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Does the Board of Directors Affect the Extent of Corporate R&D? Evidence from Italian listed companies

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Abstract

Using a panel dataset for 369 firm-year observations during the period 2005-2013 in the Italian context, we investigate the impact of certain characteristics of corporate boards on the magnitude of corporate Research and Development (R&D). Our findings reveal a negative relationship between R&D and board size on the one hand and between R&D and board ownership on the other hand. Moreover, we find strong evidence of a positive and statistically significant relationship between R&D and independent corporate board directors. In addition, we also find a relationship between R&D and board diversity effect, as measured by women and foreign members on the boardroom. Our study uses multiple econometric models to address endogeneity issues.

1. Introduction

Over the last few decades, increasing attention has been directed to the impact of corporate governance on firm innovation. According to the study by Becker-Blease (2011), innovation refers to investment in new products and services and, more generally, in knowledge generation. Investments in innovation are investment decisions that may give rise to conflicts between owners and managers due to their potentially having different objective functions. A Board of Directors composed of members with a better educational and professional background is more sensitive to innovation because it has a greater understanding, greater knowledge, and better information regarding information processes and this positively affects investments in R&D (Chen, 2014). In addition, directors with an advanced educational level possess greater skills in planning resources for R&D, in predicting value, and in finding adequate funds for such investments (Dalziel, Gentry and Bowermann, 2011). They should act as "guardians" of R&D (Kor, 2006). It should be noted, however, that the agency costs associated with the innovation decisions are likely to be high (Holmstrom 1989) because corporate managers may be tempted or forced to make sub-optimal investment decisions, which may result either in overinvestment or underinvestment. Generally, managers prefer tangible and low-risk investments and are reluctant to be risk-takers and to fully appreciate the realities of how investment projects can create long-term value; in this way, they may implement behavior resulting in underinvestment. This focus on short-term profits is referred to as "myopic management", which, according to Porter (1992), caused the declining competitiveness of the US at the end of the 1980s, the same form of decline that European competitiveness is experiencing at present (Brossard *et al*. 2013). Jensen (1986), however, argues that managers spend the company's cash flow in unprofitable investments, including R&D, in order to increase their personal compensation and the benefits arising from their position and that such investments do not always turn out to be in the best interest of shareholder wealth (because of the overinvestment).

Using a panel dataset of 369 firm-year observations covering the period 2005-2013 in the Italian context, we investigate the relationship between R&D and board composition. This study extends the previous literature in various ways. First, it examines the relationship between R&D and the board of directors and also considers the presence of a "board diversity effect." The analysis, indeed, investigates the impact of both women on corporate boards and "foreign" members on corporate boards that jointly capture the relationship between R&D and the board diversity effect. Second, this study falls within the agency theory context, considering R&D both as an element of convergence (or divergence) among the interests of majority and minority shareholders and as a proxy of risk-taking. Since the Italian context is particularly interesting with regard to ownership concentration, the board's monitoring and control roles should be more important than in most other countries. The members of the board of directors are linked, directly or indirectly, to ownership, and the presence of diversity (gender and foreign) is still marginal in the Italian context. With regard to the presence of women on corporate boards, in particular, it should be noted that the obligation to ensure gender balance refers to the recent Law 120 of 2011, requiring that by 2015 at least ome-third of the members of the board of directors of public compoanies must consist of women. Lastly, this study uses different econometric models to address endogeneity issues.

Section 2 of this study discusses related literature and provides hypothesis development. Section 3 describes the sample and survey methodology. Section 4 presents the estimation results and a discussion of the findings, whereas Section 5 provides closing observations.

2. Literature review and hypothesis development

Since the seminal piece by Schumpeter (1942), innovation has been recognized as key to both economic development and to companies' growth. Indeed, a large influential literature on endogenous growth (see Aghion and Howitt, 2006) postulates that firm-level innovation contributes significantly to a country's economic growth and development. Many prominent scholars have consistently stressed the importance of innovation and particularly the role of the Research and Development (R&D) for the growth of companies (Schumpeter, 1942; Porter, 1992; Zahra and Covin, 1995). Most recently, Harrison *et al.* (2014) found strong empirical evidence that innovation creates employment at the firm level, especially due to the introduction of new products. A recent report by the European Commission (2014), which analyses the top 2,500 companies worldwide ranked by their investments in research and development (R&D), indicates that investments in R&D by companies based in the EU have continued to grow in 2013 even in the face of the overall economic crisis across Europe; however, this growth is below the 2013 world average and lags behind public companies based in the U.S. and Japan. Arguably, the implication of this finding is that EU companies must boost R&D investments in order to remain globally competitive.

Within the context of agency theory, R&D takes on a different meaning since it represents a discordant element on the one hand between managers and shareholders in the Anglo-Saxon systems and on the other hand between majority shareholders and minority shareholders in countries with a high ownership concentration such as is the case in Italy. As it is commonly understood in the literature, investments in innovation are by nature risky, involve a long-time horizon and uncertain returns, and can be subject to both information asymmetry and moral hazard. To a large degree, corporate shareholders may be interested in investing in R&D, having a long-term view and looking towards maximizing value, while managers may have a different time perspective, namely, looking at short-term results. In Italy, in particular, the majority shareholders hold a threshold of share ownership that reaches, or exceeds, 50% of the share capital and therefore could be risk-averse since they hold undiversified portfolios.

Given such circumstances, innovation decisions are investment decisions that may generate shareholder-manager conflicts (Holmstrom, 1989). In fact, on the one hand, shareholders cannot properly evaluate investments in a long-run project either because they lack technical and scientific skills or because companies decline to fully reveal the information necessary to assess the real value of innovation; on the other hand, managers may prefer lower-risk strategies with low-variance returns, due to concerns about the impact of innovation failures on their careers, which might in turn result in under-investment in R&D and innovation (Shleifer and Vishny, 1989).

In the related literature, there exist two main views on what spurs or deters innovation. The first is that firms innovate more when managers are insulated from takeover pressures (Stein, 1988), based on the contention that the threat of takeover encourages myopic behaviour (i.e. a short-term focus) on the part of managers. The opposite view is that corporate governance systems which insulate managers from external or firm-level disciplining mechanisms lead them to reduce their innovation efforts, to shirk R&D opportunities, or even to be content with a "quiet life" (see in particular Hart, 1983; Bertrand and Mullainathan, 2003). Several studies have investigated the relationship between ownership structure and investment in R&D, considering both the presence of institutional investors (Bushee, 1998; Graves and Waddock, 1990; Eng and Shackell, 2001; Aghion *et al.* 2013; Brossard *et al.* 2013), and the ownership concentration whose shares are owned by one or only a few controlling shareholders (see for example Minetti *et al.* 2013; Rossi and Cebula, 2015), finding mixed results. Our analysis is performed within the Italian business context,

which provides an interesting environment to explore the impact of board composition on innovation. In Italy, for example, the presence of institutional investors is less widespread than in the Anglo-Saxon context. We believe that Italy is suitable for this kind of empirical investigation because of the particular composition of companies' board of directors, whose members are directly or indirectly linked to owners and show a still limited presence of women in the boardroom. In countries where the level of ownership concentration is high, the agency problems does not arise between shareholders and managers but between majority and minority shareholders. The conflict could transfer the entrenchment effect to controlling shareholders and have a negative impact on R&D outlays (Morck *et al.* 2002; Di Vito *et al.* 2010; Czarnitzki and Kraft, 2009; Munari *et al.* 2010). A high ownership concentration and the presence of a family business model could limit the implementation of risky investment projects. Most of the family wealth is invested in the company, and therefore it may occur that the equity portfolio is poorly diversified and this would increase the ownership's risk aversion to invest in riskier projects (John *et al.* 2008; Faccio *et al.* 2011; Boubaker *et al.* 2012). Board ownership, whose shareholding is in the hands of family members, could also discourage R&D investment. For the reasons stated above, in this study, we investigate the following hypothesis:

H1. There is a negative relationship between R&D and board ownership.

Previous studies of boards of directors have produced ambiguous findings. For example, regarding the board size, the theoretical arguments point to net advantages of a smaller size corporate board because it is more effective in monitoring and more cohesive in the decision making process (Lipton and Lorsch, 1992), with the optimal size being no more than eight members (Jensen, 1993). On the empirical level, nevertheless, the results are mixed. Yermack (1996) finds that a smaller board increases the value of the company, while Coles et al (2008) argue that there isn't a standard board size, but that it depends on the complexity of the company. Several studies have found a negative relationship between board size and the volatility of the performance of the companies investigated (Cheng 2008; Adams and Ferreira, 2010; Nakano and Nguyen, 2012).

In line with the *empirical* evidence, we investigate the following hypothesis:

H2. There is a negative relationship between R&D and Board size.

Miller and Triana (2009) believe that board diversity has a positive effect on innovation while Torchia *et al.* (2011) found a positive link between firm organizational innovation and gender diversity.

Since investments in R&D are more risky than other projects and since the variable R&D could be used as a reasonable proxy for risk-taking, arguably women tend to choose those investments with certain less risky payoffs. From this point of view, women are often considered to be more risk averse than men (Barber and Odean, 2001; Charness and Gneezy, 2012; Faccio *et al.* 2014), although Adams and Funk (2012) examine the relationship while considering various socio-cultural variables and conclude that women's attitude towards risk depends upon the environment in which they operate and that they are *not necessarily* more risk averse than men. In Sweden, for example, they found that women are more risk-prone than their male counterparts. In any case, we investigate the following hypothesis:

H2a: There is a negative relationship between women on the corporate board and R&D.

The theoretical literature on the composition of the board of directors emphasizes the role of independent directors since presumably they have the knowledge and skills and are able to evaluate strategic decisions and monitor the behavior of executives (Jensen and Meckling, 1976; Fama and Jensen, 1983) also through the implementation of risky investment projects that tend to balance the phenomenon of underinvestment or overinvestment. However, while

the empirical evidence on the relationship between risk-taking and independent directors has produced mostly negative results (e.g., Brick and Chidambaran, 2008; Pathan, 2009; Mathew, 2013), the empirical literature on the relationship between R&D and independents has produced mostly positive results. For example, Osma (2008) suggests that the presence of independents may contrast the myopic management behavior that leads to a reduction in R&D. The skills and expertise possessed by independents could balance the conflict between owners and managers, as independents are able to verify the opportunistic restrictions implemented through the reduction in R&D investments, and may encourage investment in innovation.

Dong and Gou (2010) observed a positive relationship between the percentage of independents and R&D, whereas Chen and Hsu (2009) found that while family ownership may discourage investments in R&D, the presence of independent directors mitigates such effects and contributes to an increase in R&D investments. Tong and Zhang (2014) found that investments in R&D reflect higher expected cash flows and a lower cost of equity, especially in companies with a higher number of independents. Even Lu and Wang (2015) found a positive relationship between the presence of independent directors in the board and investment in R&D and a negative relationship with respect to physical assets.

The high concentration in Italian ownership structures, where the behavior of the controlling shareholders is aimed at expropriating minority shareholders through the pursuit of private benefits of control, could represent a favorable environment for independents who are separate from ownership and should adopt "unbiased" behavior and act in the interest of all stakeholders. The very nature of independents may favor the resolution of a conflict between the majority shareholders and minority shareholders. Furthermore, their presence is highly recommended by the Corporate Governance Code. Therefore, in line with the theoretical arguments, the empirical evidence and the recommendations of the Corporate Governance Code, the following hypothesis is formulated:

H2b. There is a positive relationship between R&D and independents on the board.

A board composed of foreign members could have a positive impact on innovation. Several studies point out that the existence of heterogeneous corporate boards increases the company's value (Oxelheim and Randøy, 2003; Masulis *et al.* 2012; Rose *et al.* 2013), and it appears to have a positive impact on innovation (Chen *et al.* 2005). A multicultural board has a broader base of knowledge, a different attitude towards solving problems, and greater capacity in the processes of decision-making through different backgrounds, education levels, and experience. According to Miller and Triana (2009), the multi-racialism in the board noted that the company is better positioned in the market and is therefore better enabled to meet the needs of different markets.

In line with the empirical evidence, we formulate and test the following hypothesis:

H3. The presence of foreign members in the board of directors encourages investment in R&D.

3. Data and survey methodology

This investigation is based on a sample of Italian listed companies observed during the period 2005-2013. It explores the relationship between R&D outlays and the characteristics of the board of directors using 369 firm-year observations from the Italian stock market. The publicly owned companies belonging to the sample had to meet the following requirements:

     a) The availability of data regarding R&D, which were acquired through the *EU Industrial R&D Investment Scoreboard* (2005-2014) of the European Commission.

This annual ranking of the top 1,000 (or 2,500) European companies investing in R&D accounts for a very large part of European R&D.

b) The availability of financial data and Corporate Governance indicators during the entire observation period, which were acquired through *Datastream*, the *Calepino dell'azionista* (Mediobanca), *Bloomberg*, the reports on Corporate Governance and the financial statements of the individual companies, and the Consob websites.

The sample investigated consists of 41 companies for a total of 369 firm-year observations and accounts for more than 50% of the total market capitalization at the end of 2013. The sample consisted primarily of manufacturing enterprises along with a few service enterprises and excluded all financial firms (SIC code 6000 to 6999). By examining the sample, it is observed that in five companies the majority shareholder is the State, that controls the company through the Ministry of Economy and Finance; in all other cases, the companies are controlled directly or indirectly by family groups, which use trust companies, holding companies, and non-listed companies. In the period studied, the average (median) percentage of shares held by the largest shareholder amounted to 46.42% (51.27%), and in most cases the controlling shareholder is a legal entity. If the registrant shareholder controls the company under investigation by another unlisted company, it becomes difficult to trace the ownership board. From a closer examination, it has been noted that when the registrant controlling shareholder is a natural person, who may be the founder or direct relatives of the founder, then the latter is present in the board. But when the controlling shareholder is a company and not an individual, the directors' ownership cannot always be traced. In other cases, for example, we noticed that the parent company, which is often a holding company or trust company, as mentioned above, is represented on the board of directors by individuals who do not have the same surname of the founder and therefore they could be trustworthy individuals or indirect relatives, such as a wife or husband, a sister-in-law or brother-in-law, or other relatives of the members of the reference family but with a different surname. In these cases, however, the board member does not own shares. For example, in 2013, in only 20 companies was the registrant a natural person and sat on the board. This explains why in more than half of the companies investigated, the board members do not own shares in the company. In order to further investigate this phenomenon, we have cross-checked multiple data sources, and in particular we examined the reports on the corporate governance of companies included in the sample, the Consob data, Italian stock market data, corporate balance sheets, and other data were acquired directly from the websites of the companies when they were available. Interestingly, the study by Perrini *et al.* (2008) also found a median value of 0.00 examining a sample of 297 Italian listed companies.

Lastly, in order to have more information both on the board ownership and on the number of members on the board, the *Calepino dell'Azionista* by Mediobanca was also consulted.

In addition, it should be noted that during the period investigated there was an increase in the proportion of independent directors whose average presence increased from 35% in 2005 to 38% in 2013; these data are also in line with the Consob report (2014). The independent director, a highly emphasized figure at the empirical level, and requested by the Corporate Governance Codes of all the countries in the world as an example of good corporate governance, includes people with experience, independence with regard to ownership, professionalism, but above all individuals who are able to express an unbiased opinion[1]. The

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[1]An independent director is defined as "the director who does not maintain, nor has recently maintained, even indirectly, with the Company or with persons linked thereto, relationships such as to currently influence their autonomous judgement". In other words, the important role of independent directors is to express an "autonomous and unbiased judgment" (see Alvaro *et al.* 2013, p. 33). In this study, the proportion of independents was calculated as the ratio between the number of non-executive independent directors and board size. Data were collected from the reports on the corporate governance of companies in the sample and from other sources mentioned above.

presence of independents, therefore, should ensure better performance and a higher propensity to invest in risky investment projects. In fact, since independents are separate from the ownership of the company, theoretically they should be subjects who are far from the idea of preserving the wealth pursued by the majority shareholder ,who causes the latter to implement risk-averse investment policies (Morck *et al.* 2002).

The increase in the percentage of independents, the recent Law 120 of 2011 which provides for gender balance and in particular the increase of up to a third of women in the board of directors since 2015, the scarcity of foreign directors on the boards of Italian companies, the low presence of institutional investors, together with the presence of a high ownership concentration, changing legislation and the introduction of best practices of corporate governance (such as the Consolidated Finance Act and the introduction of the Corporate Governance Code) and the reluctance by businesses to invest in R&D, all are factors that make it worthwhile to examine the Italian situation.

In the following sections, we develop the research methods and perform the statistical analysis designed specifically for our unique cross-sectional data based on both econometric techniques and research objectives. In the first step, we construct and estimate the base-line ordinary least square (OLS) model. The following equation represents the regression model:

$$y_{i,t} = \mu_{i,t} + \alpha_1 \text{Board\_Composition}_{i,t} + \alpha_2 \text{B\_OWN}_{i,t} + \alpha_3 \text{ControlVariables}_{i,t} + \varepsilon_{i,t} \qquad (1)$$

where $y_{i,t}$ is the dependent variable; $\mu_{i,t}$ is the constant; α is the coefficient; $\varepsilon_{i,t}$ is the residual term. The dependent variable, $y_{i,t}$, is the amount of outlays for Research and Development (R&D) in logarithmic form. The board composition reflects a number of characteristics. We adopt the following explanatory variables: *LOG_BS* is the logarithm of the total number of members of the Board of Directors. *DUMMY_>8* is a dummy variable that assumes a value of 1 if more than eight members sit on the board and assumes a value of 0 otherwise; We consider the *DUMMY_>8* variable in order to test Jensen's thesis (1993), who argues that a smaller board is more effective in carrying out monitoring activities. He recommends that to be most effective a board must be composed of a maximum of seven or eight members. *INDEPENDENT* directors indicates the number of independent members divided by the total number of board members (or dummy variable *D_INDEP* that assumes a value of 1 if at least one third of independent members sit on the board and a value of 0 otherwise). *WOB* indicates the number of women on board divided by the total number of board members (or dummy variable *D_WOB* that takes value of 1 if at least one woman sits on the board and 0 otherwise). *D_FOREIGN* is a dummy variable that takes a value of 1 if there is at least one foreign member in the Board of Directors and a value of 0 otherwise. *B_OWN* measures the percentage of shares owned by members of the Board of Directors (or dummy variable *D_BOWN* that takes a value of 1 if at least one director owns shares and a value of 0 otherwise). The control variables are a set of firm-specific variables that includes *FIRM SIZE,* calculated as logarithm of total assets, *LEVERAGE,* calculated as total debt scaled by total assets, *FIRM AGE,* calculated as logarithm years by firm establishment, and *INDUSTRY,* that considers the four-digit SIC (Standard Industrial Classification) codes.

Table 1 provides the descriptive statistics of the variables used in this study. The average investments in R&D amounted to 203.28 million Euros with a median value of 35.00 million Euros. The average total assets of the sample is equal to 36,738.21 million Euros with a median value of 1,618.90 million Euros. The average age of the company, starting from its inception, is equal to 60.20 (median 52.00) with a range that varies from 8 to 177 years. *B_OWN* varies between 0.00% and 71.08%. On average (median) the board holds 9.94% (0.00) of the shares of the companies investigated. The presence of women on board (*WOB*) varies from 0% to 38%, and the average (median) value is equal to 6% (0.00%).

Table I. Descriptive Statistics for the Selected Variables

Variables	Obs.	Average	Median	S.D.	Min	Max
Dependent variable						
R&D (million euros)	369	203,28	35,00	591,67	2,40	3,362
Independent variable						
B_OWN (%)	369	9.94	0.00	19.80	0.00	71.08
D_BOWN	369	0.31	0.00	0.46	0	1
BOARD SIZE	369	10.62	10.00	4.30	3.23	21.67
DUMMY_>8	369	0.77	1.00	0.42	0	1
WOB	369	0.06	0.00	0.07	0.00	0.38
D_WOB	369	0.46	0.00	0.50	0	1
INDEPENDENT	369	0.41	0.40	0.22	0.00	0.95
D_INDEP	369	0.68	1.00	0.47	0	1
D_FOREIGN	369	0.40	0.00	0.49	0	1
Control variable						
FIRM AGE	369	60.20	52.00	42.88	8	177
LEVERAGE	369	36.18	33.20	23.16	0.00	97.17
FIRM SIZE (million euros)	369	36,738.21	1,618.90	98,147.47	51,53.20	446,170.00
INDUSTRY	YES					

The average percentage of *INDEPENDENT* is 41% (median 40%) with a range between 0 and 95%. In 234 of the firm-year observations, we find the presence of at least one foreign member on the board.

   We perform a comprehensive diagnostic check of classical assumptions on the residuals or error terms, for example, normality and multicollinearity, through variance inflation factors (VIF). We find that all models do not appear to have strong multicollinearity problems; in all of the specifications, we find VIF values smaller than 2.0. We adopted both Ordinary Least Square (OLS) heteroskedasticity-consistent standard error estimators and a weighted least squares estimation (WLS). To detect any endogeneity problem (Demsetz and Lehn, 1985), we used the Fixed Effect, Random Effect, and a dynamic panel dataset including system-GMM (one-step and two-step) with independent variables lagged one period to control the endogeneity problem (Anderson and Hsiao, 1981; Arellano and Bond, 1991), and additionally, we also used the Tobit model.

4. Results and discussion

   The empirical estimates are provided in Tables 2 and 3. In Table 2, we find a consistently positive and statistically significant relationship between R&D and both the *D_FOREIGN*, and *FIRM SIZE* variables, as well as a positive and statistically significant relationship between R&D and *INDEPENDENT* directors. *LOG_BS* exhibits a negative and statistically significant impact on R&D in the majority of cases.

Table II. Regression analysis between R&D as a dependent variable and Board of Directors composition.
Ordinary least square (OLS). OLS in column 2 is an Ordinary least square with independent variables lagged one year. RE is a Random-Effect model with independent variables lagged one year. GMM$_1$ is a dynamic panel data including system-GMM (one-step). GMM$_2$ is a dynamic panel data including system-GMM (two-step) with R&D and independent variables lagged one year

	OLS	OLS	RE	GMM$_1$	GMM$_2$	RE	GMM$_1$	GMM$_2$
CONSTANT	0.217	0.325	0.815**	0.207**	0.336	0.792**	0.256***	0.233
	(0.188)	(0.406)	(0.328)	(0.083)	(0.205)	(0.318)	(0.076)	(0.142)
LEVERAGE	-0.003**	-0.004*	-0.001	-0.002***	-0.002***	-0.001	-0.003***	-0.003***
	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
FIRM SIZE	0.297***	0.290***	0.080***	0.131***	0.155***	0.073***	0.136***	0.122***
	(0.029)	(0.057)	(0.027)	(0.025)	(0.025)	(0.027)	(0.025)	(0.024)
FIRM AGE	0.311***	0.313**	0.321**	0.168***	0.134*	0.314**	0.168***	0.156***
	(0.068)	(0.158)	(0.129)	(0.038)	(0.074)	(0.125)	(0.038)	(0.054)
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES
R&D$_{t-1}$				0.453***	0.387***		0.428***	0.459***
				(0.080)	(0.050)		(0.085)	(0.065)
LOG_BS	-0.307**	-0.299	-0.170*	-0.088	-0.124*			
	(0.133)	(0.311)	(0.093)	(0.058)	(0.071)			
DUMMY_>8						-0.101*	0.027	0.078**
						(0.058)	(0.029)	(0.034)
WOB	0.614*	-0.073	0.942***	-0.355**	-0.394**			
	(0.350)	(0.542)	(0.287)	(0.176)	(0.185)			
D_WOB						0.086**	-0.055**	-0.051**
						(0.038)	(0.022)	(0.022)
INDEPENDENT	0.640***	0.647**	0.090	0.380***	0.344***			
	(0.162)	(0.323)	(0.116)	(0.079)	(0.077)			
D_INDEP						0.034	0.103***	0.101***
						(0.041)	(0.029)	(0.019)
D_FOREIGN						0.099**	0.107***	0.096***
						(0.042)	(0.030)	(0.027)
B_OWN	-0.008***	-0.008***	-0.001	-0.004***	-0.003***			
	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)			
D_BOWN						-0.090	-0.200***	-0.142***
						(0.055)	(0.038)	(0.039)
R-squared	0.473	0.498						
Adj. R-squared	0.461	0.486						
F-value	40.38***	39.68***						
AR (1)					-2.65***			-2.78***
AR (2)					1.14			1.42
Sargan test				57.48***	29.08		60.53***	23.51
Wald test				1270.43***	665.30***		1442***	993.08***
χ^2	10.76***	9.75***	64.31***	11.40***	11.13***	62.90***	14.54***	15.92***
N. Obs	369	328	328	328	328	328	328	328

Notes: (*), (**) and (***) indicates significance levels of 10%, 5% and 1%, respectively. Standard Errors are given in parenthesis.

The variable *WOB* alternates in sign, and the coefficient is negative and highly statistically significant in three cases while being positive and highly statistically significant in one case and marginally so in one other case. We also find a consistently negative and statistically significant relationship between R&D and *LEVERAGE* in almost all cases. Furthermore, we find a positive and statistically significant relationship between R&D and the R&D$_{t-1}$ variable (R&D lagged one year). The relationship between *B_OWN* and R&D is always negative. These signs are in line with our expectations.

In Table 3, we show the results regarding the relationship between R&D and the board diversity effect. The relationship between R&D and *WOB* alternates its signs, depending on the model used. However, in the majority of cases, the sign is negative and statistically significant, as is true for the case of *D_WOB*. The coefficient of *LOG_BS* is always negative and in most cases statistically significant.

Table III. Regression analysis between R&D as dependent variable and Board of Directors diversity.
WLS is an Weighted least square with independent variables lagged one year. RE is a Random-Effect model with independent variables lagged one year. FE is a Fixed-Effect model with independent variables lagged one year. GMM$_1$ is a dynamic panel data including system-GMM (one-step). GMM$_2$ is a dynamic panel data including system-GMM (two-step) with R&D and independent variables lagged one year. TOBIT is a model with independent variables lagged one year.

	WLS	TOBIT	FE	RE	GMM$_1$	GMM$_2$	GMM$_1$	GMM$_1$
CONSTANT	0.558***	0.540**	0.836**	0.812**	0.275***	0.282**	0.266***	0.235***
	(0.106)	(0.264)	(0.354)	(0.323)	(0.086)	(0.137)	(0.075)	(0.076)
LEVERAGE	-0.007***	-0.008***	-0.000	-0.001	-0.003***	-0.003***	-0.003***	-0.003***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
FIRM SIZE	0.369***	0.357***	0.012	0.082***	0.151***	0.153***	0.158***	0.157***
	(0.011)	(0.022)	(0.028)	(0.027)	(0.027)	(0.024)	(0.028)	(0.027)
FIRM AGE	0.157***	0.257***	0.512**	0.341***	0.127***	0.127***	0.114***	0.122***
	(0.038)	(0.086)	(0.243)	(0.128)	(0.035)	(0.047)	(0.035)	(0.037)
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES
R&D$_{t-1}$					0.488***	0.468***	0.487***	0.451***
					(0.081)	(0.055)	(0.084)	(0.089)
LOG_BS	-0.217***	-0.359***	-0.215**	-0.214**	-0.060	-0.079		
	(0.081)	(0.115)	(0.104)	(0.087)	(0.056)	(0.072)		
WOB	-0.976***	-0.657	0.960***	0.850***	-0.536***	-0.458***		
	(0.220)	(0.437)	(0.345)	(0.281)	(0.164)	(0.156)		
D_WOB							-0.079***	
							(0.022)	
D_FOREIGN	0.291***	0.312***	0.084**	0.110***	0.115***	0.102***		0.116***
	(0.034)	(0.055)	(0.039)	(0.042)	(0.032)	(0.024)		(0.033)
R-squared	0.856		0.914					
Adj. R-squared	0.853		0.899					
F-value	272.99***		64.96***					
AR (1)						-2.73***		
AR (2)						1.32		
Sargan test					73.00***	30.55	65.35***	64.62***
Wald test					1243.95***	437.66***	1065.17***	1105.61***
χ^2	14.75***	39.96***	84.19***	64.24***	14.06***	12.69***	8.65**	8.96**
N. Obs	328	328	328	328	328	328	328	328

Notes: (*), (**) and (***) indicates significance levels of 10%, 5% and 1%, respectively. Standard Errors are given in parenthesis.

The presence of *FOREIGN* members encourages investment in R&D. The coefficient is always positive and statistically significant. Both *FIRM AGE* and *FIRM SIZE* always exhbibit positive signs and except in one case the values are always statistically significant. The relationship between R&D and *LEVERAGE* remains negative and almost always statistically significant.

The first conclusions that can be drawn are now provided. The negative relationship between R&D and *LOG_BS* could be in line with the arguments in Lipton and Lorsch (1992), Jensen (1993) and with the empirical evidence in Yermack (1996). A larger board could be more a source of discussion than the benefits in terms of heterogeneity. Our results appear contrary to the contention of Kor (2006) that directors should act as guardians of R&D. Instead, with regard to the negative relationship between R&D and *B_OWN*, the explanation could derive from the fact that the board members who "possess shares" are almost always the owners of the firm as well. In the Italian scenario, in fact, the members of the board often belong to the family that runs the firm. From an agency-theory perspective, the underinvestment phenomenon seems to emerge, which would lend support for the hypothesis of the expropriation of minority shareholders by insider shareholders. Essentially, the latter appear to be risk-averse and innovation-averse. Considering that in Italy the ownership concentration is high, and that the board of directors is a natural representation of the majority shareholders, these findings could be consistent with other studies (Minetti *et al.* 2013; Morck *et al.* 2002; Di Vito *et al.* 2010; Czarnitzki and Kraft, 2009; Munari, *et al.* 2010; Rossi and Cebula, 2015).

Moreover, we highlight a positive relationship between the propensity to invest in research and development and *FOREIGN* members of the board. These findings could be consistent with other studies (Oxelheim and Randøy, 2003; Chen *et al.* 2005; Miller and Triana 2009;

Masulis *et al.* 2012; Rose *et al.* 2013). It would also appear that there is limited evidence that, on balance, the presence of women is associated with a lower propensity to invest in R&D; these results could be consistent with aversion to risk-taking thesis (Barber and Odean, 2001) and inconsistent respect to the findings of Torchia *et al.* (2011). We find that *INDEPENDENT* directors are beneficial for R&D, and this result is consistent with Osma (2008), Dong and Gou (2010), Chen and Hsu (2009), Tong and Zhang (2014), and Lu and Wang (2015).

Finally, we effectively found confirmation for our hypotheses. Our analysis also reveals a positive and statistically significant link between R&D expenditures on the one hand and *FIRM SIZE* and *FIRM AGE* on the other hand, and negative relationship between R&D with regard to *LEVERAGE*.

5. Conclusions

Using a panel data of 369 firm-year observations during the period 2005-2013 in the Italian context, we investigate the relationship between R&D outlays and board composition. In this study, we find a negative relationship between R&D and board size. We also find a negative relationship between R&D and board ownership, and the results appear consistent with the predictions of the entrenchment theory. In business environments like Italy, one might advance the hypothesis that with a larger stake being held by firm owners, the possibility to keep diversified portfolios is lowered, and as a result, the tendency is to implement a more "conservative" strategy avoiding risky investments with uncertain payoffs. Moreover, the ownership concentration induces some kind of entrenchment behavior on the part of the controlling shareholders. Since the latter have no need to monitor managers with the control being in their hands, they do not necessarily pursue strategies aimed at long-term value creation. Besides, it should be considered that the board of directors is strongly influenced by the owners.

A finding of particular interest in this study is the positive and statistically significant impact of the presence of foreign members in the board and R&D investment outlays, as well as the relationship between R&D investments and the presence of independents on the board. We in contrast find a probable net negative relationship between R&D and women on board. Our results confirm the board diversity effect. Also noteworthy is the relationship between R&D spending on the one hand and *FIRM AGE* and *FIRM SIZE* on the other hand. In addition, we found a negative relationship between R&D and *LEVERAGE*, implying that the corporate debt level has a negative impact on innovation.

This study contributes to extant literature and extends the current knowledge about the relationship between R&D and the board of directors. Nevertheless, we acknowledge that our findings are tentative, especially because of the limited sample size and time period. Therefore, further research is needed in order to more rigorously investigate our hypotheses and contentions.

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