R&D MANAGEMENT

How do country-level governance characteristics impact the relationship between R&D and firm value?

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This article addresses the question of how country-level governance characteristics moderate the market valuation of research and development (R&D). Using a valuation model and panel data from companies in the European Union, United States, and Japan, we find that effective corporate governance allows the market to better assess a firm's R&D investments. This finding is the conjunction with the effect of the legal system, the financial system, and mechanisms of control. First, as effectiveness of investor protection increases, the market valuation of R&D projects also increases. Second, more developed financial systems do a better job assessing R&D. Third, effective control mechanisms reinforce the positive effect of R&D on a firm's market value. In sum, our findings shed light on how policymakers can increase the benefits from firms' R&D spending and thus foster economic growth and social welfare using these country-level governance characteristics.

1. Introduction

The economic literature reports the importance of technological change as a means to foster growth. According to research and development (R&D)-based models of growth, R&D activities create technological innovation (e.g., Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992), and thus, firms belonging to R&D-intensive industries tend to grow fast (García-Manjón and Romero-Merino, 2012). Clearly, R&D plays an important role in the innovation process and in the development of new products. In the microeconomic sphere, a growing body of research links the positive response of firm performance to R&D activities. For instance, Mata and Woerten (2013) find that firms that conduct R&D are more profitable than those that do not. However, the literature also suggests that the

magnitude of the market valuation of R&D depends on a number of firm-level and country-level governance characteristics.

Specifically, a number of prior studies suggests that the magnitude of the market valuation of R&D depends on several firm characteristics that primarily determine R&D investments including firm size, market share, free cash flow, labor intensity, and firm growth (see, e.g., Bundell et al., 1999; Walter, 2012). Pindado et al. (2010) develop a model that accounts for these firm characteristics in the relation between R&D and market value and find that they play a moderating role in the market valuation of R&D investments. Thongpapanl et al. (2012) find that the performance outcome of innovation, considering both the notion of alignment and adaptability, is moderated by two characteristics of the firm decision-making: autonomy and shared responsibility.

In addition, governance also reveals a key element in regard to a firm's R&D activity. Booth et al. (2006) show that the market valuation of R&D spending is affected not only by a firm's characteristics, but also by the financial environment within which it operates.[1] Hillier et al. (2011) offer additional evidence on the determinants of R&D investments by accounting for several country-level governance characteristics such as the legal protection of investors, the characteristics of the financial system, and the use of control mechanisms. Furthermore, they find that these corporate governance factors play a role in reducing the sensitivity of R&D to cash flow. More recently, Driver and Coelho (2012) also examine the influence of governance on R&D spending and of financial constraints on R&D. In contrast to Hillier et al. (2011), they focus on firm-level governance factors (i.e., structure and procedures of the board of directors and executive compensation scheme). They fail to find any positive direct impact of governance on R&D but report that stronger governance breaks any link between R&D intensity and cash flow. Previous literature addresses the question of whether country-level factors are more important than firm-level factors in explaining governance, but the evidence is not conclusive. Durnev and Kim (2007) find that firm factors are more important, whereas Doidge et al. (2004) report contrary results. Seifert and Gonenc (2012) provide evidence pointing to the importance of both country and firm variables in explaining R&D intensity.

This paper builds on these prior studies and addresses the question of whether country-level corporate governance factors in addition to being R&D determinants also moderate the relation between R&D and the value of the firm (see Figure 1). Our line of investigation thus sheds more light on firms' R&D activity by explaining the moderating role of governance on the relation between R&D and firm value. Following Mallin et al. (2006) and in line with Organisation for Economic Co-operation and Development (OECD) principles, we consider a wide definition of corporate governance that includes legal and financial characteristics in addition to other control mechanisms, such as ownership structure, board of directors, and the market for corporate control.

This study makes additional contributions to the literature. First, we offer evidence of the moderating role of corporate governance factors on the relation between R&D and firm value. Our cross-country analysis differentiates between control mechanisms and financial and legal systems in a manner that is not possible when examining one country alone or several countries with similar characteristics. Thus, we provide significant insights on the importance of corporate governance in moderating the market valuation of R&D investments. Second, we use a robust econometric technique that takes into account that R&D is linked to the strategy of the firm. Particularly, we use panel data methodology, which allows us to incorporate the unobservable heterogeneity into the analysis through an individual effect and, consequently, to capture unobservable characteristics related to the strategy of the firm (e.g., how it competes in the market, the propensity to innovate, etc.). Finally, we provide evidence that may help policymakers to promote an environment that increases the benefits obtained from R&D spending and, consequently, fosters economic growth.

2. Theory and hypotheses

2.1. The legal protection of investor

Prior research suggests that an effective legal system reduces the magnitude of market imperfections caused by agency problems and the informational asymmetries between corporate insiders and investors (Demirgüç-Kunt and Maksimovic, 1998). This benefit translates into the level of investment as investor protection affects investors' willingness to provide external financing (La Porta et al., 2002). Similarly, other studies have shown the positive impact of investor protection on corporate valuation (e.g., Doidge et al., 2004; Hail and Leuz, 2006).

Relying on this evidence, we investigate whether the legal protection of investors influences the market

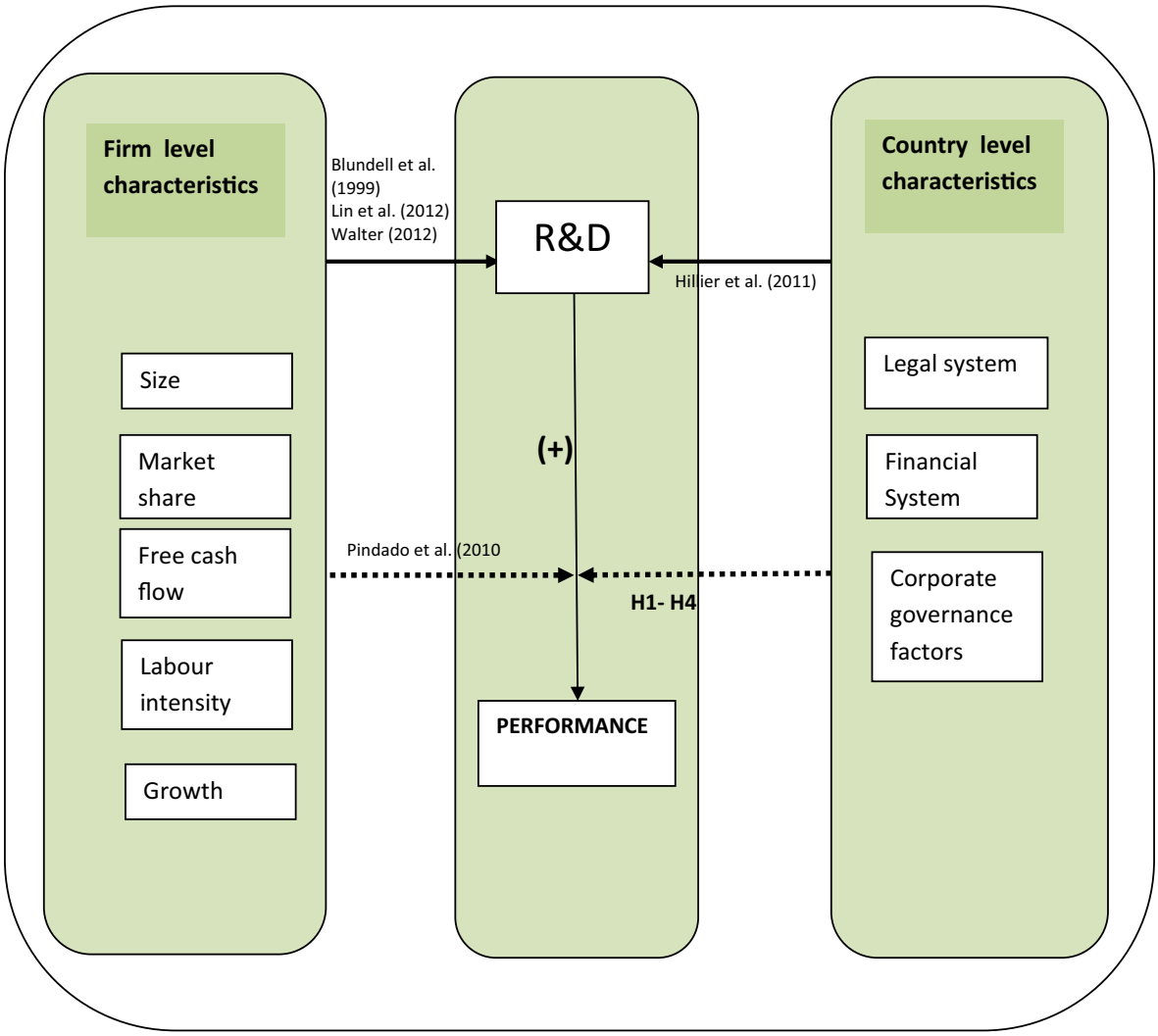

Figure 1. Conceptual framework.

valuation of R&D investments. To answer this question, we approach investor protection by means of a set of variables that has been used in law and finance literature (i.e., the origin of the law, minority shareholder protection, creditor protection, and law enforcement).

Given that R&D is associated with more opaque information and is characterized by risky (see, e.g., Keupp and Gassmann, 2009) and long-term investments, the stronger protection provided by common law countries (La Porta et al., 1997, 1998) may help to reduce the magnitude of opportunistic behavior, resulting in more positive net present value projects.

Under poor minority shareholder rights, the threat of expropriation from controlling owners increases as does the ability of corporate insiders to undertake investments that do not maximize the value of the firm. Conversely, strong investor protection limits the ability of controlling owners to expropriate minority shareholders' wealth. Particularly, Gompers et al. (2003) point out that poor investor rights increase the conflict of interest between controlling owners and minority shareholders. The literature provides evidence that strong legal protection of minority shareholders is positively related to more efficient capital allocation (La Porta et al., 1998; Wurgler, 2000). As a result, markets are expected to react negatively to R&D in the presence of weak minority shareholder protection (see, e.g., Hall and Oriani, 2006).

The protection of creditors' rights affects their willingness to provide financing and interest rate spreads. Bae and Goyal (2009) suggest that stronger protection of creditors helps to reduce spreads. Therefore, higher credit spreads may explain the expensive premium of external financing faced by firm operating in countries with poor creditor legal

protection. The availability of low-cost capital is essential for R&D, given that the level of information problems related to R&D projects is greater than that associated with fixed investments, which, consequently, drive up the cost of external financing. As a result, part of the supranormal return is spent on paying interest rates. Thus, the market would react more favorably to R&D investments undertaken by firms operating in countries with a higher level of protection of creditors' rights.

Defond and Hung (2004) report that strong law enforcement is more efficient than extensive investor protection laws in improving corporate governance. Their findings suggest that strong law enforcement makes stock prices more informative about firms' decisions. In addition, the capital should be more efficiently allocated where stock prices are more informative (Durnev et al., 2004). In this vein, Hillier et al. (2011) point out the important role played by law enforcement in mitigating opaque information and, therefore, facilitating investment in R&D.

We jointly consider these characteristics and the enforcement of the laws to examine whether more effective investor protection leads to higher market valuation of R&D investments. Hence, our first hypothesis is as follows:

H1: *The market valuation of R&D investments is higher when investor protection is more effective.*

2.2. The financial system

Schumpeter (1934) pointed out that a well-functioning financial system fosters technological innovation by identifying and financing valuable projects. Some growth models suggest that technological innovation is a channel through which the functions of the financial system affect economic growth (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). Although the literature acknowledges that technological innovation acts as a channel for growth within a financial system, few studies empirically investigate whether the degree of financial development matters to the market valuation of R&D investments. Beck and Levine (2002) find that the extent of external financing is greater in countries with a higher degree of financial development. Their findings are consistent with the notion that financial development mitigates market imperfections and, consequently, allows for less costly external finance, which thus facilitates R&D investments. Accordingly, we state the following hypothesis:

H2: *The market valuation of R&D investments is higher when the level of financial development is higher.*

2.3. Control mechanisms

To investigate how control mechanisms moderate the relation between R&D and firm value, we focus on a set of internal and external mechanisms (Hillier et al., 2011): ownership, structure and independence of the board of directors, and the market for corporate control.

Research has shown that ownership structure plays an important role in resolving conflicts of interests between shareholders and managers (Jensen and Meckling, 1976; Shleifer and Vishny, 1986) and in mitigating informational asymmetries, which are particularly severe for R&D investments (Leland and Pyle, 1977). Prior studies indicate that concentrated ownership can facilitate innovative activities (Lee and O'Neill, 2003; Belloc, 2012; Hillier et al., 2011). In contrast, Seifert and Gonenc (2012) find that concentrated ownership leads to lower R&D intensity. No consensus exists either on how a firm's ownership structure affects the market valuation of R&D. Particularly, Hall and Oriani (2006) find evidence of a substantial reduction of market valuation of R&D in German firms with a majority owner. They also find that R&D is not valued by the market when it is carried out by firms in France and Italy with significant shareholders.

Jensen (1993) argues that internal corporate control has its origin in the board of directors, which are supposed to advise and monitor management. Board structures take two dominant forms: unitary and two tiered. The unitary board structure is prevalent in Anglo-Saxon countries, specifically the United States and the United Kingdom (Hopt and Leyens, 2004; Dargenidou et al., 2007), Japan (Jackson and Moerke, 2005), and European countries except for Germany (Donald and Cahn, 2010), the Netherlands (De Jong et al., 2005), and Austria (Brändle and Noll, 2004), where the two-tier board structure is adopted. Unitary and two-tiered boards function differently. In a unitary board structure, managers and directors have the same seniority given that they jointly manage and supervise the firm's activities. In contrast, two-tier board structures have an executive and a supervisory board, which reduces the power and control of the executive managers. The members of the supervisory board are elected by the shareholders. The supervisory board appoints and supervises the executive board (Jungmann, 2006; Kim et al., 2007). Additionally, unitary boards in the United States and in the United Kingdom in particular are assumed to be more efficient than their continental European counterparts because they include a higher proportion of nonexecutive directors, thus providing on these boards with greater independence.

Particularly for R&D investment, which is characterized by high risk, a long-term horizon, and more opaque information and actions, boards with a two-tier structure or boards with a high proportion of nonexecutive directors are considered to be more effective because they can more easily replace directors who perform poorly or engage in opportunistic behavior. In other words, these boards encourage managers to undertake valuable R&D projects rather than alternative investments that provide managers with private benefits at the cost of shareholders.

The strong correlation between managerial efficiency and the stock market value is the essential premise of the market for corporate control (Manne, 1965). Jensen and Ruback (1983) argue that a strong market for corporate control checks managerial opportunism when asymmetries are severe. Thus, an active market for corporate control should enhance the firm's value by increasing the available scale and scope of economies from mergers and by takeover threats that may lead managers to maximize firm value (Brook et al., 1998). Consistent with this line of research, prior studies suggest that some antitakeover governance provisions negatively affect value (see, e.g., Gompers et al., 2003). For R&D investment in particular, Melbroek et al. (1990) find that antitakeover protection may reduce the level of R&D intensity, which in turn may facilitate managers' entrenchment and support them against any market for corporate control action. Melbroek et al.'s results refute Stein's (1988) previous findings that antitakeover amendments benefit shareholders by leading managers to undertake valuable long-term projects such as R&D investment.

We investigate how these internal and external control mechanisms jointly moderate the relation between R&D and firm value, and pose the following hypothesis:

H3: *The market valuation of R&D is higher when effective control mechanisms exist.*

2.4. Corporate governance factors

All the previously discussed corporate governance factors can interact. Thus, the question becomes a matter of the overall effect of corporate governance on the relation between R&D investment and firm value. In fact, La Porta et al. (1997, 2000) show that investor protection facilitates the development of the financial system. Similarly, Kwok and Tadesse (2006) highlight the key role played by the legal systems in differentiating financial systems across countries. In addition, Demirgüç-Kunt and Maksimovic (1998) find that both legal and financial systems reduce the magnitude of market imperfections caused by agency problems. To complete our analysis by considering the joint impact of corporate governance factors on the market valuation of R&D, we state our last hypothesis:

H4: *The market valuation of R&D investments is higher when corporate governance is effective.*

3. Data, variables, model, and estimation method

3.1. Data and variables

Our initial sample consists of all listed companies in the European Union, the United States, and Japan included on the Worldscope database between 1986 and 2003. Data on the growth of capital goods prices and the rate of interest on short- and long-term debt come from the Main Economic Indicators service of the OECD. Similar to La Porta et al. (2000), we remove companies from Luxembourg because of the very low number of listed firms. We also drop Finnish and Portuguese companies because of the lack of R&D data. As a result, the sample consists of firms from 12 countries: Austria, Belgium, France, Germany, Greece, Ireland, Italy, Spain, the Netherlands, the United States, the United Kingdom, and Japan. Furthermore, we remove financial firms because their corporate structure and strategy is fundamentally different from the rest of the sample. Our final sample is an unbalanced panel comprising 1,199 companies and 6,170 firm-year observations. An unbalanced panel is preferred to a balanced approach to mitigate survivorship bias problems. Additional details on the sample are available upon request from the authors.

A summary of the statistics including mean, standard deviation, and maximum and minimum of all the variables used in our analysis are provided in Table 1. All details on the definition and construction of these variables and indices can be found in Pindado et al. (2010) and Hillier et al. (2011).

3.2. Model and estimation method

Because we are interested in how corporate governance affects the market valuation of R&D, we use the model derived by Pindado et al. (2010). This model is based on the capital market arbitrage condition and after several algebraic manipulations (for details, see Pindado et al., 2010), the following basic model is derived:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + \beta_2 \frac{RD_{it}}{K_{it}} + e_{it} \qquad (1)$$

Table 1. Summary statistics for key variables

Variable	Mean	Standard deviation	Minimum	Maximum
$[(MV - BV) / K]_{it}$	0.833191	1.332063	–6.260119	29.59288
$(R\&D / K)_{it}$	0.0375548	0.0543905	0.0000	0.9045709
$(RI / K)_{it}$	0.0024482	0.1381163	–1.852716	0.7139664
EP_{it} $(R\&D / K)_{it}$	0.28706	0.0528392	0.0000	0.9045709
FD_{it} $(R\&D / K)_{it}$	0.0300611	0.0530864	0.0000	0.9045709
CM_{it} $(R\&D / K)_{it}$	0.0177515	0.0355728	0.0000	0.9045709
CG_{it} $(R\&D / K)_{it}$	0.0246944	0.0535678	0.0000	0.9045709
CL_{it} $(R\&D / K)_{it}$	0.0167108	0.0498566	0.0000	0.9045709
AR_{it} $(R\&D / K)_{it}$	0.0216332	0.0501993	0.0000	0.9045709
CR_{it} $(R\&D / K)_{it}$	0.0206739	0.0387908	0.0000	0.9045709
EF_{it} $(R\&D / K)_{it}$	0.0185505	0.044235	0.0000	0.8886256
MB_{it} $(R\&D / K)_{it}$	0.0179311	0.0504255	0.0000	0.9045709
OC_{it} $(R\&D / K)_{it}$	0.0094942	0.0261584	0.0000	0.2577848
EB_{it} $(R\&D / K)_{it}$	0.0254839	0.0535895	0.0000	0.9045709
MCC_{it} $(R\&D / K)_{it}$	0.0182763	0.050524	0.0000	0.9045709

The table presents summary statistics for variables in our analysis. $(MV–BV) / K)_{it}$ stands for the difference between market and book value of equity, scaled by the replacement value of total assets. $(RI / K)_{it}$ is the residual income scaled by the replacement value of total assets. $(R\&D / K)_{it}$ stands for research and development scaled by the replacement value of total assets. EP_{it} is the effective investor protection dummy. FD_{it} is the financial system development dummy. CM_{it} is the control mechanisms dummy. CG_{it} is the corporate governance dummy. CL_{it} is the common law dummy. AR_{it} is the antidirector rights dummy. CR_{it} is the creditor protection dummy. EF_{it} is the law enforcement dummy. MB_{it} is the market-based country dummy. OC_{it} is the ownership concentration dummy. EB_{it} is the board effectiveness dummy. MCC_{it} is the market for corporate control dummy. See Pindado et al. (2010) and Hillier et al. (2011) for details on the definition and construction of these variables. R&D, research and development.

where V_{it} is the market value of equity, BV_{it} is the book value of equity, K_{it} is the replacement value of total assets, RI_{it} is the residual income, and RD_{it} is all R&D costs.

This model allows us to test our hypotheses by interacting the R&D variable with several dummy variables related to each corporate governance factors. We thus derive the following extended model:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + (\beta_2 + \alpha_1 DUM_{it}) \left(\frac{RD}{K} \right)_{it} + e_{it} \quad (2)$$

where DUM_{it} stands for the several indicators of legal and financial systems and corporate control mechanisms that are built to test our hypotheses. These country-level governance indices are constructed by following Hillier et al. (2011), except for creditor rights, for which we followed Pindado et al. (2008). The previously specified model must be estimated using panel data methodology, because R&D is strongly linked to the strategy of the firm (see, e.g., Teirlinck and Spithoven, 2013), and thus, we must address the strong specificity of R&D investment. Therefore, to eliminate the risk of obtaining biased results, we control for this heterogeneity by modeling it as an individual effect, η_i, which is eliminated by taking first differences of the variables before estimating the model. Consequently, the basic specification of our model is:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + (\beta_2 + \alpha_1 DUM) \left(\frac{RD_{it}}{K_{it}} \right) + \eta_i + d_t + c_i + i_i + v_{it} \quad (3)$$

where the error term has several components besides the individual or firm-specific effect (η_i); d_t measures the time-specific effect by the corresponding time dummy variables so that we can control for the impact of macroeconomic factors on R&D and alleviate the problem of cross-sectional correlation (Petersen, 2009); c_i represents country dummy variables for country-specific effects; i_i represents industry dummy variables for industry-specific effects because R&D is strongly related to the kind of activity developed by the firm; and v_{it} is the random disturbance term.

Endogeneity is a widely accepted problem in the literature, particularly in the topics addressed in this paper (see the survey in Belloc, 2012). We thus face the challenge of dealing with the endogeneity problem that is likely to arise because the dependent variable (firm value) may also explain the R&D

Table 2. The effect of corporate governance on the market valuation of research and development

	(1)	(2)	(3)	(4)
$(RI / K)_{i,t}$	0.9801*	0.9444*	0.9766*	0.9750*
	(0.0368)	(0.0465)	(0.0376)	(0.0539)
$(R\&D / K)_{i,t-}$	3.6886*	2.9213*	2.2624*	2.5118*
	(0.1622)	(0.1185)	(0.1310)	(0.1399)
EP_{it} $(R\&D / K)_{iit}$	2.0780*			
	(0.3098)			
FD_{it} $(R\&D / K)_{it}$		2.1701*		
		(0.3416)		
CM_{it} $(R\&D / K)_{it}$			5.2290*	
			(0.5121)	
CG_{it} $(R\&D / K)_{it}$				3.2115*
				(0.2198)
t	28.30	27.86	22.10	21.89
z_1	573.93 (3)	04.52 (3)	502.02 (3)	1062.67 (3)
z_2	326.99 (12)	258.15 (12)	180.99 (12)	37.44 (12)
z_3	101.49 (7)	8.06 (8)	68.28 (7)	60.63 (7)
z_4	50.99 (7)	36.12 (7)	35.04 (7)	39.51 (7)
m_2	–0.09	–0.11	–0.12	–0.11
Hansen	267.74 (193)	258.42 (193)	302.90 (193)	296.08 (193)

Heteroskedasticity-consistent asymptotic standard errors are in parentheses. *t*-statistic is the linear restriction test under the null hypothesis $H_0: \beta_2 + \alpha = 0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relation; degrees of freedom are in parentheses. z_2 is a Wald test of the joint significance of the time dummies, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_3 is a Wald test of the joint significance of the country dummies, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_4 is a Wald test of the joint significance of industry dummies, asymptotically distributed as χ^2 under the null of no relation; degrees of freedom are in parentheses. m_2 is a serial correlation test of order 2 using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the overidentifying restrictions, asymptotically distributed as χ^2 under the null; degrees of freedom are in parentheses. $(RI / K)_{it}$ is the residual income scaled by the replacement value of total assets. $(R\&D / K)_{it}$ stands for research and development scaled by the replacement value of total assets. EP_{it} is the effective investor protection dummy, FD_{it} is the financial system development dummy, CM_{it} is the control mechanisms dummy, and CG_{it} is the corporate governance dummy. See Pindado et al. (2010) and Hillier et al. (2011) for details on the definition and construction of these variables. R&D, research and development.
*indicates significance at the 1% level.

value, as a higher value may encourage managers to undertake new R&D projects. Therefore, we estimate all models by using an instrumental variable method, namely, the generalized method of moments system developed by Blundell and Bond (1998). To be exact, we use as instruments the right-hand-side variables in the models lagged from t–1 to t–4 for the equations in differences, and only one instrument (the current difference of the abovementioned variables) for the equations in levels. To check for the validity of the instruments used in all models, we use the Hansen J statistic of overidentifying restrictions to test for the absence of correlation between the instruments and the error term. We also use the m_2 statistic, developed by Arellano and Bond (1991), to test for the lack of second-order serial correlation in the first-difference residuals and find no problem of serial correlation on the error term. Additionally, we run four Wald tests for each model and obtain good results as displayed in Table 2.

4. Results

All the hypotheses posed in Section 2 are about the moderating effect of several country-level governance characteristics on the relation between R&D and firm value. Consequently, to test these hypotheses, we follow the same methodology followed by Hillier et al. (2011). To be exact, we use a set of country-level governance indices to split the sample. The advantage of this methodology is that it provides us with a criterion to determine whether the moderating effect of each country-level governance characteristic is significantly different for countries with a high score in this characteristic as compared with

countries with a low score. This comparison is possible by means of a linear restriction test, which is an important test that allows us to reject or accept each null hypothesis in our study.

4.1. The legal protection of investors

We test H1, related to effective investor protection, by substituting DUM_{it}, for EP_{it}, in equation (3), which equals to 1 for firms operating in a country with an index of effective investor higher than the median, and 0 otherwise. According to this model, the coefficient of R&D for firms operating under less effective investor protection is β_2 (because EP_{it} equals to 0) and $\beta_2 + \alpha_1$ for firms operating under more effective investor protection (because EP_{it} equals to 1). In this last case, if both parameters are significant, a linear restriction test is needed to determine whether their sum ($\beta_2 + \alpha_1$) is significantly different from 0. Hence, the null hypothesis of no significance is H_0: $\beta_2 + \alpha_1 = 0$. The results, displayed in column 1 of Table 2, show that firms operating under more effective investor protection show higher valuation of their R&D investments ($\beta_2 + \alpha_1 = 3.6886 + 2.0780 = 5.7666$, significantly different from 0; see t value) than for firms operating under less effective protection of investor ($\beta_2 = 3.6886$). This result supports H1 and provides strong evidence confirming the positive effect of legal protection in moderating the market valuation of R&D. Our finding is consistent with the literature pertaining to the important role that the characteristics and enforcement of laws play in carrying out R&D projects. Consequently, the market reacts positively to R&D investments undertaken in an environment with strong legal protection (Hall and Oriani, 2006; Hillier et al., 2011). Particularly for R&D, the market valuation should be favorable for R&D-intensive firms operating in countries with stronger investor protection, because these projects are associated with more hidden actions, which may result in larger gains for the insider (Aboody and Lev, 2000). Therefore, the possibility that a firm undertakes risky and long-term investments, such as R&D, arises from strong investor protection. As reported by John et al. (2008), the legal protection of investor lowers incentive problems. Stronger investor protection helps to reduce the magnitude of opportunistic behavior, reflecting in a positive net present value risky investment. In addition, Gompers et al. (2003) find that as the level of shareholder rights increase, firm value also increases.

4.2. The financial system

To test the impact of the financial development outlined by H2, we substitute the dummy variable in equation (3) with the dummy variable, FD_{it}, which equals to 1 for firms operating in a country with an index of financial development higher than the median, and 0 otherwise. Column 2 of Table 2 shows that a higher level of financial development increases the market valuation of R&D. The coefficient of the R&D variable for firms operating in countries with a more developed financial system is higher ($\beta_2 + \alpha_1 = 2.9213 + 2.1701 = 5.0914$, significantly different from 0; see t value) than for those firms belonging to countries with less developed financial systems ($\beta_2 = 2.9213$). This result shows that financial development positively affects the market valuation of R&D and disentangles the neutral effect of the financial development found in Booth et al. (2006). This result supports the notion that the level of financial development helps to mitigate market imperfections, which, in turn, facilitates the availability of external financing. In this vein, Beck and Levine (2002) suggest that external financing is easier to obtain in an environment with a higher level of financial development. Capital markets should recognize this when assessing R&D investments.

4.3. Control mechanisms

We now investigate the impact of control mechanisms on the market valuation of R&D. To test this hypothesis, we introduce into equation (3) CM_{it}, which equals to 1 for firms operating under a combined corporate control index higher than the median, and 0 otherwise. Column 3 of Table 2 provides the results. The coefficient of R&D is higher for firms operating under effective (internal and external) control mechanisms ($\beta_2 + \alpha_1 = 2.2624 + 5.2290 = 7.4914$, significantly different from zero; see t value) than for those firms operating under less effective control mechanisms ($\beta_2 = 2.2624$). According to H3, this result suggests that the use of internal and external control mechanisms promotes value-maximizing investment decisions and thus leads to a higher market valuation of firms' R&D. Hall and Oriani (2006) point out the negative impact of the higher level of ownership concentration on a valuation of R&D. In this sense, our result suggests that joint internal and external control mechanisms help to mitigate the negative effect of concentrated ownership on R&D valuation.

4.4. Corporate governance

Finally, we test for the effect of corporate governance on the market valuation of R&D by using an aggregated index of corporate governance as posited by H4. Consequently, we substitute the dummy variable

in equation (3) for the dummy variable, CG_{it}, which takes value 1 when the index of corporate governance is higher than the median, and 0 otherwise. As column 4 of Table 2 shows, the coefficient of the R&D variable is higher for firms operating in countries with effective corporate governance ($\beta_2 + \alpha_1 = 2.5118 + 3.2115 = 5.7233$, significantly different from 0; see t value) than for those firms operating in countries with weaker corporate governance ($\beta_2 = 2.5118$). Consequently, this result supports our H4 that effective corporate governance increases the market valuation of R&D projects and also underlines the importance of the overarching premise of this study. Namely, this finding and the other results previously discussed provide new evidence that corporate governance plays a key role in moderating the market valuation of R&D projects. In addition, this result is consistent with Hillier et al. (2011), who find evidence supporting the hypothesis that the effect of corporate governance on the relation of R&D and firm value arises from two sources. The first comes from legal and financial systems in that both systems can interact to affect this relation further. The second is drawn from internal and external control mechanisms. In addition, according to Demirgüç-Kunt and Maksimovic (1998), both legal and financial systems reduce the magnitude of market imperfections caused by agency problems. Our findings support this notion, given the asymmetries of information that characterize R&D.

These results unanimously point to governance as a key element in the valuation of R&D. To reach such a conclusion, we rely on a set of combined governance indices. To gain additional insight we re-estimated our model after disaggregating the combined legal index and the combined index of control mechanisms effectiveness. We also tested the financial system hypothesis by using an alternative measure. The results of performing these robustness tests, which are available upon request from the authors, offer additional support for our hypotheses and shed more light on the importance of country-level corporate characteristics in explaining the valuation of R&D.

4.5. *Moderating effect of the corporate governance characteristics*

In the previous sections, we show that corporate governance characteristics play an important role in moderating the market valuation of R&D projects. To examine further which country-level corporate governance characteristic is the most efficient driver of value through its impact on R&D, we follow Hillier et al. (2011) and compute the elasticities. Specifically, we compute the elasticities for the coefficients of each variable in the four models of Table 3 by using the following formula:

$$E_k = b_k \frac{\overline{x_k}}{b'\overline{x}} \tag{4}$$

where k represents each corporate governance characteristic, b_k denotes its coefficient, $\overline{x_k}$ is its mean, and $b'\overline{x}$ is the estimate of the expected value for the dependent variable using the mean value of each regressor.

Table 3. Elasticities and power of the corporate governance characteristics

	(1)	(2)	(3)	(4)
$(RI / K)_{i,t}$	0.0120	0.0130	0.0133	0.0136
$(R\&D / K)_{i,t-}$	0.6906	0.6189	0.4716	0.5359
EP_{it} $(R\&D / K)_{iit}$	0.2974			
FD_{it} $(R\&D / K)_{it}$		0.3680		
CM_{it} $(R\&D / K)_{it}$			0.5152	
CG_{it} $(R\&D / K)_{it}$				0.4505

$(RI / K)_{it}$ is the residual income scaled by the replacement value of total assets. $(R\&D / K)_{it}$ stands for research and development scaled by the replacement value of total assets. EP_{it} is the effective investor protection dummy. FD_{it} is the financial system development dummy. CM_{it} is the control mechanisms dummy. CG_{it} is the corporate governance dummy. See Pindado et al. (2010) and Hillier et al. (2011) for details on the definition and construction of these variables. R&D, research and development.

Table 3, which reports the elasticities of all variables in our models, provides us with the explanatory power of each corporate governance characteristic. As Table 3 shows, the control mechanisms index, which takes a value of 0.5152, has the highest explanatory power. In addition, a clear difference exists between this index and the other two indices. In fact, the financial system development index takes a value of 0.3680, and the effective investor protection index takes a value of 0.2974. As expected, the aggregated index of corporate governance lies between with a value of 0.4505. According to these results, the main drivers of value are the control mechanisms, followed by financial system development and effective investor protection. Consequently, our results shed light on how these country-level governance characteristics impact the relation between R&D and firm value, which may guide policymakers in promoting appropriate characteristics in their corporate governance systems.

5. Conclusions

We investigate whether corporate governance at the country-level moderates the relation between a firm's

R&D investment and its market value. Although unexplored until now, this topic is of great interest, especially in periods of economic recession, because shaping corporate governance can be the way in which policymakers encourage economic agents to undertake R&D projects and thus foster growth. In this vein, our research provides very interesting results and sheds light on a set of country-level governance factors that strongly affect the market valuation of firms R&D spending. Specifically, our evidence points to the legal system, the financial system, and the control mechanisms as tools that the policymaker has available to foster growth, which is especially relevant during times of economic crisis.

Although this paper can help policymakers to contribute to the social welfare by promoting changes on the country-level corporate governance, it offers more limited guidance to managers about a more efficient management of R&D. To accomplish this task, information about firm-level corporate governance factors is needed. However, this information can be obtained only by studying a smaller sample of companies with a company-based survey, which is outside the scope of this paper and would be a future research project.

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Note

1. Industry differences have also proved important in the relation between innovation and performance. See recent evidence for the specific case of technology licensing in Walter (2012).

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Table S1. Breakdown of samples by country
Table S2. Sample distribution by economic sector classification
Text S1. Tests of robustness

