control for this effect by considering two proxies: the first is ratio of intangible assets to total fixed assets; the second is ratio of R&D employees to total employees (Veugelers, 1997).

We control for market structure using size of competitors as a proxy. The Capitalia survey provides a multinomial variable providing information on whether competitors are small, medium-sized or large. From a Schumpeterian perspective, the larger the competitors, the greater their R&D spending and thus the greater the need for competing in R&D investment.

The list of variables and their definitions are presented in Table 3. Table 4 provides some descriptive statistics for the sample and the variables included in the econometric analysis.

In light of the high percentage of firms not engaging in R&D, to test hypotheses 1 and 4 we use Logit estimates to analyze the factors affecting the likelihood of observing R&D spending, and Tobit regressions to estimate R&D intensity. To test hypothesis 2, we use multinomial Logit and ordinary least squares (OLS) estimates to analyze the factors affecting degree of autonomy. To test hypotheses 3a and b, we use a Probit model with sample selection to cope with potential selection bias based on our definition of spillovers, since in the outcome equation we observe only firms that did not invest in R&D.

We assume that firm size, ROI and leverage affect R&D investment. However, a reverse causality situation (i.e. that R&D has an impact on these variables) is possible which also might introduce potential endogeneity problems. This would result in correlation between the error term and the independent variables, and the estimates of the coefficients would be biased and inconsistent. We tackle this problem by using control variables at the beginning of the period (2001), as is usual in innovation studies (Cefis *et al.*, 2009; Lhuillery and Pfister, 2011). We are faced with a similar problem when using ratio of employees engaged in R&D to total employees, as a proxy for the absorptive capacity. Given the potential endogeneity of this variable even if lagged at the beginning of the period, we also include in our estimates the two-digit industry average of the same variable (Veugelers and Cassiman, 2005; Lhuillery and Pfister, 2009).

4. Empirical Results

The first hypothesis we test is whether firms belonging to groups are more likely to be involved in R&D (R&D propensity). Among the independent variables, we use a proxy for

Table 3. Variables used in the estimates

Variable	Description
R&D propensity	Dummy variable for engagement in R&D activity in 2001–2003
R&D intensity	Ratio between R&D expenses and employees in 2003
Spillovers	Dummy variables indicating whether in the period considered a firm introduced product or process innovations without investing in R&D
Diversification	Dummy variable indicating whether the affiliated company belongs to a mono-sector group (0) or to a diversified group (1)
Group	Dummy variable for the belonging to a business group
Number	Number of companies belonging to a business group
Operative	Dummy variable for the presence of operative relationships among affiliated firms of a business group
R&D independence	Multinomial dummy for the degree of autonomy by affiliated firms in R&D management: centralized (1), partially independent (2) and completely independent (3)
Autonomy	Continuous variable indicating the degree of autonomy enjoyed by affiliated firms of a group with respect to four key management functions: R&D, finance, marketing and administration
Pavitt sector dummies	Dummies for industry sectors based on Pavitt taxonomy[a]: – Scale = scale intensive sectors – Specialized = specialized supplier sectors – Science = science based sectors Supplier-dominated sectors are taken as reference
Firm size$_{t-2}$	Logarithm of the sales of the firm in 2001
Group size	Logarithm of the number of employees of the group in 2003
Leverage$_{t-2}$	Ratio between financial debts and equity in 2001
ROI$_{t-2}$	Return on assets in 2001
Competition	Size of competitors. Multinomial dummy taking values from 1 to 3 according to the average size of competitors: 1 = small; 2 = medium; 3 = large
Absorptive capacity (1)	Ratio between intangible assets and fixed assets in 2001
Absorptive capacity (2)	Ratio between the number of employees devoted to R&D and total employees in 2001

[a] To control for industry features we use the Pavitt classification of sectors based on innovation patterns (Pavitt, 1984). The classification distinguishes between four macro sectors: scale intensive, dominated suppliers, science based and specialized suppliers. In the estimates, we use supplier dominated as the reference sector.

belonging to a group, three dummy variables to account for Pavitt sectors, degree of financial leverage as a measure of financial capacity and ROI as a measure of firm profitability. Before introducing the Logit estimations, we present the correlation matrix for the main independent variables included in the regressions (Table 5). Because of the high value of the linear relation between firm size and group size, in the estimates we avoid including both variables in the same specification.[5] Table 6 shows the results of the Logit estimates for the probability that firms will engage in R&D activity.

[5] More precisely, the collinearity test detects a multicollinearity problem if both firm size and group size are included in the same specification.

Table 4. Descriptive statistics (mean values if not otherwise specified)

			Belonging to groups[a]		
	Total firms	Non-belonging to groups	Total	Head of groups	Controlled firms
Number of firms	3,446	2,342	1,104	274	826
R&D propensity (percentage of firms)	46.2	40.3	59.4	69.5	56.1
R&D intensity (euros) in 2003	1,426	1,143	2,025	2,514	1,864
Average size (sales in 2001, million euros)	35.7	12.7	86.1	99.9	81.4
ROI (per cent) in 2001	6.26	6.74	5.22	5.64	5.09
Leverage in 2001	2.36	2.55	1.95	1.90	1.95
Absorptive capacity (1)	0.085	0.077	0.102	0.085	0.107
Absorptive capacity (2)	0.034	0.032	0.039	0.048	0.036
Related diversified groups (percentage of groups)			60.35		
Unrelated diversified groups (percentage of groups)			39.65		
R&D centralized (percentage of groups)			24.90		
R&D partially independent (percentage of groups)			27.55		
R&D completely independent (percentage of groups)			47.55		

Source: Elaboration on Capitalia data-set.

[a] The sum of heads and controlled does not equal the total due to missing values for the positions of firms within groups.

As expected, firms belonging to a business group show a higher probability of investing in R&D. This result holds for all specifications. Firm size has a strong and positive influence on the probability of observing R&D activity. Past financial performance (ROI) and leverage are never statistically significant.

The empirical results highlight the importance of the sector in which the firm operates. Compared to *supplier dominated* sectors (the reference category), firms in the *specialized suppliers* and especially the *science-based* sectors show a significantly higher propensity to engage in R&D. This is not the case for *scale intensive* firms whose competitive advantage is based on the exploitation of scale economies rather than on innovation. Competitors' size increases the probability that the firm will invest in R&D. This confirms that market structure is relevant to R&D propensity. Finally, both measures of absorptive capacity (R&D stock and percentage of R&D employees) are highly significant and exhibit the expected sign.

Table 6 also presents the results of the Tobit estimates of R&D intensity. Again, in this case the group dummy shows the expected sign; however, it is not statistically significant at the same level. Therefore, we can be more confident that belonging to a group affects the probability of engaging in R&D rather than influencing the R&D intensity of member firms. The coefficients of the control variables show the same signs as for R&D propensity. According to the results presented in Table 6, we can conclude that hypothesis H_{1a} (on the propensity of affiliated firms to engage in R&D) and hypothesis H_{1b} (on R&D intensity) are supported.

Hypothesis H_2 is about the relation between diversification and the degree of autonomy over R&D and other key management functions. As a robustness exercise, we consider two

Table 5. Correlation matrix

	Group	R&D intensity	Firm size (sales)	Group size	Number	Leverage	ROI	Abs. capacity (1)	Abs. capacity (2)
Group	1								
R&D intensity	0.0478	1							
Firm size (sales)	0.4823	0.0443	1						
Group size	–	−0.0062	0.5765	1					
Number	–	−0.0105	0.1295	0.4700	1				
Leverage	−0.0225	−0.0068	−0.0191	0.0850	−0.0524	1			
ROI	−0.0940	−0.0132	−0.0649	−0.1230	0.0189	−0.0708	1		
Abs. capacity (1)	0.0815	0.0597	0.0202	−0.0124	−0.0368	−0.0134	−0.0589	1	
Abs. capacity (2)	0.0460	0.2775	0.0033	−0.0892	−0.0137	−0.0052	0.0235	0.1125	1

Source: elaboration on Capitalia data-set.

different dependent variables, “R&D independence” and “Autonomy”. For the first variable, we perform a multinomial Logit estimation; for the second variable, we perform an OLS estimation. Among the controls, we include group size (log of employees) and the number of firms in the group. We include the variable *Operative* for the presence of operative relationships among the companies belonging to a group. Operative relationships refer to the presence of input–output exchanges between companies, and co-operative relations for the main management functions. We expect a negative relationship since the stronger the relationships among the firms in a group, the more likely the need to integrate the functions of affiliated companies. Table 7 presents the results of the multinomial Logit and OLS estimates. As expected, the degree of autonomy of affiliated companies is positively associated with the degree of diversification. Group size shows a negative association with degree of autonomy of member companies. At first glance, this result might seem counterintuitive since it might be expected that bigger group size would increase the monitoring and control problems, resulting in decentralization of management responsibilities. However, the empirical evidence shows that as the size of the group increases, so does the adoption of management practices and procedures that enhance the co-ordination and control of member firms (Cainelli and Iacobucci, 2011). As expected, the number of the group’s firms shows a positive relation with these firms’ degree of autonomy in key management functions. The larger the number of firms in a group, the more difficult will be their control and monitoring, and thus their higher level of autonomy. As expected, the variable Operative has a negative sign although it is not significant at the same level in all the specifications.

Table 8 presents the results of the Logit estimates for the presence of knowledge spillovers in business group (H_{3a}). We find that a significant share of affiliated firms introduced innovations without investing in R&D. We consider two dependent variables: first, the introduction of at least one type of innovation (product, process, organizational) in the period considered; second, introduction of a product innovation. We employ a Probit two-step Heckman selection model: in the first step, we estimate a selection equation for the probability of *not* investing in R&D, and in the second step, we estimate an outcome

Table 6. R&D propensity/intensity of firms

	Logit[a]				Tobit[a]			
	Dep. var.: R&D propensity				Dep. var.: R&D intensity			
	1	2	3	4	1	2	3	4
Group	0.2694***	0.2511**	0.3318***	0.2282**	1.6141**	1.4212**	1.0392*	1.2989**
	(2.85)	(2.64)	(3.08)	(2.39)	(2.43)	(2.21)	(1.78)	(1.99)
Scale	−0.1592	−0.1625	−0.1763	−0.1365	−0.8972	−0.9021	−0.5969	−0.8687
	(−1.45)	(−1.47)	(−1.32)	(−1.22)	(−0.92)	(−0.93)	(−0.71)	(−0.91)
Special	0.8851***	0.8635***	0.6015***	0.4686***	4.9151***	4.6608***	2.9493***	1.6875**
	(9.87)	(9.60)	(5.26)	(4.29)	(3.66)	(3.54)	(3.14)	(2.17)
Science	1.2787***	1.2245***	0.6871***	0.4919**	10.3006***	9.7364***	4.0809***	4.3289**
	(6.06)	(5.82)	(2.58)	(1.99)	(4.17)	(4.17)	(2.94)	(2.47)
Firm size	0.4172***	0.4235***	0.5995***	0.4275***	2.5238**	2.5727**	2.9216**	2.5727**
	(10.53)	(10.57)	(11.25)	(10.72)	(2.34)	(2.37)	(2.32)	(2.35)
ROI	−0.2294	−0.1386	−1.0185	−1.0012	−3.1668	−2.2713	−4.3591	−3.5772
	(−0.43)	(−0.26)	(−1.43)	(−0.49)	(−0.86)	(−0.62)	(−1.24)	(−0.99)
Leverage	−0.0019	−0.0021	−0.0057	−0.3212	−.0260	−0.0296	−0.0403	−0.0202
	(−0.69)	(−0.74)	(−1.20)	(−0.60)	(−1.04)	(−1.08)	(−1.28)	(−0.93)
Competitor's size	0.1563***	0.1551***	0.1486**	0.1392**	0.5713	0.5820	0.2702	0.4257
	(2.73)	(2.716)	(2.00)	(2.41)	(1.37)	(1.41)	(0.69)	(1.01)
Abs. capacity (1)		0.9331***				8.5646***		
		(3.29)				(3.00)		
Abs. capacity (2)			57.5551***				89.369***	
			(7.50)				(3.47)	
Abs. capacity (2)				22.2267***				161.0543***
(mean value)				(6.38)				(2.86)
No. of observations	3,194[b]	3,194[b]	3,145[b]	3,194[b]	3,315	3,197[b]	3,148[b]	3,197[b]
					2,069 left-censored obs.	1,963 left-censored obs.	1,933 left-censored obs.	1,963 left-censored obs.

Table 6 – *continued*

	Logit[a]				Tobit[a]			
	Dep. var.: R&D propensity				Dep. var.: R&D intensity			
	1	2	3	4	1	2	3	4
Wald χ^2 (prob. $> \chi^2$)	346.32 (0.0000)	348.20 (0.0000)	268.53 (0.000)	363.39 (0.000)				
F (prob. $> F$)					3.77 (0.0004)	4.17 (0.0001)	5.67 (0.0000)	3.92 (0.0001)
Pseudo R^2	0.0910	0.0936	0.4099	0.1041				

Note: ***Significant at 1 per cent; **significant at 5 per cent; *significant at 10 per cent.
Source: Elaboration on Capitalia data-set.
[a] Robust standard errors in parentheses. The regressions include a constant term.
[b] The number of observations in this model is reduced because of limited availability of data.

Table 7. Determinants of the R&D independence (autonomy) for companies belonging to business groups

	Multinomial Logit[a]		OLS[a]	
	Dep. var.: R&D independence		Dep. var.: autonomy	
	Outcome: R&D independence = 3			
	1	2	1	2
Diversification	0.7920***	0.7662***	0.4623***	0.3984***
	(3.76)	(3.54)	(3.49)	(2.91)
Group size	−0.3212***	−0.3443***	−0.2080***	−0.2388***
	(−5.38)	(−4.87)	(−5.90)	(−5.67)
Number		0.0013		0.0015**
		(1.02)		(2.30)
Scale	−0.0876	−0.0669	−0.0393	−0.0404
	(−0.33)	(−0.25)	(−0.22)	(−0.21)
Science	−0.2713	−0.3252	−0.1039	−0.1862
	(−0.71)	(−0.84)	(−0.43)	(−0.76)
Special	0.1093	0.1103	0.1848	0.1931
	(0.49)	(0.48)	(1.23)	(1.26)
Operative	−0.7507**	−0.6687*	−0.5297**	−0.4903**
	(−1.99)	(−1.76)	(−2.28)	(−2.01)
No. of observations	720	695[b]	718	693[b]
Wald χ^2 (prob. > χ^2)	58.66	58.31		
	(0.0000)	(0.0000)		
F (prob. > F)			9.89	8.20
			(0.0000)	(0.0000)
Pseudo R^2	0.0431	0.0439		
R^2			0.0692	0.0681

Note: ***Significant at 1 per cent; **significant at 5 per cent; *significant at 10 per cent.

Source: Elaboration on Capitalia data-set.

[a] Robust standard errors in parentheses. The regression includes a constant term.

[b] The number of observations in this model is reduced because of limited availability of data.

equation for the probability of introducing innovation. Following Wooldridge (2002: 570–571), in the outcome equation we consider a strict subset of the variables used in the selection equation.

We find weak evidence that knowledge spillovers are more likely to arise in diversified groups (H_{3a}). Indeed, there are contrasting views (agency and resource-based) on this relation. As mentioned in Section 2, the positive relation between diversification and knowledge spillovers is compatible with the fact that in the Italian context, the agency view is barely relevant given the predominance of family-owned firms and the lack of separation between ownership and control (Barca and Becht, 2001). It may depend also on the limitations of our proxy for degree of diversification. H_{3b} is supported by the empirical evidence: in all the specifications, controlled firms are more likely to benefit from knowledge spillovers than heads of groups.

Table 8. Presence of knowledge spillovers in business groups

	Probit with selection[a]			Probit with selection[a]		
	Dep. var.: spillovers			Dep. var.: spillovers		
	Product/process/organizational innovations			Product innovations		
	1	2	3	1	2	3
Innovation						
Diversification	0.2216	0.2581*	0.2302	0.2425	0.3162**	0.2110
	(1.45)	(1.85)	(1.50)	(1.24)	(2.12)	(1.14)
Scale	−0.0543	−0.1140	−0.0615	−0.1344	−0.2239	−0.1160
	(−0.36)	(−0.73)	(−0.40)	(−0.72)	(−1.23)	(−0.66)
Special	−0.5214***	−0.4526***	−0.5351***	−0.1196**	−0.0014	−0.1695**
	(−3.42)	(−2.81)	(−3.45)	(−0.56)	(−0.01)	(−0.78)
Science	0.2782	0.6647	0.3095	0.3520	0.6855*	0.2425
	(0.59)	(1.53)	(0.65)	(0.66)	(1.73)	(0.48)
ROI	0.1598	0.2023	0.1527	−0.8821	−0.9057	−0.7621
	(0.21)	(0.25)	(0.20)	(−0.89)	(−0.87)	(−0.79)
Leverage	0.0161	0.0202	0.0151	0.0238	0.0264*	0.0215
	(1.19)	(1.29)	(1.18)	(1.58)	(1.65)	(1.46)
Head vs controlled	−0.3754**	−0.3213**	−0.3675**	−0.4935**	−0.4941**	−0.4868**
	(−2.42)	(−1.96)	(−2.33)	(−2.41)	(−2.23)	(−2.54)
No R&D						
Diversification	−0.1858**	−0.1140	−0.1953**	−0.1901**	−0.1419	−0.2009**
	(−2.09)	(−1.03)	(−2.20)	(−2.13)	(−1.29)	(−2.25)
Scale	0.2852**	0.3709**	0.2819**	0.2848**	0.3656**	0.2769**
	(2.47)	(2.41)	(2.45)	(2.46)	(2.38)	(2.40)
Special	−0.4406***	−0.2432**	−0.2905***	−0.4405***	−0.2449**	−0.2771***
	(−4.33)	(−2.06)	(−2.52)	(−4.32)	(−2.07)	(−2.43)
Science	−0.7310***	−0.2042	−0.5151**	−0.7301***	−0.2316	−0.4972**
	(−3.47)	(−0.77)	(−2.24)	(−3.49)	(−0.90)	(−2.19)
Firm size	−0.1826***	−0.2910***	−0.1838***	−0.1807***	−0.2932***	−0.1787***
	(−4.83)	(−6.21)	(−4.91)	(−4.69)	(−6.14)	(−4.61)
ROI	0.3348	1.0850*	0.3239	0.3316	1.0860*	0.3305
	(0.62)	(1.67)	(0.60)	(0.62)	(1.67)	(0.61)
Leverage	−0.0006	−0.0036	−0.0008	−0.0006	0.0036	−0.0007
	(−0.07)	(−0.37)	(−0.08)	(−0.06)	(0.37)	(−0.08)
Competitor's size	−0.0513	−0.0442	−0.0439	−0.0461	−0.0258	−0.0381
	(−0.86)	(−1.61)	(−0.73)	(−0.75)	(−0.31)	(−0.63)
Head vs controlled	−0.3514***	−0.2165	−0.3651***	−0.3529***	−0.2059	−0.3677***
	(−3.38)	(−1.61)	(−3.50)	(−3.38)	(−1.52)	(−3.52)
Abs. Capacity (1)	−0.1922			−0.2774		
	(−0.72)			(−1.03)		
Abs. Capacity (2)		−43.6072***			−43.5631***	
		(−6.24)			(−6.18)	
Abs. Capacity (2) (mean value)			−7.6542**			−8.4205***
			(−2.46)			(−2.75)

Table 8 – *continued*

	Probit with selection[a]			Probit with selection[a]		
	Dep. var.: spillovers			Dep. var.: spillovers		
	Product/process/organizational innovations			Product innovations		
	1	2	3	1	2	3
No. of observations	934	916[b]	934	934	916[b]	934
Censored obs.	560	549	560	560	549	560
Uncensored obs.	374	367	374	374	367	374
Wald χ^2	27.20	21.72	27.87	15.23	20.25	15.29
(prob. $> \chi^2$)	(0.0003)	(0.0028)	(0.0002)	(0.0332)	(0.0050)	(0.0325)
Wald test χ^2 ($\rho = 0$)	4.30	11.11	4.08	0.82	9.94	1.09
(prob. $> \chi^2$)	(0.0381)	(0.0009)	(0.0434)	(0.3660)	(0.0016)	(0.2963)

Note: ***Significant at 1 per cent; **significant at 5 per cent; *significant at 10 per cent.
Source: Elaboration on Capitalia data-set.
[a] Robust standard errors in parentheses. The regression includes a constant term.

Table 9 presents the empirical results for R&D propensity and R&D intensity of controlled firms, as a function of the degree of centralization/autonomy in R&D management. Hypotheses H_{4a} and H_{4b} are both supported by the empirical estimates. The industry dummies show the expected sign and the influence of firm size on both R&D propensity and intensity are highly significant. This result is consistent with the hypothesis that the incentive effect provided by greater autonomy prevails over potential free-riding effects induced by the presence of knowledge spillovers which, as shown above, mainly benefit controlled companies.

5. Conclusions

This paper set out to investigate the relation between firms' organization and R&D by focusing on firms belonging to business groups. It provides three original contributions: (a) it examines how the internal characteristics of business groups influence the R&D propensity and intensity of affiliated firms; (b) it analyzes the presence and role of R&D spillovers among affiliated firms and (c) it distinguishes between R&D propensity and R&D intensity.

Overall, our results confirm a positive association between R&D investment and group affiliation. This is compatible with the presence of an internal capital market and the assumption that affiliated firms co-ordinate their R&D investments and share its results, thus internalizing potential spillovers. We suggest that the incentive to share R&D results is different for the group owner, and the controlled firms. The head of a group is more interested in the sharing of R&D results among controlled companies because the group head benefits from part of the affiliates' profits. This is not the case for controlled companies; they do not receive a share of the profits and also might be in competition with one another. Moreover,

Table 9. R&D propensity/intensity of controlled firms in business groups

	Logit[a]				Tobit[a]			
	Dep. var.: R&D propensity				Dep. var.: R&D intensity			
	1	2	3	4	1	2	3	4
R&D independence	0.5303***	0.5309***	0.2881**	0.5608***	1.7401***	1.7467***	.9286**	1.9497***
	(5.02)	(5.02)	(2.30)	(5.16)	(3.58)	(3.66)	(2.01)	(4.06)
Scale	−0.4795**	−0.4821**	−0.5427**	−0.4678**	−1.0070	−1.1348	−1.4211**	−1.004
	(−2.22)	(−2.23)	(−1.79)	(−2.14)	(−0.90x)	(−1.05)	(−2.03)	(−0.94)
Special	0.8278***	0.8213***	0.3280***	0.4765**	2.9843	2.5865***	1.4002**	0.1467
	(4.15)	(4.10)	(1.31)	(2.05)	(3.45)	(3.20)	(1.99)	(0.11)
Science	1.2536***	1.2389***	0.5356	0.7512*	7.4415***	6.5512***	2.1788	3.1541
	(3.15)	(3.06)	(1.03)	(1.72)	(3.30)	(3.23)	(0.96)	(1.09)
Firm size	0.3023***	0.3032***	0.4884***	0.3101***	0.7902***	0.8304***	0.9746***	0.8285***
	4.02	(4.01)	(5.06)	(4.17)	(3.02)	(3.14)	(4.23)	(3.27)
ROI	−0.3616	−0.3475	−1.8795	−0.3875	−3.2980	−2.5297	−6.2460**	−3.1724
	(0.34)	(−0.33)	(−1.56)	(−0.38)	(−0.78)	(−0.60)	(−2.34)	(−0.79)
Leverage	0.0013	0.0012	−0.0141	0.0016	−0.0214	−0.0337	−0.1742	−0.0222
	(0.07)	(−0.07)	(−0.82)	(0.09)	(−0.28)	(−0.44)	(−1.32)	(−0.29)
Competitor's size	0.0467	0.0478	0.1004	0.124	1.1191	1.2016	0.7078	0.8171
	(0.39)	(0.40)	(0.62)	(0.10)	(1.53)	(1.62)	(1.57)	(1.35)
Abs. capacity (1)		0.1308				7.4226		
		(0.25)				(1.57)		
Abs. capacity (2)			102.4798***				70.2216***	
			(5.76)				(5.60)	
Abs. capacity (2) (mean value)				0.1790***				143.3971*
				(2.74)				(1.94)
No. of observations	690	690	677[b]	690	690	690	677[b]	690
					356 left-cens. obs.	356 left-cens. obs.	347 left-cens. obs.	356 left-cens. obs.

Table 9 – *continued*

	Logit[a]				Tobit[a]			
	Dep. var.: R&D propensity				Dep. var.: R&D intensity			
	1	2	3	4	1	2	3	4
Wald χ^2	80.75	80.71	76.72	86.42				
	(0.0000)	(0.0000)	(0.0000)	(0.0000)				
(prob. $> \chi^2$)								
F (prob. $> F$)					7.37	6.53	8.22	6.65
					(0.0000)	(0.0000)	(0.0000)	(0.0000)
Pseudo R^2	0.0991	0.0992	0.4701	0.1098				

Note: ***Significant at 1 per cent; **significant at 5 per cent; *significant at 10 per cent.

Source: Elaboration on Capitalia data-set.

[a] Robust standard errors in parentheses. The regressions include a constant term.

[b] The number of observations in this model is reduced because of limited availability of data.

managers of the head of the group are more likely to have a better understanding of the innovation processes in controlled firms. We found that controlled companies benefit more than group heads from knowledge spillovers.

We argued that the choice between R&D centralization and autonomy is strongly associated with group diversification. Specifically, we found that in less-diversified groups, centralization of R&D activity prevails, and in more diversified groups, R&D is more likely to be carried out autonomously by member companies. Moreover, we find that autonomy in R&D management enhances both the propensity for and intensity of R&D in controlled firms, despite the presence of knowledge spillovers which could induce free riding behavior. Knowledge spillovers seem more important in diversified groups, although this result is not robust to various empirical specifications. Recall also that the theoretical literature reaches no consensus on this point. Analysis of this issue would require more elaborate measures of group diversification than are possible using the Capitalia data-set.

In this paper, we distinguished between R&D intensity and R&D propensity. This distinction is relevant given that R&D investments often involve fixed costs, and as a consequence are subject to threshold levels. We find that the belonging to a group may enable affiliated firms to achieve this threshold level.

Overall, our empirical results underline the importance of considering the internal organization of business groups when studying the behavior and performance of affiliated firms related to R&D decisions.

One of our empirical findings is that group affiliation has a stronger impact on R&D propensity than on R&D intensity. This might be because the internalization of positive spillovers is more likely to influence the propensity to invest in R&D but not necessarily the amount of the R&D investment (R&D intensity). Moreover, the coordination of R&D efforts and their centralization may produce efficiency effects which reduce the amount of R&D needed to obtain the expected results. This conjecture opens new directions for further research.

Analysis of these issues would require data on the R&D investments of all the companies in a single group, and more detailed information on the mechanisms for sharing R&D results.

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