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Research and Development, Market Valuation and Cash Flow Sensitivity: The influence of firm's characteristics and corporate governance factors.

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CHAPTER I

INTRODUCTION TO THE STUDY

I.1. Motivation

The economic growth literature has documented the importance of technological change to fostering economic growth in the micro and macroeconomic spheres. According to research and development (R&D)-based models of growth, technological innovation is created by R&D activities (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). From the growth theory perspective, there is no doubt about the important role played by R&D to develop new products and innovation processes, and consequently, leading to growth. As a result, special attention has been devoted to R&D spending, which is not considered a cost anymore, but a value-maximizing investment, in that R&D spending yields some supra-normal profits. Moreover, it is worth noting that the European Union hopes to increase its R&D spending and innovation to 3% of its Gross Domestic Product (GDP) by 2010, in order to become more competitive (European Council 2002).

At the microeconomic level, a growing body of studies has investigated the relationship between R&D and firm value.[1] In general, the results indicate a positive market response to R&D efforts (Doukas and Switzer, 1992; Chauvin and Hirschey, 1993; Szewczyk et al., 1996; Chen and Ho, 1997; Chan et al., 2001; Bae and Kim, 2003; Eberhart et al., 2004; Cannolly and Hirschey, 2005; Hall and Oriani, 2006). Moreover, some of these papers indicate that the market response to R&D spending depends on some characteristics of the

[1] The seminal work by Griliches (1981) draws attention to the fact that R&D creates intangible capital and that the market may capture this in the valuation of R&D spending.

firm. For example, Doukas and Switzer (1992) provide evidence that the rate of return to R&D announcements by American firms is greater for those firms operating in highly concentrated industries. For France, Germany and Italy, Hall and Oriani (2006) suggest that the market response to R&D is favorable for firms with a lower level of ownership concentration.

However, as emphasized by Booth et al. (2006), the development and implementation of R&D investments require financial resources. In this sense, the finance literature suggests that cash flow is one of the more important determinants of a firm's investments. The availability of internal financial resources is of special importance for R&D. Due to its relative uniqueness, the extent of asymmetric information associated with R&D is larger than that associated with tangible assets (Aboody and Lev, 2000). These information problems increase the cost of external financing, and consequently, part of the supra-normal profits obtained from R&D projects are spent on paying the premium of external financing faced by firms highly dependent on external funds. Thus, firms have a propensity to finance their R&D projects with internal resources. Moreover, R&D investments involve more risk and are more difficult to collaterize than tangible investments. Consequently, firms with high levels of cash flow are more motivated to undertake R&D investment.

Since the seminal paper by Fazzari et al. (1988) about financing constraints and corporate investments was published, an increasing number of studies have investigated the sensitivity of investment to internal funds.[2] They argue that, in the presence of market imperfections, external funds may not provide a perfect substitute for internal funds, given that the premium of external financing faced by firms will be higher. For example, Islam and Mozumdar (2007) find that a firm's investments are positively related to internal cash, supporting the assumption that internal and external funds are not perfect substitutes. Specifically for R&D, Domadenik, et al. (2008) find a positive elasticity of R&D investment

[2] See, Bond and Meghir (1994); Whited (1998); Love (2003); Allayannis and Mozumdar (2004); Almeida and Weisbach (2004); Islam and Mozumdar (2007); Agca and Mozumdar (2008).

to internal funds, whereas in the long run, elasticity is insignificant in the case of tangible assets. They point to the greater information and moral hazard problems associated with R&D projects as the possible explanation for this. This argument is consistent with Cleary et al. (2007) who provide theoretical support for the direct relationship between investment-cash flow sensitivity and asymmetric information. Additionally, Ascioglu et al. (2008) provide empirical evidence that confirms the severe effect of asymmetric information on the sensitivity of investment to cash flow fluctuations.

The finance literature suggests that the magnitude of the market imperfection caused by agency and informational problems is correlated with corporate governance factors. The legal system differences across countries could be an explanation for the level of these market frictions. According to La Porta et al. (1998, 1999, and 2000), strong legal protection helps to reduce the conflict of interest between insiders and outsiders, thus increasing the willingness of investors to provide less costly external finance. Under better legal protection, investors are more likely to identify valuable projects (Wurgler, 2000). If legal protection plays an important role in mitigating market imperfections, then the effective protection of investors influences the level of financial system development. In this sense, La Porta et al. (1997, 2000) show that investor protection facilitates the development of financial systems. Kwok and Tadesse (2006) point out the substantial role played by the legal systems in differentiating financial systems across countries. Beck and Levine (2002) find that firms with a strong dependence on external financing grow faster in countries with higher levels of financial development and more efficient legal systems. Islam and Mozumdar (2007) show evidence that the sensitivity of corporate investments to internal cash flow is higher for firms operating in countries with less developed financial markets.

Financial systems may also influence firm-level investments by reducing the level of market imperfections. With this in mind, and to enlarge our field of study, we consider a wider definition of corporate governance than is used in other studies (see, Mallin et al., 2006). In addition to the legal and financial systems, we also investigate the role played by several control mechanisms, namely, ownership structure, board of directors and the market for corporate control in moderating the relationship between R&D-cash flow.

Ownership structure is one of the control mechanisms widely studied. The financial literature shows evidence of its importance in mitigating the conflict of interests between owners and managers in the firm (Jensen and Meckling, 1976; Shleifer and Vishny, 1986). Francis and Smith (1995) suggest that ownership concentration alleviates the agency costs associated with innovation, taking into account that agency conflicts are encouraged by asymmetric information and that R&D investment increases the informational asymmetries.

Since the recent corporate governance scandals, boards of directors have drawn attention from regulators. Much earlier, Jensen (1993) argued that internal corporate control has its origin in the board of directors. Board structures and their composition vary across countries. Specifically, there are two main board systems: unitary and two-tier. In continental European, with exception of Germany, the Netherlands and Austria that have adopted the two-tier system, unitary board structure is predominant. In Anglo-Saxon countries, such as the United States (US) and the United Kingdom (UK), the predominant board system is the unitary board. In these countries, the boards include a higher proportion of non-executive directors, which confers a higher independence as compared to their Continental European counterparts.

With respect to the market for corporate control, its primary function is to discipline management. In this environment, investors would be more confident; consequently, the premium required for external finance would be lower when there is an active market for corporate control.

The above-mentioned arguments and existing finance literature lead to extend our study to investigate whether or not corporate governance factors also play an important role in moderating the relationship between R&D and firm value. Surprisingly, very little empirical work has been devoted to this issue (Booth et al., 2006; Hall and Oriani, 2006). For instance, Hall and Oriani, 2006 suggest that firms belonging to the UK have a better market valuation of their R&D investments. Their findings are consistent with Booth et al. (2006), who suggest that, the higher the portion of financing equity, the higher the market valuation of R&D spending.

Besides the financial systems, other corporate governance factors may moderate the market response to R&D investments. For example, poor investor rights could increase the conflict of interest between insiders and outsiders, and consequently, the capital may be allocated inefficiently (Wurgler, 2000; La Porta et al, 2002). For R&D intensive-firms, the market valuation could be favorable when operating in countries with stronger investor protection, given that R&D projects are associated with increased informational opacities, which may result in larger gains for insiders (Aboody and Lev, 2000). In addition, in countries with stronger law enforcement, the stock prices are more informative about a firm's decisions (Defond and Hung, 2004).

From an agency perspective, managers can act in their own benefit, seeking power, prestige, risk reduction and compensation at the cost of shareholders' wealth. Several control mechanisms, both internal and external, can be put in place to align the interests of managers and shareholders. Although research has shown evidence of the important role played by the ownership structure in resolving the conflict of interests between shareholders and managers (Jensen and Meckling, 1976; Shleifer and Vishny, 1986), existing literature on the relationship between ownership and firm value has provided competing hypotheses and conflicting evidence.[3] Regarding R&D investment, the evidence of the importance of ownership in moderating the market valuation of R&D efforts is not unanimous. For example, Szewczyk et al. (1996) found a positive influence of institutional ownership on the market response to R&D announcements. Hall and Oriani (2006) documented that when French and

[3] See, La Porta et al. (2002); Claessens et al. (2002); Gompers et al. (2004); Adams and Santos (2006); Kvist et al. (2006).

Italian firms had a single shareholder with more than a 33% share, the R&D investment was not valued by the market. However, Booth et al. (2006) do not find support for the ownership concentration effect. Given the R&D investment characteristics, another internal control mechanism expected to moderate the market valuation of R&D investment is the board of directors. An effective board could lead managers to undertake valuable R&D projects instead of other investments that may be carried out for their private benefit at the cost of shareholders. Regarding external control mechanisms, in countries with an active market for corporate control, the market response to R&D investments could be higher. In this environment, takeover threats could lead managers to maximize the value of the firm by undertaking profitable investments. Specifically for R&D investments, Meulbroek et al. (1990) suggest that antitakeover protection may reduce the level of R&D intensity.

I.2. Research questions and structure of the study

Building upon these early studies, the main objective of this study is to provide answers to the following research questions: i) how do several characteristics of the firm moderate the relationship between R&D spending and firm value; ii) do corporate governance factors help to reduce the sensitivity of R&D investments to cash flow; and iii) do corporate governance factors influence the market valuation of R&D spending.

Since the research questions clearly defined, we organized our study as follows: In chapter II, we derive a valuation model based on the capital market arbitrage condition.

A considerable body of research has identified several firm characteristics as determinants of R&D expenditures. These include size, firm growth, free cash flow, market share, external finance dependence, labor intensity and capital intensity. We go a step further by investigating whether or not certain firm characteristics, besides being determinants of R&D spending by themselves, also play an important role in moderating the relationship between R&D spending and firm value. Therefore**,** taking the factors listed above as firm-specific characteristics affecting the firm's decision to undertake R&D investment, we pose several hypotheses that allow us to analyze how these characteristics influence the relationship between R&D and firm value.

Regarding our second research question, since one of the main determinants of R&D is cash flow (Hall 1992; Himmelberg and Petersen 1994; Bloch 2005), it is necessary to study the impact of corporate governance factors on the sensitivity of R&D to fluctuations in cash flow. A considerable body of research has examined the sensitivity of tangible investment to cash flow (Fazzari, et al. 1988; Whited, 1992; Bond and Meghir, 1994; Whited, 1998; Love, 2003; Allayannis and Mozumdar, 2004; Almeida and Weisbach, 2004; Agca and Mozumdar, 2008). The main hypothesis is that, in the presence of market imperfections, external funds may not provide a perfect substitute for internal funds, given that the premium of external financing faced by firms will be higher. Then, In Chapter III, we derive an econometric model in order to investigate how corporate governance structures facilitate R&D by interacting with cash flow and several corporate governance indicators.

The third question is answered in Chapter IV. Taking our valuation model, in which the dependent variable is constructed to capture the fluctuation of a firm's value when the explanatory variable changes, to test several hypotheses based on the finance literature documenting the correlation between corporate governance factors and valuation. In addition, we consider that R&D is linked to the strategy of the firm, since panel data methodology allows us to incorporate the unobservable heterogeneity into the analysis through an individual effect. This effect captures characteristics related to the strategy of the firm, such as how the firm competes in the market, the propensity to innovate and other unobservable characteristics.

I.3. Contribution to the literature and policy-makers

Our study makes a significant contribution in at least eight ways. First, we derive a valuation model based on the capital market arbitrage condition. This model demonstrates that firm value is dependent upon residual income and R&D spending and it implies a perfect tool for studying how firm characteristics affect the market valuation of R&D spending. As a result, the analytical derivation of a testable model is a quite important contribution in that our paper develops from a well-known equilibrium in the economic theory.

Second, we offer new evidence regarding how several firm characteristics influence the relationship between R&D investments and firm value in a cross-country analysis. Specifically, we analyze the impact of the some firm characteristics on the relationship between R&D and value in the Eurozone countries. As far as we know, this is the first time a study of these countries has been conducted, not only on the moderating effects we analyze here, but also on the analysis of the effect of R&D on firm value.

The third contribution refers not only to the use of a robust econometric technique, but also takes into account that R&D is linked to the strategy of the firm. Panel data allows us to incorporate this unobservable heterogeneity through the incorporation of individual firm characteristics in the cross-country sample.To control for endogeneity problems, the models are estimated by using the Generalized Method of Moments, which embodies all the Instrumental Variable Methods.

Forth, we offer additional evidence on the determinants of R&D investment in a cross-country analysis. There has been considerable work on the determinants of R&D using data from just one country. By jointly considering eleven countries, our research is able to differentiate between institutional, regulatory and legal systems, which is impossible when examining one country alone.

Fifth, we present evidence for the first time on how corporate governance affects R&D investment and its sensitivity to cash flow. The objective of corporate governance is to introduce efficiency in resource allocation, and, consequently, this effect will be reflected on the quality of information, which could help to reduce the level of information asymmetries and agency costs. Thus, our work is useful in characterizing the appropriate country level corporate governance structures that promote and facilitate R&D and, consequently, encourage faster economic growth.

Sixth, with a sample comprised of firm data from Eurozone countries, the US, the UK and Japan, we offer evidence of the impact of several corporate governance factors in moderating the relationship between R&D and a firm's value.

Seventh, our research is able to differentiate between control mechanisms, and financial and legal systems that are not possible when examining one country alone. We are, therefore, able to provide significant insights on the importance of these corporate governance indicators in moderating the market response to R&D investments.

The Eighth contribution refers, not only to that this study provides interesting ideas to be taken into account when making decisions at the firm level, but also at the country level, given that there are corporate governance indicators that should be taken into account by the policy decision maker. In doing so, both types of decision makers would substantially increase the effectiveness of R&D spending, which would benefit the whole society.

I.4. Main findings

Our findings show evidence supporting the important role played by firm characteristics in moderating the market valuation of R&D spending. Specifically, size and growth exert a positive effect on the relationship between R&D and firm value. On the contrary, free cash flow, dependence on external financing, labor and capital intensity negatively affect the market response to R&D. Surprisingly, we find that market share affects the relationship between firm value and R&D spending rather than the value of the firm, and, as a result, the supra-normal profits are highly dependent on the amount of R&D spending.

Second, our results reveal that the sensitivity of R&D to cash flow is moderated by several corporate governance features. The legal protection exerts an important effect on the dependence of R&D on cash flow. The R&D projects undertaken by firms operating in common law countries are less sensitive to cash flow fluctuations, since common law is more effective in mitigating asymmetric information than civil law, and consequently, largely reduces the cost of external funds. We find that the high level of minority shareholders' protection substantially lessens the sensitivity of R&D to cash flow. Our findings also support the argument that stronger law enforcement contributes to mitigating the asymmetric information problem between insiders and outsiders, and consequently, reduces the cost of external finance. It also lessens the sensitivity of R&D to cash flow. Regarding the effectiveness of legal protection, our findings corroborate the importance of legal protection in reducing the sensitivity of R&D to cash flow, and are consistent with the literature pointing out that strong legal protection contributes to reducing the market imperfections caused by the agency problem. We also show evidence on the important role played by the financial system development in the sensitivity of R&D to cash flow. Given that R&D is one of the mechanisms to achieve economic growth, these results are consistent with the literature that indicates the relevant link between financial system and economic growth. We find that the bank-based financial systems play a better role in reducing the sensitivity of R&D investment to cash flow than market-based systems. The reasons for this, among others, are that, in the market-based system, the market pressure may lead the manager to undertake short-term investment in order to maintain the short-term earnings growth; and the internal channel between firm and bank helps to reduce the asymmetric information problems between firm and investors. Important evidence is that control mechanisms affect negatively the relationship between R&D and cash flow. In other words, they contribute to lessen the sensitivity of R&D to cash flow fluctuations.

Third, we find that the positive relationship between a firm's value and R&D spending is also moderated by several corporate governance characteristics, besides the firm's characteristics. Specifically, all the legal protection indices exert a positive effect on this relation. An explanation is that a stronger legal protection of investors lessens information asymmetry, consequently increasing the ability of investors to identify valuable R&D projects. A positive effect is also found for firms operating in market-based financial systems.

This result is consistent with Booth et al. (2006), who that equity financing matters in the market valuation of R&D spending. In contrast to Booth et al. (2006), our results support the financial system development hypothesis, consistent with the view that, when firms are operating in countries with a higher level of financial development, they grow faster, especially when they rely on external finance (Back and Levine, 2002). Regarding control mechanisms, an effective board of directors and an active market for corporate control are positively correlated with the market response to R&D investment. In contrast, a higher level of ownership concentration negatively affects the relationship between R&D and firm value. This result is consistent with Hall and Oriani (2006), suggesting that the capital markets take the risk of expropriation of minority shareholders into account when assessing R&D investments. In this sense, and controlling for investor protection of minority shareholders, we find that firms with high degree of ownership concentration operating in countries with weak investor protection of minority shareholders have a lower market valuation than those ones with high concentration of ownership belonging to countries with strong investor protection of minority shareholders.

To sum up, we defend the following thesis: *"The positive effect of R&D on a firm's value is moderated by the firm's characteristics and corporate governance factors, which mitigate the sensitivity of R&D to cash flow."*

CHAPTER II

HOW DO FIRM CHARACTERISTICS INFLUENCE THE RELATIONSHIP BETWEEN R&D AND FIRM VALUE?

Introduction

Over the last 10 years, the academic literature has provided evidence on the importance of the role played by research and development (hereafter R&D) in economic growth (see, for instance; Jones, 1995; and, more recently, Bowns et al., 2003; Arnold, 2006). As a result, scholars have paid increasing attention to the R&D spending, which is not considered as a cost anymore, but rather as a value-increasing investment in that R&D spending yields some supra-normal profits.

Moreover, the seminal work by Griliches (1981) draws attention to the fact that R&D spending creates intangible capital for a firm, and indicates that the market should show this in the valuation of the firm. More recently, several empirical studies analyze the market response to R&D spending, and their results indicate that, in general, R&D investments are positively valued by the market (see, for instance, Doukas and Switzer, 1992; Chauvin and Hirschey, 1993; Szewczyk et al., 1996; Chen and Ho, 1997; Chan et al., 2001; Bae and Kim, 2003; Eberhart et al., 2004; Cannolly and Hirschey, 2005). Furthermore, some of these papers indicate that the market response to the R&D spending depends on firm size. For instance, Cannolly and Hirschey (2005) find support for size advantages in the valuation effects of R&D investments.

The stock market valuation of R&D spending is also affected by the financial environment, as shown by Booth et al. (2006). Their results support the notion that the relative size of the equity and private loan markets influence the way in which R&D is valued. Specifically, they document that the greater the portion of equity financing (or the lower the portion of bank loan financing), the stronger the market valuation of R&D spending. Therefore, Booth et al. (2006) conclude that the institutional source of financing matters.

In this context, the aim of this study is to analyse how several firm characteristics moderate the relationship between firm value and R&D spending. Our idea is that the market valuation of R&D spending is not only affected by the financial environment (see Booth et al., 2006), but also by some firm characteristics besides size (see Cannolly and Hirschey, 2005). Although there is no previous evidence on this point, there are some studies that identify several firm characteristics (such as size, firm growth, free cash flow, market share, external finance dependence, labour intensity and capital intensity) as determinants of a firm's R&D (see, for instance, Blundell et al., 1999; Galende and Suárez, 1999; Del Monte and Papagni, 2003; Negassi, 2004). Therefore, in this work we go a step forward in that we investigate whether or not certain firm characteristics, besides being themselves determinants of R&D spending, also play an important role in moderating the relationship between firm value and R&D spending. Accordingly, we pose several hypotheses that allow us to analyse how size, growth, free cash flow, market share, external finance dependence, labour intensity and capital intensity influence the positive relationship between R&D and firm value.

To achieve our goal, we first derive a valuation model based on the capital market arbitrage condition. This model shows that the firm value depends on the residual income and the R&D spending and, therefore, it is a perfect tool to study how firm characteristics affect the market valuation of R&D spending. Thus, our study relies on strong theoretical arguments for each firm characteristic and on the results from the estimation of the valuation model. However, to allow a direct comparison of the results reported in earlier literature, we also perform robustness checks that address the effectiveness of the valuation model by using alternative dependent variables based on the market value of common equity and the market-to-book ratio (Chauvin and Hirschey, 1993; Bae and Kim, 2003).

The estimation is carried out by the Generalized Method of Moments (GMM), hence we use the panel data methodology that eliminates the individual heterogeneity and controls for endogeneity problems. Since the data quality requirements of this methodology are very high, we have extracted our data from an international database (Worldscope) and for all the eurozone countries[4].

Our results reveal that the positive relationship between firm value and R&D spending is moderated by several firm characteristics. Specifically, size exerts a positive effect on this relation due to economies of scale, easier access to capital markets and R&D cost spreading. A positive effect is also found regarding firm growth in that a high rate of growth allows the firm to take greater advantage of the supra-normal profits arising from R&D projects. In contrast, free cash flow negatively affects the market valuation of R&D spending, since firms with high levels of free cash flow could use these funds to undertake negative net present value (NPV) R&D projects. Interestingly, we find that market share affects the relationship between firm value and R&D spending rather than firm value and, as a result, the supra-normal profits are highly dependent on the amount of R&D spending. The dependence on external financing negatively affects the market valuation of R&D spending because of the higher information asymmetry associated with R&D projects. Labour and capital intensity both negatively influence the impact of R&D spending on firm value: the first one because the supra-normal profits are diluted among employees, and the second one because capital intensive firms face greater financial constraints.

This chapter is presented in four sections. In Section II.1, we derive the valuation model depending on residual income and R&D spending, and explain the theoretical arguments behind our hypotheses. Section II.2 describes our data set and the econometric

[4] Note that the eurozone countries provide us with an ideal environment for our market share arguments.

method used to test our hypotheses. The results are discussed in Section II.3, and the Section II.4 presents the conclusions.

II.1 Model and Hypotheses

The development of our model to study the relationship between R&D and firm value is based on the well-known capital market arbitrage condition (e.g. Whited, 1992, and Blundell et al., 1992). According to this condition, the net after-tax return for shareholders in firm *i* during period *t* is obtained in two ways: current dividends and capital appreciation. Therefore, shareholders will maintain their shares as long as the return obtained equals their required after-tax return. This equilibrium can be expressed by the following equation:

$$r_{it}V_{it} = (E_t V_{i,t+1} - V_{it}) + E_t D_{i,t+1} \quad (1)$$

where V_{it} is the value of equity of firm *i* at the end of period *t*, $D_{i,t+1}$ are the dividends paid by firm *i* at time $t+1$, r_{it} is the after-tax return required by shareholders, and E_t is the conditional expectation on information known at moment *t*.

Solving (1) forward for V_{it} yields the following expression for the market value of equity:

$$V_{it} = E_t \sum_{j=1}^{\infty} \frac{D_{i,t+j}}{(1+r_{it})^j} \quad (2)$$

The value of dividends may be calculated by using the following Clean Surplus Relation (CSR):

$$BV_{it} = BV_{i,t-1} + \pi_{it} - D_{it} \quad (3)$$

The CSR in Equation (3) proposes that the book value of equity in period t (BV_{it}) depends on the book value of equity at the beginning of the period ($BV_{i,t-1}$), the net income (π_{it}) and the dividends (D_{it}). Solving Equation (3) for dividends, we obtain:

$$D_{it} = BV_{i,t-1} + \pi_{it} - BV_{it} \quad (4)$$

Substituting Equation (4) into Equation (2) yields:

$$V_{it} = E_t \sum_{j=1}^{\infty} \frac{(BV_{i,t+j-1} + \pi_{i,t+j} - BV_{i,t+j})}{(1+r_{it})^j} \tag{5}$$

Algebraic manipulation[5] allows Equation (5) to be rewritten as:

$$V_{it} = BV_{it} + E_t \sum_{j=1}^{\infty} \frac{(\pi_{i,t+j} - rBV_{i,t+j-1})}{(1+r)^j} - \frac{E_t(BV_{i,t+\infty})}{(1+r)^{\infty}} \tag{6}$$

Following Dechow et al. (1999) and Myers (1999), we assume that the last term in Equation (6) is zero. In addition, as usual in the economic literature, we consider that the residual income is:

$$RI_{i,t+j} = \pi_{i,t+j} - rBV_{i,t+j-1} \tag{7}$$

Therefore, the firm market value can be expressed as:

$$V_{it} = BV_{it} + E_t \sum_{j=1}^{\infty} \frac{RI_{i,t+j}}{(1+r)^j} \tag{8}$$

Consequently, attention should be paid to the second term in Equation (8). We assume that the expected residual income conditional on date t information depends on two factors. First, the residual income could have either a trend (increasing or declining) or be constant. For instance, Green et al. (1996) assume that the expected values of future residual incomes can be modelled as declining at rate δ. As a result Equation (9) holds:

$$\sum_{j=1}^{\infty} \frac{RI_{i,t+j}}{(1+r)^j} \approx \frac{(1-\delta)}{(r+\delta)} RI_{it} \tag{9}$$

The other two possible outcomes refer to an increasing trend for the expected values of future residual incomes at rate δ, and a constant value for the future residual incomes, which yield the following equations, respectively:

$$\sum_{j=1}^{\infty} \frac{RI_{i,t+j}}{(1+r)^j} \approx \frac{(1+\delta)}{(r-\delta)} RI_{it} \tag{10}$$

[5] See Appendix 2.

$$\sum_{j=1}^{\infty} \frac{RI_{i,t+j}}{(1+r)^j} \approx \frac{(1+r)^n - 1}{r(1+r)^n} \; RI_{it} \tag{11}$$

Second, Sougiannis (1994) argues that the impact of R&D on market value can be obtained indirectly through earnings. The idea is that the impact of past R&D expenditures on current market value can be captured by the investments undertaken by the firm, which yield earnings and, as a consequence, have a substantial impact on the current residual income. Furthermore, Sougiannis (1994) shows that this effect is much larger than the direct effect of new R&D information conveyed directly by R&D measures. Therefore, past R&D expenditures should be a factor to explain the residual income conditional on date t information. The point is how many lags should be considered. According to Sougiannis (1994), lagged values of R&D rarely convey addition information in explaining market value, once current residual income has been included as an explanatory variable in the valuation model. As a result, the best solution is to enter the current R&D spending into the valuation model, and use several lagged R&D values to estimate its current value by an instrumental variables method. In this study, as explained in Section II.2, we use the Generalized Method of Moments, since this method embeds the other instrumental variables methods as special cases (see Ogaki, 1993).

Taking into account the two factors mentioned above, the conditional expectation term in Equation (8) could be written as:

$$E_t \sum_{j=1}^{\infty} \left[\frac{RI}{(1+r)^j} \right] = \beta_1 RI_{it} + \beta_2 RD_{it} + e_{it} \tag{12}$$

where RD_{it} stands for the research and development spending, and e_{it} is a random error arising from the approximation process of the expectation term. β_1 and β_2 are the parameters of the model, the value of the former being dependent on the assumptions made in Equations (9), (10) or (11).

Substituting the expectation in Equation (12) into Equation (8) yields the following regression model:

$$V_{it} = BV_{it} + \beta_1 RI_{it} + \beta_2 RD_{it} + e_{it} \tag{13}$$

As a method of controlling for size, all the variables in Equation (13) have been scaled by the replacement value of total assets[6], and rearranging terms we obtain the final model:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + \beta_2 \frac{RD_{it}}{K_{it}} + e_{it} \tag{14}$$

Actually, the left hand side term in our model is the difference between market and book value of equity. From a theoretical point of view, this difference captures the fluctuation of firm value when the explanatory variables change. In fact, our dependent variable is adjusted by the changes in market value that are due to the purchase of new assets. Therefore, by construction, our valuation model tells us that the residual income and R&D variables are positively related to firm value.

In this work, we focus on the market valuation of R&D spending. Therefore, the first outcome from our valuation model is that there is a positive relationship between firm value and R&D spending. This theoretical result is consistent with prior empirical studies (see, for instance, Chan et al., 2001; Booth et al., 2006), and it thus provides a theoretical basis for our first hypothesis:

Hypothesis 1. Research and development spending positively affects firm value.

Since Schumpeter (1961), scholars have widely studied the relationship between R&D and firm size. As surveyed in Lee and Sung (2005), diverse results have been found by the empirical literature. Some studies find a linear and positive relationship, while others suggest that R&D and firm size are independent. The earliest studies of the relationship between firm size and R&D find a positive relationship[7], which is interpreted as support for the Schumpeterian hypothesis. Furthermore, Arvanitis (1997) finds that the positive relationship between R&D expenditures and firm size depends on the firm industry. However, Cohen et al.

[6] Deflating by controlling for size is a usual way to avoid heteroskedasticity problems in econometric models.
[7] See Cohen and Klepper (1996) for details about these papers.

(1987) investigate the Schumpeterian hypothesis and show that, overall, firm size has a statistically insignificant effect on R&D intensity when either fixed industry effects or measured industry characteristics are taken into account. Recently, Lee and Sung (2005) find that the R&D-size relationship is probably stronger for industries with high technological opportunity. Note that this result is consistent with previous findings already reported by Cohen and Klepper (1996).

More important than the relationship between R&D and size is how size moderates the relationship between R&D and value. Cannolly and Hirschey (2005) show findings supporting the importance of size advantages to the valuation effects of R&D spending. This result is consistent with Chauvin and Hirschey (1993), who find that the R&D activity of larger firms appears to be relatively more effective than that of smaller ones, based on a market value perspective. Moreover, the advantages in technological competition (particularly the economies of scale in R&D, the easier access to capital markets and, sometimes, the R&D cost spreading) are commonly attributed to large firms (see Cohen and Klepper, 1996). Within this context, we use our valuation model to go further in the analysis of the role played by firm size in moderating the relationship between R&D and value. Accordingly, we pose our second hypothesis:

Hypothesis 2. The impact of research and development on firm value is greater for larger than for smaller firms.

To test this hypothesis, we extend on the model in Equation (14) by interacting R&D with a dummy variable that distinguishes between large and small firms. The resultant model would be:

$$\frac{V_{it}-BV_{it}}{K_{it}}=\beta_1\frac{RI_{it}}{K_{it}}+(\beta_2+\alpha_1 DS_{it})\left(\frac{RD}{K}\right)_{it}+e_{it} \tag{15}$$

where DS_{it} is a dummy variable equal to 1 if the firm is larger than the sample mean, and 0 otherwise. Firm size is measured as the natural logarithm of the replacement value of total assets. According to this model, the coefficient of R&D for small firms is β_2 (since DS_{it} takes value zero); whereas $\beta_2+\alpha_1$ is the coefficient for large firms (since DS_{it} takes value one). In this last case, if both parameters are significant, a linear restriction test is needed in order to know whether their sum ($\beta_2+\alpha_1$) is significantly different from zero. Hence the null hypothesis of no significance is $H_0: \beta_2+\alpha_1=0$.

Economic literature assumes that R&D spending facilitates the success of the firm in the product market and, as a result, that R&D spending leads to a higher rate of growth. However, Del Monte and Papagni (2003) summarize the results found by different studies over the last 20 years. Based on the analysis of these studies, they come to the conclusion that a significant relationship between research intensity and firm growth has not always been found. Nevertheless, Del Monte and Papagni (2003) provide evidence revealing a positive relationship between R&D and the rate of growth. Furthermore, they argue that the variable proxying for innovation efforts (including R&D) could be endogenous. This means that firms with a higher rate of growth would increase their size and, according to the Schumpeterian hypothesis, they will undertake more R&D projects. In this context, our study focuses on how a firm's growth affects the market valuation of its R&D spending. Our argument is that firms growing at a higher rate will make the most of the supra-normal profits arising from the R&D projects and, consequently, the market will provide them with a better valuation than that of the remaining firms. Therefore, our third hypothesis would be as follows:

Hypothesis 3. The impact of research and development on firm value is greater for firms with a higher rate of growth than for firms with a lower rate of growth.

This hypothesis can be tested by substituting the dummy variable in Equation (15) with another dummy variable, DG_{it}, which takes value 1 for firms whose rate of growth is above the sample mean, and 0 otherwise.

Another firm characteristic that may influence the relationship between R&D and firm value is the free cash flow. Jensen (1986) defines a firm's free cash flow as the cash flow in excess of that required to fund all positive NPV projects when discounted at the relevant cost of capital. According to Jensen's theory, firms with a high level of free cash flow (hereafter, HFCF firms) are prone to use these funds in negative NPV projects. Several studies on investment find support for Jensen's theory (see, for example, Del Brio et al., 2003a and 2003b) in that firms having a low (high) free cash flow level are expected to experience positive (negative) market reaction to investment announcements. However, there are other studies (see, for instance, Szewczyk et al., 1996, and Chen and Ho, 1997) that do not find enough evidence to support this theory, although this lack of support may be due to the fact that their measure of free cash flow is a cash flow measure. In addition, except for Szewczyk et al. (1996), the abovementioned studies are focused on tangible assets investments. Consequently, our study contributes to this strand of literature by analyzing how the level of free cash flow affects the relationship between R&D spending and firm value. According to Jensen's theory, the effect of HFCF firms' R&D projects on their market value should be lower than that of low free cash flow firms (LFCF firms), in that the managers of LFCF firms are not so encouraged to undertake negative NPV projects. Consequently, our fourth hypothesis would be as follows:

Hypothesis 4. The impact of research and development on firm value is greater for firms with low free cash flow levels than for ones with high free cash flow levels.

We test this hypothesis by substituting the dummy variable in Equation (15) with another dummy variable, $DFCF_{it}$, which takes value 1 for firms with a level of free cash flow higher than the sample mean, and 0 otherwise. To avoid entering a bias in our study because of an unsuitable measure of free cash flow, we follow Miguel and Pindado (2001) in the construction of the free cash flow variable. The idea is to build an index that takes high values when cash flow is high and investment opportunities low, which indicates that the firm suffers from severe free cash flow problems; and vice versa if the level of cash flow is low and the level of investment opportunities is high. Note that this index is consistent with Jensen's (1986) definition of free cash flow as cash flow that is not consumed by investment opportunities. Consequently, our measure of free cash flow is the result of the interaction between cash flow and the inverse of investment opportunities (see Appendix 1).

Recent literature has pointed out the influence of the relationship between market share and R&D spending on firm value. In fact, there is previous evidence suggesting that market share and R&D are complementary to each other in a firm's market valuation (see Nagaoka, 2004). Blundell et al. (1999) investigate the relationship between innovation and market share, and find that firms with high market share innovate more and, hence, their market valuation is higher. In order to check the robustness of this result, they enter into their model the interaction between innovation stock and market share, finding a positive coefficient for the interaction term. Given that the R&D process is a wellspring of innovation (see Booth et al., 2006), these findings show evidence on the importance of market share in moderating the relationship between R&D and firm value. In addition, Blundell et al. (1999) suggest that this positive influence plays a considerable role in creating barriers to entry that, hence, should be captured by firm value. To provide additional evidence on this matter, we test the advantages of market share, and thus we pose our fifth hypothesis:

Hypothesis 5. The impact of research and development on firm value is greater for firms with high market share than for ones with low market share.

This hypothesis can be tested by substituting the dummy variable in Equation (15) with another dummy variable, DMS_{it}, which takes value 1 for firms whose market share level is larger than the sample mean, and 0 otherwise. Market share is calculated as described in the Appendix 1.

The external finance dependence (hereafter EFD) is another firm characteristic that is expected to moderate the relationship between R&D and firm value. We follow Rajan and Zingales (1998) and define EFD as capital expenditures minus cash flow divided by capital expenditures. Therefore, the EFD measure captures the part of a firm's investments that cannot be financed by internal resources and that therefore requires the firm to obtain external funds. Rajan and Zingales (1998) show that industries with EFD grow relatively faster in countries with developed financial markets. These authors also argue that the bank-based system has a comparative advantage when financing the industries intensive in tangible assets. Consequently, it would be more difficult to raise funds to undertake investments in intangibles assets. Moreover, a traditional interpretation of the innovation-market power correlation is that failures in financial markets force firms to rely on their own retained earnings to finance their innovation (see Blundell et al, 1999). Therefore, in particular for R&D, the availability of internal financial resources would be less costly, considering that the extent of information asymmetry associated with R&D is larger than that associated with tangible assets, due to the relative uniqueness of R&D (see Aboody and Lev, 2000). Accordingly, we derive the following hypothesis.

Hypothesis 6. The higher the dependence on external financing, the lower the impact of research and development on firm value.

This hypothesis can be tested by substituting the dummy variable in Equation (15) with another dummy variable, $DEFD_{it}$, which takes value 1 for firms whose external finance dependence level is larger than the sample mean, and 0 otherwise.

The relationship between human capital and R&D activities has drawn attention from empirical research. Galende and Suárez (1999) find evidence supporting the hypothesis that a high stock of qualified human capital increases the probability of R&D activities. In the same vein, Gustavsson and Poldahl (2003) show the importance of human capital for R&D spending. Furthermore, Beck and Levine (2002) focus on assessing whether R&D-intensive and labour-intensive industries grow faster depending on the orientation of the financial system (bank-based versus market-based). However, they do not find evidence supporting the idea that the orientation of the financial system favours labour-intensive industries. We go a step forward in studying labour-intensive firms instead of industries. Our argument is that the effect of labour intensity on the relationship between firm value and R&D spending is negative, in that the supra-normal profits of R&D spending are diluted among employees, especially when employees have intensively been involved in the firm's R&D projects. As a result, our seventh hypothesis would be as follows:

Hypothesis 7. The higher the labour intensity, the lower the impact of research and development on firm value.

We test this hypothesis by substituting the dummy variable in Equation (15) with another dummy variable, DLI_{it}, which takes value 1 for firms whose labour intensity level is higher than the sample mean, and 0 otherwise. We defined the labour intensity as the ratio between the number of employees and sales revenue.

Capital intensity is also related to R&D activities (see Galende and Suárez, 1999). Hsiao and Tahmiscioglu (1997) find that capital intensive firms face more difficulties in financing investment projects. Consequently, capital intensive firms would face greater financial constraints, which may lead them to undertake fewer R&D projects, and these projects may be poorly assessed by capital markets because the cost of capital for capital intensive firms would be higher. Consequently, our last hypothesis is as follows:

Hypothesis 8. The impact of research and development on firm value is lower for capital intensive firms.

This hypothesis can be tested by substituting the dummy variable in Equation (15) with another dummy variable, DCI_{it}, which takes value 1 for firms whose capital intensity level is larger than the sample mean, and 0 otherwise. In this study, capital intensity is defined as the ratio between the replacement value of tangible assets and sales revenue.

II.2. Data and estimation method

II.2.1. Data

To test the hypotheses posed in the previous section we used data from the eurozone countries extracted from an international database, Worldscope. Additionally, international data such as the growth of capital goods prices, the rate of interest of short term debt, and the rate of interest of long term debt, were extracted from the Main Economic Indicators published by the Organization for Economic Cooperation and Development (OECD).

For each country we constructed an unbalanced panel comprising companies for which information for a least six consecutive years from 1986 to 2003 was available[8]. This strong requirement is a necessary condition since we lost one-year data in the construction of some variables (see Appendix 1), we lost another year-data because of the estimation of the model in first differences, and four consecutive year information is required in order to test for second-order serial correlation, as Arellano and Bond (1991) point out. We need to test for the second-order serial correlation because our estimation method, the Generalized Method of Moments (GMM), is based on this assumption.

As occurs in La Porta et al. (2000), we had to remove Luxembourg from our sample, since there are just a few companies listed in Luxembourg's stock exchange. We also had to remove all the countries (namely Finland and Portugal) for which samples with the abovementioned requirement could not be selected[9]. As a result, our panel comprises Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands and Spain. Table II.1 provides the structure of the sample in terms of companies and number of observations per country. Note that the details of the data reported by the different tables of this study are provided after removing the first-year data. These first-year data are only used to construct several variables, but not in the estimation of the models. Therefore, tables refer exclusively to the data used to estimate the models.

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[8] Note that before this date there is no information available for research and development, which is the main topic of our research.
[9] Note that the information on research and development usually presents a lot of missing values in databases.

Table II.1

Structure of the samples by country

Country	Number of companies	Percentage of companies	Number of observations	Percentage of observations
Germany	83	30.63	722	30.25
France	76	28.04	683	28.61
Spain	2	0.74	17	0.71
Netherlands	18	6.64	174	7.29
Belgium	7	2.58	70	2.93
Ireland	28	10.33	240	10.05
Greece	10	3.70	78	3.27
Austria	9	3.32	83	3.48
Italy	38	14.02	320	13.41
Total	271	100.00	2,387	100.00

Data of companies for which the information is available for at least six consecutive years between 1986 and 2003 were extracted. After removing the first year data only used to construct several variables (see Appendix 1), the resultant samples comprise 83 companies (722 observations) for Germany, 76 companies (683 observations) for France, 2 companies (17 observations) for Spain, 18 companies (174 observations) for the Netherlands, 7 companies (70 observations) for Belgium, 28 companies (240 observations) for Ireland, 10 companies (78 observations) for Greece, 9 companies (83 observations) for Austria and 38 companies (320 observations) for Italy.

Table II.2 shows the structure of the resultant unbalanced panel used in the estimation, according to the number of annual observations per company. To be exact, our unbalanced panel comprises 271 companies and 2,387 observations. Using an unbalanced panel for a long period (16 years) is the best way to solve the survival bias caused when some companies are delisted, and consequently, dropped from the database.

Table II.2

Structure of the panel

No. of annual observations per company	Number of companies	Percentage of companies	Number of observations	Percentage of observations
16	2	0.74	32	1.34
15	5	1.84	75	3.14
14	28	10.33	392	16.42
13	10	3.70	130	5.45
12	16	5.90	192	8.04
11	17	6.27	187	7.83
10	22	8.12	220	9.22
9	26	9.60	234	9.80
8	34	12.54	272	11.40
7	27	9.96	189	7.92
6	44	16.24	264	11.06
5	40	14.76	200	8.38
Total	271	100.00	2,387	100.00

Data of companies for which the information is available for at least six consecutive years between 1986 and 2003 were extracted. After removing the first year data used only to construct several variables (see Appendix 1), the resultant unbalanced panel comprises 271 companies (2,387 observations).

Finally, Table II. 3 provides the allocation of all companies to one of nine broad economic sector groups in accordance with the Economic Sector Code. Note that financial services companies have been excluded from our study due to their specificity.

Table II.3

Sample distribution by economic sector classification

Economic sector	Number of companies	Percentage of companies	Number of observations	Percentage of observations
Basic Materials	43	15.88	394	16.51
Consumer – Cyclical	39	14.39	327	13.70
Consumer – Non Cyclical	48	17.71	402	16.84
Health Care	33	12.18	330	13.82
Energy	7	2.58	80	3.35
Capital Goods	64	23.62	519	21.74
Technology	25	9.22	251	10.52
Utilities	12	4.42	84	3.52
Total	271	100.00	2,387	100.00

All companies in our panels have been allocated to one of nine broad economic industry groups in accordance with the Economic Sector Code, excluding Financial Services.

Using the information from the database described above we constructed all the variables in our models following the procedure detailed in the Appendix 1. Our dependent variable is a measure of firm value, and the explanatory variables in the basic model are residual income and research and development. We have also estimated an extended version of the model including two control variables: market share and long term debt. The summary statistics (mean, standard deviation, maximum and minimum) are provided by Table II.4.

Table II.4

Summary statistics

Variable	Mean	Standard deviation	Minimum	Maximum
$(MV\text{-}BV)/K)_{it}$	0.6191	1.0738	-0.4323	20.7136
$(RI/K)_{it}$	0.0202	0.0553	-0.7848	0.2638
$(R\&D/K)_{it}$	0.0300	0.0350	0.0000	0.4132
MS_{it}	0.0015	0.0036	4.21e-07	0.0416
$(LTD/K)_{it}$	0.0535	0.0449	0.0000	0.2662

$(MV\text{-}BV)/K)_{it}$ stands for the difference between market and book value of equity, scaled by the replacement value of total assets, $(RI/K)_{it}$ is residual income scaled by the replacement value of total assets, $(R\&D/K)_{it}$ is research and development scaled by the replacement value of total assets, MS_{it} is market share and $(LTD/K)_{it}$ is long term debt scaled by replacement value of total assets. See Appendix 1 for details on the definitions of these variables.

To analyse how certain firm characteristics moderate the relationship between firm value and research and development, we have used a set of dummy variables constructed as explained in the Appendix 1[10]. The number of zeros and ones for each dummy variable is provided in Table II.5.

Table II.5
Dummy variables

Dummy variable	Number of zeros	Percentage of zeros	Number of ones	Percentages of ones
DS_{it}	1,112	46.59	1,275	53.41
DGR_{it}	1,493	62.55	894	37.45
$DFCF_{itt}$	434	18.18	1,953	81.82
DMS_{it}	1,770	74.15	617	25.85
$DEFD_{it}$	1,545	64.73	842	35.27
DLI_{it}	1,470	61.58	917	38.42
DCI_{it}	1,326	55.55	1,061	44.45

DS_{it} denotes a size dummy, DGR_{it} is a growth dummy, $DFCF_{it}$ denotes a free cash flow dummy, DMS_{it} is a market share dummy, $DEFD_{it}$ *is* an external finance dependence dummy, DLI_{it} is a labour intensity dummy and DCI_{it} is a capital intensity dummy. See Appendix 1 for details on the definitions of these variables.

[10] Note that both the basic and extended versions of the model have also been estimated by accounting for the interactions described in Section II.2.

II.2.2. Estimation method

All the models specified in this study have been estimated by using the panel data methodology. To be exact, the estimation is carried out by the Generalized Method of Moments (GMM). Two issues have been considered to make this choice. First, unlike cross-sectional analysis, panel data allow us to control for individual heterogeneity. This point is crucial in our study because the decision of undertaking R&D projects in a firm is very closely related to the firm specificity and, more importantly, the effect of research and development on firm value is strongly linked to the specificity of each firm. Therefore, to eliminate the risk of obtaining biased results, we have controlled for this heterogeneity by modelling it as an individual effect, $\eta_{i,}$ which is then eliminated by taking first differences of the variables. Consequently, the basic specification of our model would be as follows:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + \beta_2 \frac{RD_{it}}{K_{it}} + \eta_i + d_t + c_i + v_{it} \qquad (16)$$

where the error term has several components, besides the abovementioned 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 effects of macroeconomic variables on firm value; c_i are country dummy variables standing for the country-specific effect, which are necessary in that our models are estimated using data from several countries; finally, v_{it} is the random disturbance.

The second issue we can deal with by using the panel data methodology is the endogeneity problem. The endogeneity problem is likely to arise since the dependent variable (firm value) may also explain research and development in that a higher value may encourage managers to undertake new R&D projects. Therefore, all models have been estimated by using instruments. To be exact, we have used all the right-hand-side variables in the models lagged two and three times as instruments in the difference equations and just one instrument in the level equations, since we use the system GMM developed by Blundell and Bond (1998).

Finally, we have checked for the potential misspecification of the models. First, we use the Hansen J statistic of over-identifying restrictions in order to test the absence of correlation between the instruments and the error term. Tables II.6 to II.9 show that the instruments used are valid. Second, we use the m_2 statistic, developed by Arellano and Bond (1991), in order to test for the lack of second-order serial correlation in the first-difference residuals. Tables II.6 to II.9 show that there is no second-order serial correlation (m_2) in our models. Note that although there is first-order serial correlation (m_1), this is caused by the first-difference transformation of the model and, consequently, it does not represent a specification problem of the models. Third, our results in Tables II.6 to II.13 provide good results for the following three Wald tests: z_1 is a test of the joint significance of the reported coefficients; z_2 is a test of the joint significance of the time dummies; and z_3 is a test of the joint significance of the country dummies.

II.3. Results

In this section, we first summarize the main results obtained by estimating our basic model. Then, we comment on the findings from an extended model, which are totally consistent with those from the basic model.

II.3.1. Results from the basic model

Table II. 6

Results of the basic model (I)

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	11.0025*	11.6254*	9.6344*	12.4897*
	(0.2886)	(0.2171)	(0.2591)	(0.9209)
$(R\&D/K)_{it}$	14.8585*	7.3350*	12.1961*	22.4653*
	(0.4367)	(0.3152)	(0.2089)	(0.1351)
$DS_{it}(R\&D/K)_{it}$		14.5066*		
		(0.2558)		
$DGR_{it}(R\&D/K)_{it}$			13.7147*	
			(0.1495)	
$DFCF_{it}(R\&D/K)_{it}$				-15.8905*
				(0.8444)
t		131.94	127.78	42.35
z_1	961.62 (2)	16800.65 (3)	10141.03 (3)	21580.58 (3)
z_2	52.16 (16)	628.79 (16)	624.99 (16)	682.60 (16)
z_3	54.11(8)	76.33 (8)	148.75 (8)	157.88 (8)
m_1	-3.22	-2.24	-3.30	-2.38
m_2	-0.87	0.58	-0.82	0.95
Hansen	134.03 (122)	104.80 (139)	101.02 (139)	101.71 (139)

Notes: The regressions are performed by using the panel described in Tables II.1 to II.3. The rest of the information needed to read this table is: i) Heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) t is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_2+\alpha_1=0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; vii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; viii) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, degrees of freedom in parentheses.

Column 1 of Table II.6 reports the results from the basic model based on the capital market arbitrage condition. The coefficient for the residual income variable is positive, as predicted by our valuation model. In addition, the coefficient for the R&D variable is positive, confirming the important role played by R&D in increasing the value of the firm. Consequently, this last result is in accordance with financial literature (see, for instance, Chan et al., 2001; Booth et al., 2006) and supports Hypothesis 1.

This first result is the starting point for testing other interesting hypotheses about how several firm characteristics moderate the positive relationship between firm value and R&D. Column 2 of Table II.6 shows notable results on the role played by size in the abovementioned relationship. Specifically, we find that the R&D coefficient for large firms ($\beta_1+\alpha_1=7.3350+14.5066=21.8416$)[11] is greater than the coefficient for small firms ($\beta_1=7.3350$). This result supports Hypothesis 2 in that R&D spending has a greater impact on the firm value of large firms. This result is also consistent with the Schumpeterian hypothesis. Moreover, there are other factors that explain why R&D is more effective in large firms than in small ones, such as economies of scale, the easier access to capital market and the R&D cost spreading.

Regarding firm growth, our results provide a new view for the economic literature. As shown in Column 3 of Table II.6, the R&D coefficient for firms with a high rate of growth ($\beta_1+\alpha_1=12.1961+13.7147=25.9108$, see t value for its statistical significance) is greater than the R&D coefficient for firms with a low rate of growth ($\beta_1=12.961$). Our third hypothesis is totally confirmed by this result, and we provide new evidence going further in the relation between R&D spending and firm growth. Specifically, we show that a firm's growth

[11] Note that the linear restriction test whose null hypothesis is $H_0:\beta_1+\alpha_1=0$ provides a result rejecting this null hypothesis, see the t value in Table II.6.

positively affects the market valuation of its R&D spending. This higher valuation arises thanks to the greater advantage that firms with a higher rate of growth take from the supra-normal profits yielded by R&D projects.

Regarding the effect of free cash flow on the relationship between firm value and R&D spending, our results also provide interesting empirical evidence. As can be seen in column 4 of Table II.6, the R&D coefficient for HFCF firms ($\beta_1+\alpha_1$=22.4653-15.8905=6.5748)[12] is lower than the coefficient for LFCF firms (β_1=22.4653). This result is consistent with our Hypothesis 4, and it can be interpreted as evidence supporting the free cash flow theory in that HFCF firms could use their free cash flow to undertake negative NPV R&D projects, which would obviously be rejected in the case of LFCF firms.

The results on how market share moderates the relationship between firm value and R&D spending are shown in Column 1 of Table II.7. These results are in agreement with our Hypothesis 5, since they reveal that the R&D coefficient is higher for firms with high market share ($\beta_1+\alpha_1$=12.7357+10.2647=23.0004, see t value for its significance), than for firms with low market share (β_1=12.7357). Consequently, our results confirm that the higher the market share of the firm, the more effective the R&D spending and, therefore, the higher the market valuation. Actually, there is a simple reason for this fact in that R&D spending yields some supra-normal profits for each euro sold; hence the overall benefits will be greater as the market share rises.

[12] The t value resulting from the linear restriction test (see Table II.6) tells us that this coefficient is significantly different from zero.

Table II.7

Results of the basic model (II)

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	10.2722*	8.12318*	10.1172*	9.7657*
	(0.1869)	(0.2068)	(0.1486)	(0.1680)
$(R\&D/K)_{it}$	12.7357*	22.4936*	19.2024*	23.2176*
	(0.3052)	(0.2475)	(0.1388)	(0.1776)
$DMS_{it}(R\&D/K)_{it}$	10.2647*			
	(0.4091)			
$DEFD_{it}(R\&D/K)_{it}$		-12.94138*		
		(0.3291)		
$DLI_{it}(R\&D/K)_{it}$			-11.4951*	
			(0.1048)	
$DCI_{it}(R\&D/K)_{it}$				-7.9051*
				(0.1067)
t	40.20	27.17	58.75	77.92
z_1	1085.88 (3)	10727.40 (3)	13995.65 (3)	14246.17 (3)
z_2	130.48 (16)	492.27 (16)	193.13 (16)	474.54 (16)
z_3	306.59 (8)	125.92 (8)	50.53 (8)	105.69 (8)
m_1	-3.10	-2.55	-2.03	-2.42
m_2	-0.95	0.75	0.27	0.20
Hansen	174.06 (139)	101.88 (139)	105.51 (139)	108.56 (139)

Notes: The regressions are performed by using the panel described in Tables II.1 to II.3. The rest of the information needed to read this table is: i) Heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) *t* is the t-statistic for the linear restriction test under the null hypothesis $H_0{:}\beta_2+\alpha_1=0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; vii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; viii) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, degrees of freedom in parentheses.

Since Rajan and Zingales (1998), the dependence on external financing has played an important role in the recent development of economic theory. We also provide interesting results on how the dependence on external financing affects the market valuation of R&D spending. Column 2 of Table II.7 shows that the R&D coefficient is lower for firms with higher external finance dependence ($\beta_1+\alpha_1$=22.4936 – 12.9414=9.5522, which is statistically significant, see t value) than for those with lower external finance dependence (β_1=22.4936). This result supports our Hypothesis 6, and confirms that firms with higher dependence on external financing face an important handicap in undertaking R&D projects. In fact, the higher information asymmetry associated with this kind of project substantially increases the cost of external financing. As a result, part of the supra-normal profits yielded by the R&D projects are spent on paying the premium of external financing faced by firms highly dependent on external financing and, consequently, the market reaction to R&D spending is lower than for the remaining firms.

We now move on to the analysis of the effect of labour intensity on the relationship between firm value and R&D spending. As shown in Column 3 of Table II.7, the R&D coefficient is lower for labour intensive firms ($\beta_1+\alpha_1$=19.2024 – 7.9051=11.2973, which is statistically significant, see t value) than for the remaining firms (β_1=19.2024). Consequently, in agreement with Hypothesis 7, the market valuation of R&D spending is lower for labour intensive firms, since the supra-normal profits from R&D projects are diluted among employees.

Finally, we also provide results on how capital intensity affects the market valuation of R&D spending. Specifically, column 4 of Table II.7 reveals that the R&D coefficient is lower for capital intensive firms ($\beta_1+\alpha_1$=23.2176 – 11.4951=11.7225, statistically significant, see t value) than for the remaining firms (β_1=23.2176). This evidence supports our last hypothesis, and shows that capital intensive firms face greater financial constraints and, as a result, the market valuation of their R&D projects is lower.

II.3.2. Results from the extended model

Green et al. (1996) derive a valuation model for R&D also based on the residual income. Apart from other differences in the derivation process, they include some control variables. Therefore, we extend on our basic model by means of two control variables as a robustness check for our results. Specifically, we enter into the model market share and long term debt as control variables[13]. Consequently, our extended model would be as follows:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + \beta_2 \frac{RD_{it}}{K_{it}} + \beta_3 MS_{it} + \beta_4 \frac{LTB_{it}}{K_{it}} + e_{it} \qquad (17)$$

The results for this extended model, also accounting for the interactions described in Section II.2, are presented in Tables II.8 and II.9.

[13]The first variable is defined as a firm's sales over the sales of its industry, while the second variable is the long term debt scaled by replacement value of total assets (see Appendix for details).

Table II.8

Results of the extended model (I)

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	10.0110*	9.8028*	9.9920*	11.6941*
	(0.1206)	(0.3687)	(0.2840)	(0.2529)
$(R\&D/K)_{it}$	14.7337*	7.2297*	11.9983*	22.9706*
	(0.1894)	(0.4693)	(0.2829)	(0.2541)
MS_{it}	1.4050	-3.2543	-2.5640	2.3925
	(1.9730)	(4.4929)	(5.3124)	(3.7596)
$(LTD_{it}/K)_{it}$	1.5270*	4.0269*	3.9690*	2.1794*
	(0.1775)	(0.4407)	(0.4462)	(0.3318)
$DS_{it}(R\&D/K)_{it}$		15.7089*		
		(0.2849)		
$DGR_{it}(R\&D/K)_{it}$			11.4697*	
			(0.1363)	
$DFCF_{it}(R\&D/K)_{it}$				-16.7261*
				(0.1192)
t		61.02	108.61	21.18
z_1	3525.52 (4)	3001.95 (5)	9091.80 (5)	9617.32 (5)
z_2	501.14 (16)	373.53 (16)	281.75 (16)	224.94 (16)
z_3	202.39 (8)	115.04 (8)	94.25 (8)	39.82 (8)
z_4	38.21 (2)	44.50 (2)	40.47 (2)	24.62 (2)
m_1	-2.99	-1.90	-3.01	-2.29
m_2	-0.90	0.61	-0.65	0.96
Hansen	216.39 (208)	99.88 (208)	102.44 (208)	99.76 (208)

Notes: The regressions are performed by using the panel described in Tables II.1 to II.3. The rest of the information needed to read this table is: i) Heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) *t* is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_2+\alpha_1=0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship degrees of freedom in parentheses; vii) z_4 is a Wald test of the joint significance of the control variables, asymptotically distributed as χ^2 under the null of no relationship degrees of freedom in parentheses; viii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; ix) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, degrees of freedom in parentheses.

Table II.9

Results of the extended model (II)

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	9.5559*	7.5429*	8.9114*	9.0097*
	(0.6504)	(0.2939)	(0.2616)	(4.2329)
$(R\&D/K)_{it}$	12.7598*	21.9724*	20.3908*	22.3864*
	(0.1346)	(0.2346)	(0.2415)	(0.2726)
MS_{it}	0.2939	0.7860	-7.3866	-3.7571
	(0.6406)	(4.0164)	(4.0267)	(4.2329)
$(LTD_{it}/K)_{it}$	2.1563*	4.2457*	4.3628*	2.3187*
	(0.9785)	(0.4693)	(0.3570)	(0.3287)
$DMS_{it}(R\&D/K)_{it}$	9.4015*			
	(0.1333)			
$DEFD_{it}(R\&D/K)_{it}$		-10.5011*		
		(0.3846)		
$DLI_{it}(R\&D/K)_{it}$			-10.7438*	
			(0.1397)	
$DCI_{it}(R\&D/K)_{it}$				-10.1333*
				(0.1826)
t	99.05	29.76	37.10	39.71
z_1	4625.05 (5)	4214.38 (5)	7641.76 (5)	5021.96 (5)
z_2	4235.45 (16)	341.38 (16)	245.02 (16)	103.88 (16)
z_3	1884.85 (8)	82.82 (8)	121.54 (8)	84.67 (8)
z_4	243.67 (2)	41.32 (2)	81.90 (2)	24.89 (2)
m_1	-2.95	-2.27	-1.82	-2.23
m_2	-0.94	0.68	0.20	0.22
Hansen	252.72 (208)	102.49 (208)	97.44 (208)	105.85 (208)

Notes: The regressions are performed by using the panel described in Tables II.1 to II.3. The rest of the information needed to read this table is: i) Heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) t is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_2+\alpha_1=0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; vii) z_4 is a Wald test of the joint significance of the control variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; viii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; ix) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, degrees of freedom in parentheses.

The main characteristic of these results is that they are in total agreement with those for the basic model discussed in the previous section. Specifically, the coefficients for residual income and R&D variables always show the expected positive sign. In addition, the role played by firm characteristics in moderating the relationship between firm value and R&D spending is exactly the same as that found in the basic model. Overall, this evidence provides an excellent robustness check of our results.

Furthermore, the two control variables also shed light on the role played by certain firm characteristics[14]. The coefficient of the long term debt variable is always positive, revealing the benefits resulting from the fact that interest payments are tax deductible, while the coefficient of the market share variable is not significant. Consequently, this result strongly supports our approach in explaining the role of certain firm characteristics in that some of them (such as market share), despite not being significant in explaining value, play an important role in moderating the relationship between firm value and R&D spending.

II.3.3. Alternative Measure of Dependent Variable

We also intended to provide a comparison of our results regarding the value relevance of the R&D investment to those reported in earlier studies. With this purpose in mind, we have re-estimated all our models by using an alternative dependent variable that allows us a direct comparison with previous evidence on the effect of R&D on firm valuation. Specifically, we have constructed an alternative dependent variable following Lie (2001) and Chang et al. (2006), the market-to-book ratio. This variable is computed as $MB_{it}= (TA_{it}+V_{it}-BV_{it})/TA_{it}$, where TA_{it} is the book value of total assets, V_{it} is the market value of equity and BV_{it} is the book value of common equity. The results of the re-estimation of our models using this alternative dependent variable are provided in Tables II.10 and II.11. Confirming the results of prior studies that use this measure (see, for example, Bae and Kim, 2003), we find that the market positively assesses R&D investment.

[14] The Wald test of the joint significance of the control variables provides positive results (see z_4 in Tables II.8 and II.9).

Table II.10

Using Market-to-book ratio as dependent variable (I)

The regressions are performed by using the panel described in Tables I-III. The market-to-book ratio as measured by $MB_{it}= (TA_{it}+V_{it}-BV_{it})/TA_{it}$, where TA_{it} is the book value of total assets, V_{it} is the market value of equity and BV_{it} is the book value of common equity. The rest of the information needed to read this table is as follows: i) heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) t is the t-statistic for the linear restriction test under the null hypothesis H_0: $\beta_2+\alpha_1 = 0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; viii) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, with degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	8.5711*	11.6086*	8.8507*	12.5011*
	(0.1852)	(0.2283)	(0.1978)	(0.1386)
$(R\&D/K)_{it}$	22.2913*	5.8411*	12.4670*	24.1447*
	(0.2269)	(0.4558)	(0.2728)	(0.2170)
$DS_{it}(R\&D/K)_{it}$		17.1546*		
		(0.3626)		
$DGR_{it}(R\&D/K)_{it}$			13.7870*	
			(0.2031)	
$DFCF_{it}(R\&D/K)_{it}$				-18.8499*
				(0.1479)
t	140.12	129.95	95.47	21.88
z_1	9851.23 (2)	7094.60 (3)	4964.44 (3)	16133.40 (3)
z_2	512.93 (15)	598.45 (16)	311.50 (15)	967.48 (15)
z_3	108.74 (5)	60.63 (5)	41.94 (5)	89.10 (5)
m_1	-1.96	-2.28	-3.21	-2.40
m_2	0.34	0.49	-1.17	0.95
Hansen	98.31 (105)	102.99 (139)	100.96 (139)	102.24 (139)

Table II.11

Using Market-to-book ratio as dependent variable (II)

The regressions are performed by using the panel described in Tables I-III. The market-to-book ratio as measured by $MB_{it}= (TA_{it}+V_{it}-BV_{it})/TA_{it}$, where TA_{it} is the book value of total assets, V_{it} is the market value of equity and BV_{it} is the book value of common equity. The rest of the information needed to read this table is as follows: i) heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) t is the t-statistic for the linear restriction test under the null hypothesis H_0: $\beta_2+\alpha_1 = 0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; viii) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, with degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	9.1190* (0.2202)	6.5839* (0.26043)	9.2353* (0.1772)	9.2221* (0.2012)
$(R\&D/K)_{it}$	11.8197* (0.3332)	24.05622* (0.3184)	20.8207* (0.2471)	24.3732* (0.2318)
$DMS_{it}(R\&D/K)_{it}$	9.7531* (0.4467)			
$DEFD_{it}(R\&D/K)_{it}$		-14.94205* (0.5191)		
$DLI_{it}(R\&D/K)_{it}$			-11.1941* (0.2337)	
$DCI_{it}(R\&D/K)_{it}$				-11.6714* (0.1895)
t	33.91	20.13	24.82	57.67
z_1	671.11(3)	4639.94(3)	8691.84(3)	6528.57 (3)
z_2	98.67(16)	236.93(15)	573.62(15)	319.81 (16)
z_3	142.23(5)	68.12(5)	58.00 (5)	40.87 (5)
m_1	-2.78	-2.48	-2.00	-2.33
m_2	-1.05	0.58	-0.28	0.11
Hansen	182.(161)	101.07(139)	105.46(139)	103.94 (139)

As we have already pointed out, this positive relationship is the starting point to test our hypotheses. As shown in Tables II.10 and II.11, the re-estimation of our models totally confirms our previous evidence. That is, there is a strong link between some firm characteristics and the market reaction to R&D efforts. Again, firm size, growth and market share advantages make R&D valuation greater. On the contrary, free cash flow, labor and capital intensity, and dependence on external financing negatively influence the market response to R&D spending.

Finally, we also check our previous results by using the market value of common equity (V_{it}) as the dependent variable (see, for instance, Chauvin and Hirschey, 1993). Once again, the results confirm the positive relationship between a firm's R&D spending and its market value found in previous research, as shown in Tables II.12 and II.13.

Table II.12

Market value of equity as dependent variable (I)

The regressions are performed by using the panel described in Tables I-III. The rest of the information needed to read this table is as follows: i) heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) t is the t-statistic for the linear restriction test under the null hypothesis H_0: $\beta_2+\alpha_1 = 0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vii) m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; viii) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, with degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	10.03514*	11.69*	9.8406*	12.5552*
	(0.18038)	(0.1916)	(0.2370)	(0.1564)
$(R\&D/K)_{it}$	21.27845*	7.708*	12.2031*	22.8030*
	(0.1777)	(0.3628)	(0.1596)	(0.1257)
$DS_{it}(R\&D/K)_{it}$		14.4256*		
		(0.2881)		
$DGR_{it}(R\&D/K)_{it}$			13.8253*	
			(0.1266)	
$DFCF_{it}(R\&D/K)_{it}$				-16.1966*
				(0.08935)
t	165.48	133.32	145.57	39.72
z_1	14481.58(2)	16914.47(3)	9361.31 (3)	27361.14(3)
z_2	1899.50(15)	348.27 (15)	670.25 (15)	608.57(15)
z_3	100.71 (2)	67.42 (2)	47.92 (2)	125.60(5)
m_1	-2.08	-2.25	-3.30	-2.43
m_2	0.52	0.57	-0.93	0.95
Hansen	104.99(105)	103.72(139)	105.02 (139)	102.94 (139)

Table II.13

Market value of equity as dependent variable (II)

The regressions are performed by using the panel described in Tables I-III. The rest of the information needed to read this table is as follows: i) heteroskedasticity consistent asymptotic standard error in parentheses; ii) * indicates significance at the 1% level; iii) *t* is the t-statistic for the linear restriction test under the null hypothesis H_0: $\beta_2+\alpha_1 = 0$; iv) z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; v) z_2 is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vi) z_3 is a Wald test of the joint significance of the country dummy variables, asymptotically distributed as χ^2 under the null of no relationship, with degrees of freedom in parentheses; vii) m_i is a serial correlation test of order *i* using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation; viii) Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of no relationship between the instruments and the error term, with degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)
$(RI/K)_{it}$	9.9195* (0.1925)	7.8866* (0.2093)	10.0549* (0.1524)	9.9043* (0.1721)
$(R\&D/K)_{it}$	12.2004* (0.2853)	23.0906* (0.2760)	19.5891* (0.1505)	23.4113* (0.1512)
$DMS_{it}(R\&D/K)_{it}$	8.9445* (0.4078)			
$DEFD_{it}(R\&D/K)_{it}$		-13.6156* (0.3286)		
$DLI_{it}(R\&D/K)_{it}$			-8.6364* (0.2091)	
$DCI_{it}(R\&D/K)_{it}$				-11.4304* (0.1165)
t	37.66	24.19	41.31	74.5464
z_1	1073.08 (3)	6938.00 (3)	15788.38 (3)	13830.93 (3)
z_2	129.34 (16)	334.00 (15)	240.21 (15)	617.44 (15)
z_3	220.36 (5)	160.66 (5)	50.48 (5)	137.19 (5)
m_1	-3.00	-2.53	-2.03	-2.44
m_2	-0.96	0.74	0.23	0.19
Hansen	190.52(161)	99.23(139)	103.39(139)	107.85 (139)

Furthermore, this last test corroborates that several firm characteristics (namely, size, firm growth and market share) positively affect this relation, while others (specifically, free cash flow, dependence on external finance, labor intensity and capital intensity) exert a negative effect, as can be seen in Tables II.12 and II.13.

II.4. Conclusions

This work focuses on how firm characteristics moderate the relationship between firm value and R&D spending. Taking the capital market arbitrage condition as our starting point, we derive a valuation model in which firm value depends on residual income and R&D spending. By using this model we interact several firm characteristics with R&D in order to investigate the role played by these characteristics in the market valuation of R&D spending.

Our results reveal a positive relationship between firm value and R&D spending. Furthermore, this relation is moderated by several firm characteristics. Particularly, size increases the market valuation of a firm's R&D spending, since size provides economies of scale, easier access to capital markets and R&D cost spreading. Firm growth also positively affects the relationship between firm value and R&D spending because firms with a high rate of growth make the most of their supra-normal profits arising from the R&D projects. On the other hand, free cash flow has a negative effect on the abovementioned relation in that firms with high free cash flow could be tempted to use the free cash flow to undertake negative net present value R&D projects. Regarding market share, we find a positive effect on the relationship between firm value and R&D spending, rather than on firm value, which means that the supra-normal profits are highly dependent on the amount of R&D spending. The dependence on external financing is a handicap negatively assessed by the market when firms undertake R&D projects, due to the higher information asymmetry associated with this kind of project. Labour intensity also has a negative effect on the market valuation of R&D spending, since the supra-normal profits from R&D projects are diluted among employees. There is also a negative effect of capital intensity on the relationship between firm value and R&D spending because of the greater financial constraints faced by capital intensive firms.

Finally, this study provides interesting ideas to be taken into account when making decisions at the firm level and in order to attain more effective R&D spending, in that the R&D intensity strongly depends on the characteristics of the firm. Apart from the effect of the financial environment, there are several firm characteristics that also moderate the market valuation of R&D spending. Therefore, the financial environment should be taken into account by the policy decision maker, whereas firm characteristics should be accounted for by shareholders and managers. In doing so, both types of decision makers would substantially increase the effectiveness of R&D spending, which would benefit the whole society.

CHAPTER III

THE IMPACT OF CORPORATE GOVERNANCE ON RESEARCH AND DEVELOPMENT: A CASH FLOW SENSITIVITY ANALYSIS

Introduction

Over fifty years ago, Solow (1956) argued that technological change had a positive impact on economic growth. Since then, policy-makers have paid attention to research and development (R&D) and focused efforts on providing an economic environment to encourage R&D. King and Levine (1993), La Porta, Lopez-de-Silanes, Shleifer and Vishny (1997, 1998), Rajan and Zingales (1998), Beck, Levine and Loayza (2000), Beck and Levine (2002), and Demirgüç-Kunt and Maksimovic (2002) have shown that macro factors, such as legal and financial development, positively impact upon economic growth. Given that economic, financial and regulatory development are essentially exogenous inputs to corporate decision-making, it is of interest to examine the extent to which these factors facilitate R&D.

Until now, the R&D literature has focused on two main areas. The first investigates the important role played by R&D on the market value of firms (see Doukas and Switzer, 1992; Chauvin and Hirschey, 1993; Szewczyk, Tsetsekos and Zantout, 1996; Chen and Ho, 1997; Chan, Lakonishok and Sougiannis, 2001; Bae and Kim, 2003; Eberhart, Maxwell and Siddique, 2004; Cannolly and Hirschey, 2005). The second investigates the main determinants of R&D spending, such as cash flow, debt, size and industry classification (see Galende and Suárez, 1999; Cumming and Macintosh, 2000; Lee and Sung, 2005).

Surprisingly, there is very little work that investigates the effect of corporate governance on R&D. Beck and Levine (2002) find that firms with a strong dependence on external financing grow faster in countries with higher levels of financial development and more efficient legal systems. Booth, Junttila, Kallunki, Rahiala and Sahlström (2006) analyse how the financial environment influences the stock market valuation of R&D spending. Their results support the notion that the relative size of equity and private loan markets influence the way in which R&D is valued; the greater the portion of equity financing, the higher the market valuation of R&D spending. Lee and O'Neill (2003) analyze the relationship between ownership structure and R&D in US and Japanese firms and provide evidence that stock concentration is positively related to the level of R&D investment in the US, while there is no relationship in Japan.

The aim of this study is to analyse how firm and country level corporate governance structures facilitate R&D investment. Since the most influential determinant of R&D is cash flow (Hall 1992; Himmelberg and Petersen 1994; Bloch 2005), it is also necessary to study the impact of these factors on the R&D-cash flow relationship. There is a considerable body of research that examines the sensitivity of tangible investment to cash flow (Fazzari, Hubbard and Petersen, 1988; Whited, 1992; Bond and Meghir, 1994; Whited, 1998; Love, 2003; Allayannis and Mozumdar, 2004; Almeida and Weisbach, 2004; Agca and Mozumdar, 2008). The main hypothesis is that, in the presence of market imperfections, external funds may not provide a perfect substitute for internal funds, given that the premium for external financing faced by firms will be higher.

Because market imperfections, such as agency problems and asymmetric information, give rise to a premium for external finance (Islam and Mozumdar, 2007), R&D is likely to incur a higher premium since the activity is characterized by opaque information flows and private managerial knowledge. Consequently, we investigate which corporate governance factors lessen the sensitivity of R&D to cash flow because of their effect on transparency and accountability within the business environment. Following Mallin, Pindado and de la Torre (2006), we consider a broad definition of corporate governance that incorporates legal and financial characteristics in addition to other control mechanisms. This definition of corporate governance is consistent with the Organization for Economic Cooperation and Development (OECD) principles on corporate governance.

Our study makes a significant contribution to the literature in at least three ways. First, we offer additional evidence on the determinants of R&D investment in a cross-country analysis. There is considerable work on the determinants of R&D (see above). However, this tends to be based on just one country. Our research is able to differentiate between institutional, regulatory and legal systems, which is impossible when examining only one country alone.

Second, our analysis pays especial attention to the specificity of R&D investment in that the level of R&D is strongly linked to the strategy of the firm (that is, how the firm competes in the market, the propensity to innovate, and other unobservable characteristics). Panel data allows us to incorporate this unobservable heterogeneity into the analysis through the incorporation of individual firm characteristics in the cross-country sample.

Third, we present evidence for the first time on how corporate governance affects R&D investment and its sensitivity to cash flow. The objective of corporate governance is to introduce efficiency in resource allocation. This will clearly have an impact on the quality of information flowing from a firm, which should, in turn, result in a reduction in information asymmetries and agency costs. Consequently, our research is useful in characterizing the appropriate corporate governance systems in countries to promote and facilitate R&D and, consequently, encourage faster economic growth.

Our results reveal that the sensitivity of R&D to cash flow is moderated by corporate governance. First, R&D undertaken by firms operating in common law countries is less sensitive to cash flow fluctuations, suggesting that common law systems are more effective in mitigating asymmetric information than civil law.[15] We also report that a high level of

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[15] This has also been found in Demirgüç-Kunt and Maksimovic (1998).

minority shareholder protection and better law enforcement substantially lessens the sensitivity of R&D to cash flow. This result is consistent with La Porta et al. (1998) and Wurgler (2000) who show that strong minority shareholder rights are crucial for efficient capital allocation, suggesting in turn that strong legal protection contributes to a reduction in agency costs.

Second, we present evidence on the important role played by financial system development on the sensitivity of R&D to cash flow. Bank-based financial systems play a better role in reducing the sensitivity of R&D investment to cash flow than market-based systems. There are several explanations, such that in a market-based system, myopic investor objectives may lead managers to prefer short-term investment in order to maintain short-term earnings growth. In addition, the internal information channel between firms and banks in bank-based environments will reduce the asymmetric information problems that are more prevalent in market-based systems.

Third, managerial control mechanisms lessen the sensitivity of R&D to the fluctuation of cash flow. Firms with effective boards and countries with a stronger market for corporate control undertake R&D, which is less dependent on cash flow fluctuations. Finally, we study how the combination of firm and country-level corporate governance influences R&D and, overwhelmingly, our results suggest that strong corporate governance facilitates the development of R&D.

The remainder of this chapter is structured as follows. In the next section, we develop our model and explain the theoretical arguments to support the selection of the explanatory variables. We then go on to describe the corporate governance features considered in the analysis, and review the theoretical arguments behind our central hypotheses, in Section III.2. Next, in Section III.3, we describe the data and estimation methodology, and report the empirical results in Section III.4. Finally, in Section III.5, we conclude with a discussion of the main findings and a summary of the study.

III.1. EMPIRICAL MODEL

In this section we justify our explanatory variables on the basis of prior empirical research and theoretical reasoning. Each variable is taken in turn, beginning with the most important - cash flow. Available internal financial resources are necessary for R&D investment and cash flow is particularly significant in this regard. Asymmetric information is considerably larger for R&D than that associated with tangible fixed investments, and consequently, the cost of external funds to finance R&D activities will necessarily be higher. Domadenik, Prasnikar and Svejnar (2008) report a positive elasticity of R&D investment related to internal funds, whereas long-run elasticity is insignificant in the case of tangible assets. They propose that greater information and moral hazard issues associated with R&D projects are a possible explanation for their findings. This is consistent with Cleary, Povel and Raith, (2007), who provide theoretical support for the direct relationship between investment-cash flow sensitivity and asymmetric information. Firms with high levels of cash flow are also more strongly motivated to undertake R&D investment, and thus the expected relationship between cash flow and R&D investment is a direct one (Ascioglu, Hegde and McDermott, 2008).

The next variable to be considered is long-term debt. According to Modigliani and Miller (1958), in a perfect capital market, capital structure does not influence corporate investment decisions. Hall (1992) argues that this independence may not be realistic due to several factors that affect the decision to undertake investment: i) the costs of external funds may be higher than internal sources due to information reasons; ii) the cost of capital may differ across financial resources for tax reasons; and iii) the cost of capital varies across types of investment. Therefore, external capital does not provide a perfect substitute for internal funds and these market imperfections encourage firms to finance R&D projects through internal resources. Islam and Mozumdar (2007) find that corporate investments are positively related to internal cash, supporting the assumption that internal and external funds are not perfect substitutes. Moreover, the probability of bankruptcy forces firms to rely on their own retained earnings to finance innovations (see Blundell, Griffith and Reenen, 1999). Accordingly, we expect a negative impact of debt on R&D investment.

Following Lev and Sougiannis (1996), and recognizing that strong returns on R&D would encourage/incentivize future R&D investment, we use lagged values of R&D to explain current R&D expenditure. Dunlap-Hinkler, Kotabe, Mishra and Parente (2007) also measure R&D resources by using the lag of R&D spending. Other control variables we consider are firm size, market share, tangible assets, and dividends.

Since Schumpeter (1961), scholars have studied the relationship between R&D and firm size. Some research suggests a linear and positive relationship; whereas others suggest that R&D and firm size are independent (see, for example, Lee and Sung, 2005). Blundell et al. (1999) investigate the relationship between innovation and market share, and find that firms with high market share innovate more. Given that the R&D process is a wellspring of innovation (see Booth et al., 2006), market share is considered as a control variable in our analysis.

There is evidence suggesting that firms with a high level of investment in physical capital face more financial constraints (Aghion, Bond, Klemm and Marinescu, 2004; Hsiao and Tahmiscioglu, 1997; Fazzari et al. 1988), and that this affects their ability to invest in R&D. In this sense, we expect a negative relationship between tangible assets and R&D. Finally, we also expect an inverse relation between dividends and R&D since firms that pay more dividends may invest less in R&D (Fama and French, 2001).

To incorporate the unobservable heterogeneity across firms in our analysis, we incorporate these specificities through individual effects (η_i) in a panel data specification.

Consequently, the core explanatory model is:

$$\left(\frac{RD}{K}\right)_{it} = \beta_0 + \beta_1\left(\frac{RD}{K}\right)_{i,t-1} + \beta_2\left(\frac{CF}{K}\right)_{i\,t-1} + \beta_3\left(\frac{LDT}{K}\right)_{i,t-1} + \beta_4\left(\frac{TANG}{K}\right)_{i,t-1} + \\ + \beta_5\left(\frac{DIV}{K}\right)_{i,t-1} + \beta_6 S_{i,t-1} + \beta_7 MS_{i,t-1} + \eta_i + \varepsilon_{it} \quad (18)$$

where *RD, CF, LDT, TANG, DIV, S* and *MS* denote research and development, cash flow, long-term debt, tangible fixed assets, dividends, size and market share, respectively.[16]

III.2. HYPOTHESES

In this section, we rely on previous literature to derive our hypotheses about the role of country level corporate governance structures in facilitating research and development. It is worth noting that, following Mallin, Pindado and de la Torre (2006), we consider a wider definition of corporate governance that incorporates the characteristics of legal and financial systems, ownership structure, boards of directors, and the market for corporate control. This definition of corporate governance is also consistent with the Organization for Economic Cooperation and Development (OECD) Principles on Corporate Governance (2004).

III.2.1. Investor Protection

Since the seminal work of La Porta et al. (1997, 1998) on legal development and quality of enforcement across countries, scholars have investigated the efficiency of legal systems for corporate finance (Bianco, Jappelli and Pagano, 2005; La Porta et al., 1999, 2000, 2002; La Porta, Lopez-de-Silanes and Shleifer, 2006). La Porta et al. (1997, 1998) compare common and civil law systems and report significant variation in the level of investor protection and regulatory enforcement across countries. Common law countries protect investors better than civil law countries, which results in differences in the level of economic development and debt and equity market liquidity. Moreover, these cross-country differences affect firm-level investment decisions and investor willingness to provide external financing (La Porta et al., 1998; Demirgüç-Kunt and Maksimovic, 1998). As a result, there is likely to

[16] The subscript *i* refers to the company and *t* refers to the time period. ε_{it} is the random disturbance. The variables have been scaled by the replacement value of total assets to avoid heteroskedasticity problems.

be more firm-level investment in countries with strong investor protection combined with a lower cost of external funding.

The availability of low-cost funding is essential to R&D, considering that the extent of asymmetric information associated with R&D projects is much greater than that associated with tangible assets (Aboody and Lev, 2000). According to Demirgüç-Kunt and Maksimovic (1998), differences across international legal systems affect the magnitude of market imperfections caused by agency problems, and information asymmetries between insiders and investors. Consequently, if the legal system is able to mitigate their effect, strong investor protection would facilitate investment in R&D. Consequently, common law systems are expected to reduce the sensitivity of R&D to fluctuations in cash flow.

Hypothesis 1a. Firms belonging to common law countries will exhibit a lower sensitivity of R&D to cash flow than firms in civil law countries.

To test this hypothesis, we extend the basic model, Equation (18), by interacting cash flow with a dummy variable that distinguishes between common and civil law countries.

$$\left(\frac{RD}{K}\right)_{it} = \beta_0 + \beta_1\left(\frac{RD}{K}\right)_{i,t-1} + (\beta_2 + \alpha_1 DCL)\left(\frac{CF}{K}\right)_{i,t-1} + \beta_3\left(\frac{LDT}{K}\right)_{i,t-1} + \beta_4\left(\frac{TANG}{K}\right)_{i,t-1} + \beta_5\left(\frac{DIV}{K}\right)_{i,t-1} + \beta_6 S_{i,t-1} + \beta_7 MS_{i,t-1} + \eta_i + \varepsilon_{it} \quad (19)$$

where DCL_{it} is a dummy variable equal to 1 if the firm belongs to a common law country, and 0 if the firm belongs to a civil law country. This classification is made following La Porta et al. (1997, 1998). With this model, the coefficient of cash flow under civil law is β_2 (since DCL_{it} takes value zero); whereas $\beta_2+\alpha_1$ is the coefficient for common law (since DCL_{it} takes value one). In this last case, if both parameters are significant, a linear restriction test is needed in order to determine whether their sum ($\beta_2+\alpha_1$) is significantly different from zero.

One of the most important characteristics of a legal system that could affect R&D is the protection of minority shareholders. Weak legal protection of minority shareholders may increase the probability that corporate insiders undertake investment that does not maximize value, given that the minority shareholder rights are positively related to better capital allocation (La Porta et al., 1998; Wurgler, 2000). In addition, in an environment with poor minority shareholder rights, markets may respond negatively to R&D (Hall and Oriani, 2006). In this work, we extend previous research by investigating whether strong minority shareholder protection reduces the sensitivity of R&D to cash flow. In this vein, our next hypothesis is:

*Hypothesis 1b***.** *The protection of minority shareholder rights mitigates the sensitivity of R&D to cash flow.*

La Porta et al. (1997, 1998) compute an index to proxy for the level of minority shareholder rights, which they term "Antidirector Rights". The index is constructed by combining six indices (whether a proxy vote by mail is allowed, shares are not blocked before the annual general meeting, cumulative voting or proportional representation exists, oppressed minorities mechanisms exist, pre-emptive rights exist, and the minimum percentage to call an extraordinary shareholders' meeting) into an aggregate score. We use their combined index to build a dummy variable, DAR_{it}, which takes a value of 1 for firms that belong to a country with antidirector rights higher than the sample median, and 0 otherwise. Consequently, substituting the dummy variable in Equation (19) with the new dummy variable, DAR_{it}, we can test Hypothesis 1b.

To examine this issue more fully, the extent to which minority shareholder laws are enforced should also be investigated. Better law enforcement may mitigate the asymmetric information problem between insiders and outsiders, and consequently, reduce the cost of external finance. As a result, better law enforcement should lessen the sensitivity of R&D to fluctuations in cash flow, thereby encouraging investment in R&D.

Hypothesis 1c. Better law enforcement reduces the sensitivity of R&D investment to cash flow.

La Porta et al. (1998) measures law enforcement using two indices: "Efficiency of the Judicial System" and "Law and Order". "Efficiency of the Judicial System" is based on data published by Business International Corporation and "Law and Order" relates to the country law and order tradition collated from data created by International Country Risk, a country risk rating agency. We combine these two indices to build, by aggregating them, a combined law enforcement index. Consequently, to test Hypothesis 1c, we substitute the dummy variable in Equation (19) with another dummy variable, DEF_{it}, which takes a value of 1 for firms belonging to a country with high levels of law enforcement, and 0 otherwise.

Hypothesis 1d. Firms operating in countries with higher effective investor protection exhibit a lower sensitivity of R&D to cash flow.

This hypothesis can similarly be tested by substituting the dummy variable in Equation (19) with another dummy variable, DEP_{it}, which takes a value of 1 for firms belonging to a country with a high index of effective investor protection (above the median), and 0 otherwise.

III.2.2. The Financial System

Schumpeter (1911) argues that financial services are essential for technological innovation and economic development, and King and Levine (1993) report a strong correlation between different measures of financial development and growth. Several studies have examined this correlation and posed two main questions: i) Is there a relationship between financial system development and economic growth? and ii) Does financial system orientation (market-based versus bank-based) influence the cost of external financing (see, for instance, Rajan and Zingales, 1998; Beck et al., 2000; Beck and Levine, 2002; Levine, 2002; Demirgüç-Kunt and Maksimovic, 2002).

We develop this further by investigating the role played by financial systems in moderating the relationship between R&D and cash flow. Bank-based systems mitigate R&D agency costs and informational asymmetry because banks hold both equity and debt in firms and the internal information channel between firms and banks helps to reduce this asymmetry. Moreover, bank-oriented systems have advantages over their market-oriented counterparts in financing firm expansion, in promoting the establishment of new firms, and in efficiently allocating capital (see Beck and Levine, 2002). Therefore, some firms are willing to pay the premium required by banks in order to obtain continued support for their long-term growth (see, for instance, Hoskisson, Kim, Wan and Yiu, 2008).

Given that R&D projects are characterized by long-term investment and opaque information flows, we investigate whether bank-based systems are more efficient than market-based systems for financing R&D projects; and consequently, whether the orientation of the financial system reduces R&D sensitivity to cash flow. Banks also exert an important role in identifying firms with investment opportunities, acquiring information, and mobilizing capital to exploit economies of scale, which all improve the effectiveness of resource allocation (see, for instance, Diamond, 1984; Allen and Gale, 1999).

*Hypothesis 2a***.** *R&D investment is less sensitive to cash flow in bank-oriented systems than in market-oriented ones.*

We test this hypothesis by substituting the dummy variable in Equation (19) with another dummy variable, DMB_{it}, which takes a value 1 for firms operating in market-based economies, and 0 otherwise. The data is drawn from Demirgüç-Kunt and Levine (2001), who document and detail those countries that have market-based and bank-based systems.

In addition to the orientation of the financial system, we jointly consider the characteristics of bank and market systems, and build an index that more fully reflects financial system development. Beck and Levine (2002) find that external financing is more common in countries with a high degree of financial system development. Moreover, Islam and Mozumdar (2007) show that the sensitivity of corporate investments to internal cash flow is higher for firms that operate in countries with less developed financial markets. Accordingly, we predict that financial system development will mitigate the sensitivity of R&D to cash flow.

Hypothesis 2b. Financial system development reduces the sensitivity of R&D to cash flow

This hypothesis is tested by substituting the dummy variable in Equation (19) with another dummy variable, $DFSD_{it}$, which takes the value of 1 for firms belonging to a country with a high index of financial system development, and 0 otherwise. The construction of this measure of financial system development is based on indicators of banking development and market development[17].

III.2.3. Control Mechanisms

Ownership structure is perhaps the most widely studied control mechanism in corporate governance. Research provides strong evidence on the importance of ownership structure in resolving the conflict of interests between shareholders and managers (Jensen and Meckling, 1976; Shleifer and Vishny, 1986), as well as its importance in mitigating informational asymmetries, which are particularly severe for R&D investments (Leland and Pyle, 1977). In this sense, research supports the argument that ownership structure plays an important role in the development of R&D projects. For instance, Lee and O'Neill (2003) analysed the impact of ownership structure on R&D investments in the United States and Japan**.** Their findings indicate that stock concentration is positively related to the level of R&D investment in the US, but is not related to the level of R&D in Japan. They argue that this difference is based on the relative importance of agency (USA) and stewardship costs (Japan) in these environments.

[17] The index of market development is defined as the average of two measures: market capitalization to GDP and Total Value Traded to GDP; the index of banking development is the average of three variables: bank liquid liabilities, bank assets and deposit bank domestic all standardised by GDP.

Francis and Smith (1995) suggest that ownership concentration alleviates the agency cost associated with innovation, controlling for the fact that agency conflicts are encouraged by asymmetric information. Consequently, ownership concentration may play an important role in lessening the sensitivity of R&D investment to fluctuations in cash flow.

Hypothesis 3a. R&D is less sensitive to cash flow in firms with a concentrated ownership.

Following La Porta et al. (1998), we construct an index measuring Ownership Concentration[18]. Consequently, to test Hypothesis 3a, we substitute the dummy variable in Equation (19) with the dummy variable, DOC_{it}, which takes a value of 1 for firms with high levels of ownership concentration[19] and 0 otherwise.

In recent years, optimal board structures have drawn considerable attention from regulators and industry practitioners. Jensen (1993) argued that internal corporate control has its origin in the board of directors, and the literature has pointed out the important role played by the board of directors in firm decision-making (see for instance, Fama and Jensen, 1983; Jensen 1993). In this vein, the board of directors is one of the main mechanisms of governance to deal with agency conflicts between managers and shareholders.

Several empirical studies have shown that board structure is influenced by firm-specific characteristics such as industry, size, and firm age (for example Denis and Sarin, 1999; Adams and Mehran, 2003; Raheja, 2005; Boone, Field, Karpoff and Raheja, 2007). Anglo-Saxon boards may seem more efficient as a control mechanism, given the higher proportion of non-executive directors (or independent directors). From an agency perspective, an independent board is a mechanism to reduce informational opacity[20]. Additionally,

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[18] Some recent papers by Carlin and Mayer (2003) and Leuz, Nanda and Wysocki (2003) also use the same index.

[19] Higher than the median percentage of ownership by three largest shareholders in the 10 largest non financial, privately owned domestic firms.

[20] Note that reducing the informational opacity will lead to a lower investment sensitivity to cash flow, as showed by Ascioglu et al. (2008) .

resource dependence theory (Pfeffer and Salancik, 1978) suggests that firms with independent boards are better at interfacing with the external environment.

On the other hand, the effectiveness of the board as a corporate governance tool is also determined by its internal structure. With respect to internal board structure, we consider the existence of unitary and two-tier boards. The unitary board structure is prevalent in Anglo-Saxon countries (specifically USA and UK – Hopt and Leyens, 2004; Dargenidou, McLeay and Raonic, 2007), Japan (Jackson and Moerke, 2005) and European countries except for Germany, the Netherlands and Austria (De Jong, Gispert, Kabir and Renneboog, 2002; Maassen and van den Bosch, 1999) where the two-tier board structure has been adopted.

In a single-tier 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 supervisory board, which reduces the power and control of executive boards. Thus, it may be easier to replace a director with poor performance or opportunistic behaviour than in firms with a single-tier board. Accordingly, the effectiveness of the board may have a positive impact on R&D spending, given that R&D projects are higher risk and long-term in nature. Consequently, an effective board could lead managers to undertake R&D investment instead of other short-term alternatives. We define a dummy variable, DEB_{it}, to proxy for board structure and which takes the value of 1 when a country has a two-tier board structure or when non-executive directors represent a significant proportion (50% or more) on boards, and 0 otherwise.

Hypothesis 3b. Effective boards encourage R&D projects and, as a result, lessen the sensitivity of R&D to cash flow.

The market for corporate control is an external mechanism that may affect firm-level investment, given that the takeover market plays an important role in disciplining management. One of the features of a market-based financial system is the existence of active markets for corporate control (Jensen and Ruback, 1983; Franks and Mayer, 1996). In contrast, this type of activity in bank-based financial systems is limited (Berglöf and Perotti, 1994; Franks and Mayer, 1998; Höpner and Jackson, 2001). For instance, in Japan the influence of banks and the strength of cross-shareholdings, typical of *keiretsus*, represent the main structural barriers to takeovers, and in Germany, from 1945 to 1995 only three hostile takeovers took place (Franks and Mayer, 1997 and 1998).

In countries with active markets for corporate control, investors are likely to be more confident of the disciplinary power of the market in constraining managerial behavior. This would have the concomitant impact of reducing the corporate cost of capital. In addition, Jensen and Ruback (1983) have argued that a strong market for corporate control checks managerial opportunism when asymmetries are severe. In this sense, we examine whether an active market for corporate control reduces the sensitivity of R&D to cash flow. The respective dummy variable we use, $DMCC_{it}$, takes a value of 1 for firms operating in countries with an active market for corporate control[21] and, 0 otherwise.

Hypothesis 3c. R&D is less sensitive to cash flow in countries with active markets for corporate control.

We also construct a combined index of control, DCM_{it}, computed as the sum of ownership concentration, board effectiveness and market for corporate control, and we analyse its influence on moderating the relationship between cash flow and R&D. DCM_{it} takes a value of 1 for firms with a combined corporate control index above the sample median, and 0 otherwise.

Hypothesis 3d. Higher levels of corporate control reduce the sensitivity of R&D to cash flow.

III.2.4. Corporate Governance Factors

Valuable insights can be gained by analyzing the aggregate effects of corporate governance factors on the sensitivity of R&D to cash flow. There are some precedents to this.

[21] Ireland, Netherlands, UK and US. The classification coincides with the market-based countries, with the exception of Ireland.

La Porta et al. (1997, 2000) show that investor protection facilitates the development of financial systems. Kwok and Tadesse (2006) point out the substantial role played by legal systems in differentiating between financial systems across countries. In addition, Demirgüç-Kunt and Maksimovic (1998) suggest that both legal and financial systems reduce the magnitude of market imperfections caused by agency problems. Consequently, there is enough evidence to argue that the effect of corporate governance on the sensitivity of R&D to cash flow could arise from two sources. The first source could be either the legal or financial system, in that both systems could interact to further affect the sensitivity of R&D to cash flow. The second source is drawn from the internal and external control mechanisms, as explained in the previous section.

Consequently, we posit that a good corporate governance system has a mitigating impact on the sensitivity of R&D to cash flow. As a result, our last hypothesis would be as follows:

Hypothesis 4. Good corporate governance reduces the sensitivity of R&D to cash flow.

We test this hypothesis by substituting the dummy variable in Equation (19) with another dummy variable, DCG_{it}, which takes value 1 when the index of corporate governance is higher than the median, and 0 otherwise. Our corporate governance index is defined as the average of the effective investor protection index (*DEP*), the financial system development index (*DFSD*), and control mechanisms index (*DCM*).

III.3. Data and Methodology

Our initial sample consists of all listed companies in the European Union, US, and Japan that are included on the WorldScope database for the years 1990 - 2003. Data on the growth of capital goods prices, and the rate of interest on short-term and long-term debt come from the Main Economic Indicators service of the OECD.

Similar to La Porta et al. (2000), companies from Luxembourg are removed because of the very low number of listed firms. Finnish and Portuguese companies had to be dropped because of a lack of R&D data for these countries. As a result, the sample comprises of companies from eleven countries, namely Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands, US, UK and Japan. In addition, financial firms were dropped because their corporate structure is fundamentally different from the rest of the sample. Table III.1 provides the structure of the sample in terms of companies and number of observations per country. The distribution of firms used in this study mirror that of the whole sample of firms listed in each country with the US, Japan and UK making up most of the sample.

Table III.1

Breakdown of Samples by Country

This table presents a breakdown of sample companies into country of incorporation. To be included in the sample, there must be six consecutive years of financial information included R&D between 1990 and 2003. Financial firms were not included in the financial system because of the nature of their data. Financial information comes from WorldScope and economic data is taken from the OECD.

Country	*Number of companies*	*Percentage of companies*	*Number of observations*	*Percentage of observations*
Austria	14	1.09	101	1.56
Belgium	12	0.93	87	1.35
France	105	8.16	798	12.34
Germany	105	8.16	808	12.50
Greece	20	1.55	132	2.04
Ireland	32	2.49	257	3.98
Italy	43	3.34	339	5,24
Japan	350	27.19	1,400	21,65
Netherlands	26	2.02	224	3.46
UK	209	16.24	836	12,93
USA	371	28.83	1,484	22,95
Total	**1,287**	**100**	**6,466**	**100**

The data is an unbalanced panel, which comprises of 1,287 companies and 6,466 firm-year observations. An unbalanced panel was preferred to a balanced approach in order to mitigate survivorship bias problems. In our case, we used an unbalanced panel because the sample period is fairly long (14 years) and many companies delisted, merged or were acquired between 1990 and 2003. Imposing a requirement that all firms must have the same number of observations would reduce the sample to an unacceptable size and thus firms that ceased to exist were also included in the final sample.

Table III.2 presents the breakdown of the sample by economic sector. Companies are categorized according to their Compustat Economic Sector Code, a classification system pertaining to nine different industry groupings (including financial firms)[22].

[22] To avoid a huge number of dummy variables in the model, we use the most general industrial classification system.

Table III.2
Sample distribution by economic sector classification

The table presents a breakdown of the sample into industrial groups, classified using Compustat Economic Sector Codes. 1000 Materials includes all construction materials, chemicals, gasses and commodity firms. 2000 Consumer – Discretionary includes automobile manufacturers, homebuilders, hotels, casinos, retail, and electrical appliance firms. 3000 Consumer – Staples includes food and drug retail and brewers. 3500 Health Care includes health care, and pharmaceuticals. 4000 Energy includes all types of oil and gas firms. 6000 Industrials includes conglomerates, construction, aerospace and defence, heavy machinery, airlines, marine, trucking, railroads, and office services and supplies. 8000 Information Technology includes telecommunications, IT, software, electronics, and semiconductor firms. 9000 Utilities includes electric, gas, water, and shipping firms. Economic Sector Code 5000 Financial was not included in the sample research design.

Economic sector Code	Number of companies	% of companies	Number of observations	% of observations
1000 Materials	216	16.78	1,068	16.52
2000 Consumer – Discretionary	139	10.80	752	11.63
3000 Consumer – Staples	223	17.33	1120	17.32
3500 Health Care	227	17.64	1,070	16.55
4000 Energy	28	2.17	179	2.77
6000 Industrials	270	20.98	1,339	20.71
8000 Information Technology	139	10.80	723	11.18
9000 Utilities	45	3.50	215	3.32
Total	**1,287**	**100**	**6,466**	**100**

The spread of firms across industries is balanced with most companies listed within the 6000 Industrials grouping. As would be expected, the total number of firms in the 4000 Energy and 9000 Utilities industry groups is quite low with 73 companies in total, less than 6 percent of the total sample. All the industries, with the exception of financial firms, are well represented in the sample providing a strongly representative sample for testing our major hypotheses. Table III.3 provides the summary statistics (mean, standard deviation, maximum and minimum).

Table III.3
Summary Statistics for Key Variables

The table presents summary statistics for key variables in our analysis. *(RD/K)* is measured by research and development scaled by the replacement value of total assets, *(CF/K)* is cash flow scaled by the replacement value of total assets, *(LTD/K)* is long term debt scaled by replacement value of total assets, *(TANG/K)* is tangible fixed assets scaled by replacement value of total assets, *(DIV/K)* is total dividends scaled by the replacement value of total assets, *(S)* Size is the logarithm of the replacement value of the firm's assets (€000s), and *(MS)* Market Share is a firm's total sales as a proportion of sales by all other firms in its Economic Sector Code . See Appendix 1 for more detail on the definitions of these variables.

Variable	Mean	Standard deviation	Minimum	Maximum
(RD/K)	0.0331	0.0466	0.0000	0.4634
(CF/K)	0.0495	0.1032	-0.8719	0.5985
(LTD/K)	0.0656	0.0661	0.0000	0.6064
(TANG/K)	0.2522	0.1477	0.0022	0.9684
(DIV/K)	0.0110	0.0204	0.0000	0.6934
S	13.5688	2.1446	6.2095	19.8770
MS	0.0005	0.0015	< 0.0001	0.02756

Table III.4 presents the distribution of country level corporate governance variables used in the analysis. Given that the variables individually enter the empirical model as interactive variables, linear dependency is of more importance than a measure of correlation. The spread of the dummy variables is quite broad and no one variable is a linear function of any other combination of variables. This implies that the individual regressions to test each hypothesis provide incremental information.

Table III.4

Summary Statistics for Corporate Governance Factors Across Countries

The table presents summary statistics for key corporate governance variables in our analysis. *DCL* equal to 1 if a firm is domiciled in a common law country and zero otherwise. *DAR* is equal to 1 if the firm is domiciled in a country with anti-director rights above the median for the sample and zero otherwise. DEF is equal to 1 if the firm is domiciled in a country with legal enforcement stronger than the median country in the sample and zero otherwise. *DEP* is equal to 1 if the firm is domiciled in a country with investor protection stronger than the median and zero otherwise. *DMB* equal to 1 if a firm is domiciled in a market-based country and zero otherwise. *DFSD* is equal to 1 if the firm is domiciled in a country with financial system development above the median for the sample and zero otherwise. *DOC* is equal to 1 if the firm belong to a country with ownership concentration (measued by three largest shareholders in the 10 largest non financial, privately owned domestic firms) higher than the median and zero otherwise. *DEB* is equal to 1 if the firm is domiciled in a country with a two-tier board structure system or when non-executive directors represent a significant proportion (50% or more) on boards financial and zero otherwise. *DMCC* is equal to 1 if the firm is domiciled in a country with an active market for corporate control and zero otherwise. DCM_{it} takes a value of 1 for firms with a combined corporate control index (computed as the sum of ownership concentration, board effectiveness and market for corporate control) above the sample median, and 0 otherwise *DCG* takes the value of 1 when a firm has a corporate governance index value higher than the sample median, and 0 otherwise. The corporate governance index is defined as the average of the shareholder rights index *(DEP)*, the financial system development index *(DFSD)*, and ownership concentration *(DOC)*, effective board of directors (*DEB*), market for corporate control (*DMCC)*.

Country	DCL_{it}	DAR_{it}	DEF_{it}	DEP_{it}	DMB_{it}	$DFSD_{it}$	DOC_{it}	$DMCC_{it}$	DEB_{it}	DCM_{it}	DCG_{it}
Austria	0	1	1	0	0	1	1	0	1	1	1
Belgium	0	0	1	0	0	0	1	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0
Germany	0	1	0	0	0	1	1	0	1	0	0
Greece	0	0	0	0	0	0	1	0	0	0	0
Ireland	1	1	0	1	0	0	0	1	1	1	1
Italy	0	0	0	0	0	0	1	0	0	0	0
Japan	0	1	1	1	0	1	0	0	0	0	1
Netherlands	0	1	1	0	1	1	0	1	1	1	1
UK	1	1	0	1	1	1	0	1	1	1	1
USA	1	1	1	1	1	1	0	1	1	1	1
No. of zeros	3,889	1,356	3,171	2,489	3,923	1,613	4,999	3,665	2,756	3,565	2,164
% of zeros	60.15	20.97	49.03	38.49	60.66	24.95	77.31	56,68	42.62	55.12	33.47
No. of ones	2,577	5,110	3,295	3,987	2,543	4,853	1,467	2,801	3,710	2,901	4,302
% of ones	39.85	79.03	50.97	61.51	39.34	75.05	22.69	43.32	57.38	44.88	66.53

Our main econometric methodology draws on panel data techniques. All the models specified in this study have been estimated using the panel data methodology. Specifically, the estimation is carried out by the Generalized Method of Moments (GMM). Since R&D is strongly linked to the strategy of the firm, our methodology has to address the strong specificity of R&D investment. In this vein, unlike cross-sectional analysis, panel data methods allow us to control for individual heterogeneity. Therefore, to eliminate the risk of obtaining biased results, we have controlled for this heterogeneity by modelling it as an individual effect, η_i, which is then eliminated by taking first differences of the variables. Consequently, the basic specification of our model is as follows:

$$\left(\frac{RD}{K}\right)_{it} = \beta_0 + \beta_1\left(\frac{RD}{K}\right)_{i,t-1} + \beta_2\left(\frac{CF}{K}\right)_{i,t-1} + \beta_3\left(\frac{LDT}{K}\right)_{i,t-1} + \beta_4\left(\frac{TANG}{K}\right)_{i,t-1} + \beta_5\left(\frac{DIV}{K}\right)_{i,t-1} + \beta_6 S_{i,t-1} + \beta_7 MS_{i,t-1} + \eta_i + d_t + c_i + i_i + v_{it} \quad (20)$$

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 variables on R&D; c_i are country dummy variables representing country-specific effects; i_i are industry dummy variables standing for industry-specific effects, since R&D is strongly related to the kind of activity developed by the company; and finally, v_{it} is the random disturbance term.

The analysis also faces the challenge of dealing with factor endogeneity. This is likely to arise since the explanatory variables are simultaneously determined with R&D. Therefore, all models have been estimated by using instruments. To be exact, we have used each right-hand-side variable in the models lagged one to three times as instruments in the difference equations and just once in the level equations, since we use the system GMM developed by Blundell and Bond (1998).

Finally, we check for potential misspecification of the models. First, we use the Hansen *J*-statistic of over-identifying restrictions in order to test for the absence of correlation between the instruments and the error term. Second, we use the m_2 statistic, developed by Arellano and Bond (1991), in order to test for the lack of second-order serial correlation in the first-difference residuals. Third, we carry out four Wald tests for linear restrictions. These are z_1, which is a test of the joint significance of the reported coefficients; z_2 is a test of the joint significance of the time dummies; z_3 is a test of the joint significance of the country dummies; and z_4 is a test of the joint significance of industry dummies.

III.4. RESULTS

In this section, we summarize the results obtained from our base theoretical model.

We then focus on extending the model through the testable hypotheses.

III.4.1.Basic Results

Column 1 of Table III.5 presents the parameter estimates of the GMM panel data regression of R&D expenditure on our control variables. With the exception of Market Share, all the variable coefficients are statistically significant and have the expected sign. Taking each in turn, the coefficient for the lagged R&D variable is positive, indicating the time persistence of R&D expenditure. Firms with high R&D in one year are likely to continue to invest heavily in R&D in the future. Consistent with our base hypothesis, the cash flow coefficient is positively related to R&D investment. Long-term debt negatively affects R&D, consistent with earlier work by Hall (1992, 1996). Size, dividends and tangible assets are all as expected. Surprisingly, the Market Share coefficient is significant and negative. While inconsistent with our core model, a negative influence for market share has been suggested previously by Vossen (1999). Vossen (1999) shows that, especially for firms with high market share, the return from new products cannibalises sales of existing, which may lead to less innovative corporate behavior.

Table III.5
The Effect of Legal Development on Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1990 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *DCL* equal to 1 if a firm is domiciled in a common law country and zero otherwise. *DAR* is equal to 1 if the firm is domiciled in a country with anti-director rights above the median for the sample and zero otherwise. DEF is equal to 1 if the firm is domiciled in a country with legal enforcement stronger than the median country in the sample and zero otherwise. *DEP* is equal to 1 if the firm is domiciled in a country with investor protection stronger than the median and zero otherwise.

	(1)	(2)	(3)	(4)	(5)
$(CF/K)_{i,t-1}$	0.00849*	0.014286*	0.02674*	0.01488*	0.01475*
	(0.00051)	(0.00042)	(0.00068)	(0.00050)	(0.00044)
$(R\&D/K)_{i,,t-1}$	0.77764*	0.77451*	0.78476*	0.78220*	0.77388*
	(0.00131)	(0.00116)	(0.00103)	(0.00099)	(0.00116)
$(LTD/K)_{i,t-1}$	-0.01066*	-0.00855*	-0.00955*	-0.00631*	-0.00762*
	(0.0087)	(0.00050)	(0.00088)	(0.00087)	(0.00049)
$(DIV/K)_{i,t-1}$	-0.028091*	-0.02760*	-0.02742*	-0.03385*	-0.02816*
	(0.00053)	(0.00039)	(0.00039)	(0.00031)	(0.00041)
$(TAN/K)_{i,t-1}$	-0.00928*	-0.011452*	-0.01294*	-0.01233*	-0.01073*
	(0.00063)	(0.00038)	(0.00050)	(0.00055)	(0.00039)
$(SIZE)_{i,t-1}$	0.00011*	0.00009*	0.00017*	0.00018*	0.00012*
	(0.00003)	(0.00003)	(0.00004)	(0.00003)	(0.00003)
$(MS)_{i,t-1}$	- 0.55583*	-0.53445*	-0.65999*	-0.63182*	-0.54928*
	(0.04076)	(0.03723)	(0.04118)	(0.03498)	(0.03485)
$DCL_{it}\ (CF/K)_{i,t-1}$		-0.00700*			
		(0.00043)			
$DAR_{it}\ (CF/K)_{i,t-1}$			-0.01988*		
			(0.00070)		
$DEF_{it}\ (CF/K)_{i,t-1}$				-0.01027*	
				(0.00102)	
$DEP_{it}\ (CF/K)_{i,t-1}$					-0.00743*
					(0.00045)
t		26.23	5.26	16.45	26.63
z_1	57703.66 (7)	92371.40 (8)	96675.92 (8)	83707.42 (8)	93728.78 (8)
z_2	216.42 (12)	935.97 (12)	1092.59 (12)	509.08 (12)	665.48 (12)
z_3	149.77 (9)	183.18 (9)	365.96 (9)	425.62 (9)	180.68 (9)
z_4	334.81 (7)	530.49 (7)	531.56 (7)	938.70 (6)	536.04 (7)
m_1	-3.49	-3.50	-3.51	-3.52	-3.50
m_2	0.45	0.45	0.44	0.44	0.45
Hansen	361.35 (313)	382.91 (356)	378.08 (356)	374.24 (356)	378.20 (356)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. t is the t-statistic for the linear restriction test under the null hypothesis $H_0{:}\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

III.4.2.The Legal Protection of Investors

Table III.5 also shows the impact of the legal system on the sensitivity of R&D to cash flow. In Column 2, we find that the cash flow coefficient for firms belonging to common law countries ($\beta_2+\alpha_1$=0.0143-0.0070=0.0073, significantly different from zero, t=26.23) is significantly smaller than the coefficient for firms belonging to civil law countries (β_2=0.0143). This result supports Hypothesis 1a, and suggests that countries whose laws have a common origin facilitate R&D investment. This is primarily because common law environments are more effective at reducing information asymmetry than civil law countries, which consequently reduces the cost of external funds.

The smaller cash flow coefficient in Column 3 for firms belonging to countries with higher minority shareholder protection ($\beta_2+\alpha_1$=0.0267-0.0199=0.0068, t=5.26) is supportive of Hypothesis 1b. There is a negative correlation between strong protection of minority shareholders and the sensitivity of R&D to cash flow. That is, a high level of antidirector rights helps to reduce the sensitivity of R&D to cash flow. This is in agreement with La Porta et al. (1998) and Wurgler (2000) in that strong legal protection of minority shareholders is related to more efficient capital allocation.

Research and development in firms belonging to countries with better levels of law enforcement ($\beta_2+\alpha_1$=0.0149-0.0103=0.0046, t=16.45) is less sensitive than in countries with poor enforcement of laws (β_2=0.0149). Again, this is consistent with Hypothesis 1c, in that law enforcement is another way to mitigate the asymmetric information problem between insiders and outsiders. This leads to a reduction in the cost of external funds, which thereby lessens the sensitivity of R&D to cash flow.

Finally, Column 5 indicates that firms operating under more effective investor protection exhibit R&D investment which is less sensitive to cash flow ($\beta_2+\alpha_1$=0.0147-0.0074=0.0073, t=26.63) than in other countries (β_2=0.0147). This result not only supports Hypothesis 1d, but is convincing proof of the importance of legal protection in reducing the sensitivity of R&D to cash flow.

III.4.3.The Financial System

Table III.6 presents the estimation of model (19) replacing the legal dummy variable by the financial system dummy variable.

Table III.6

The Effect of the Financial System on Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1990 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *DMB* equal to 1 if a firm is domiciled in a market-based country and zero otherwise. *DFSD* is equal to 1 if the firm is domiciled in a country with financial system development above the median for the sample and zero otherwise.

	(1)	(2)
$(CF/K)_{i,t-1}$	0.00731* (0.00032)	0.01209* (0.00047)
$(R\&D/K)_{i,,t-1}$	0.78737* (0.00102)	0.78240* (0.00108)
$(LTD/K)_{i,t-1}$	-0.01142* (0.00066)	-0.01056* (0.00080)
$(DIV/K)_{i,t-1}$	-0.02855* (0.00026)	-0.02579* (0.00037)
$(TAN/K)_{i,t-1}$	-0.01251* (0.00044)	-0.00975* (0.00043)
$(SIZE)_{i,t-1}$	0.00020* (0.00002)	0.00006 (0.00003)
$(MS)_{i,t-1}$	-0.64742* (0.02989)	-0.61692* (0.03557)
$DMB_{it}\ (CF/K)_{i,t-1}$	0.00556* (0.00122)	
$DFSD_{it}\ (CF/K)_{i,t-1}$		-0.00357* (0.00067)
t	12.59	15.63
z_1	95839.25 (8)	67031.56 (8)
z_2	1073.23 (12)	573.94 (12)
z_3	441.08 (9)	598.22 (9)
z_4	679.42 (7)	775.11 (7)
m_1	-3.48	-3.50
m_2	0.45	0.44
Hansen	371.80 (356)	371.20 (356)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. t is the t-statistic for the linear restriction test under the null hypothesis $H_0{:}\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Column 1 shows that market-based financial systems increase the sensitivity of R&D expenditure to cash flow. Companies in bank-based environments have a lower sensitivity (β_2=0.0073) than firms operating in a market-based financial system ($\beta_2+\alpha_1$=0.0073+0.0056=0.0129, t=12.59). This result supports Hypothesis 2a, suggesting that bank-based financial systems mitigate asymmetric information problems associated to R&D. In market-based economies, such as the U.S. and U.K., market pressure leads managers to undertake short-term investment in order to maintain short-term earnings growth. One of the consequences of this behaviour is that R&D spending is more likely to fall in periods of constrained cash flow.

Column 2 shows that a higher level of financial system development reduces the sensitivity of R&D to cash flow. The coefficient for firms operating in countries with a high level of financial system development is lower ($\beta_2+\alpha_1$=0.0121-0.0036=0.0085, t=15.63) than for those firms belonging to countries with lower level of financial system development (β_2=0.0121). This suggests that more developed financial system improves the efficiency of capital allocation resulting in firm R&D that is less sensitive to cash flow. Hypothesis 2b is therefore supported and is consistent with the rationale that firms in countries with more developed financial systems have R&D expenditure which is less sensitive to cash flow.

III.4.4. Control Mechanisms

In this section, the impact of corporate control mechanisms on the sensitivity of research and development to cash flow is investigated. Column 1 of Table III.7 shows that firms with higher ownership concentration are less sensitive to cash flow constraints when undertaking R&D. Specifically, the coefficient is smaller for firms with concentrated ownership ($\beta_2+\alpha_1$=0.0113-0.0047=0.0066, t=20.86) than for widely held firms (β_2=0.0113). This result supports Hypothesis 3a and is consistent with the agency theory perspective proposed by Lee and O'Neill (2003).

Table III.7

The Effect of Corporate Control Mechanisms on Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1990 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *DOC* is equal to 1 if a firm has higher than the median percentage of ownership by three largest shareholders in the 10 largest non financial, privately owned domestic firms in the country and zero otherwise. DEB is equal to 1 if the firm is domiciled in a country with a two-tier board structure system or when non-executive directors represent a significant proportion (50% or more) on boards financial and zero otherwise. *DMCC* is equal to 1 if the firm is domiciled in a country with an active market for corporate control and zero otherwise. We construct a combined corporate control index computed from the sum of ownership concentration, board effectiveness and market for corporate control dummies. *DCM* takes a value of 1 for firms with a combined corporate control index above the sample median, and 0 otherwise.

	(1)	**(2)**	**(3)**	**(4)**
$(CF/K)_{i,t-1}$	0.01126*	0.02078*	0.01099*	0.01202*
	(0.00051)	(0.00062)	(0.00039)	(0.00039)
$(R\&D/K)_{i,,t-1}$	0.79120*	0.78521*	0.78236*	0.78173*
	(0.00102)	(0.00096)	(0.00092)	(0.00101)
$(LTD/K)_{i,t-1}$	-0.01249*	-0.00882*	-0.01147*	-0.01025*
	(0.00067)	(0.00085)	(0.00077)	(0.00070)
$(DIV/K)_{i,t-1}$	-0.02533*	-0.02654*	-0.02784*	-0.02694*
	(0.00045)	(0.00039)	(0.00037)	(0.00039)
$(TAN/K)_{i,t-1}$	-0.01032*	-0.01160*	-0.01213*	-0.01156*
	(0.00043)	(0.00048)	(0.00041)	(0.00053)
$(SIZE)_{i,t-1}$	0.00011*	0.00018*	0.00009	0.00004
	(0.00003)	(0.00004)	(0.00003)	(0.00003)
$(MS)_{i,t-1}$	-0.64676*	-0.67684*	-0.60361*	-0.59031*
	(0.05011)	(0.04441)	(0.04140)	(0.03563)
$DOC_{it}\ (CF/K)_{i,t-1}$	-0.00474*			
	(0.00069)			
$DEB_{it}\ (CF/K)_{i,t-1}$		-0.01387*		
		(0.00066)		
$DMCC_{it}\ (CF/K)_{i,t-1}$			-0.00157*	
			(0.00058)	
$DCM_{it}\ (CF/K)_{i,t-1}$				-0.00256*
				(0.00050)
t	20.86	16.69	20.37	23.01
z_1	1.0e+05 (8)	91686.11 (8)	1.4e+05 (8)	94651.85 (8)
z_2	758.56 (12)	463.47 (12)	547.32 (12)	636.09 (12)
z_3	300.54 (9)	370.50 (9)	192.82 (9)	253.90 (9)
z_4	647.08 (7)	926.83 (7)	459.29 (7)	634.05 (7)
m_1	-3.50	-3.51	-3.50	-3.50
m_2	0.45	0.44	0.45	0.45
Hansen	370.30 (356)	376.58 (350)	372.92 (356)	381.73 (356)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. *t* is the t-statistic for the linear restriction test under the null hypothesis $H_0: \beta_3 + \alpha = 0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Consistent with the main argument in Hypothesis 3b, the board dummy variable coefficient in Column 2 suggests that an effective board facilitates R&D investment and reduces the sensitivity of R&D to cash flow. The coefficient of the cash flow for firms with effective boards is lower ($\beta_2+\alpha_1$=0.0208-0.0139=0.0069, t=16.69) than for other firms (β_2=0.0208), highlighting the role of effective boards in corporate strategy.

Column 3 shows the effect of the market for corporate control on the sensitivity of R&D to cash flow. Countries with an active market for corporate control have a smaller coefficient ($\beta_2+\alpha_1$=0.0109-0.0016=0.0093, t=20.37) than those firms operating in other countries (β_2=0.0109). Building on Jensen (1991), who shows a positive relationship between R&D spending and merger and acquisition activity, our results imply that the fear of a takeover may restrain opportunistic and myopic managerial behaviour.

Finally, in Column 4, the coefficient for the aggregate impact of corporate control mechanisms on the sensitivity of R&D to cash flow is presented. The coefficient for the firms operating in countries with a high level of corporate control is lower ($\beta_2+\alpha_1$=0.0120-0.0026=0.0094, t=23.01) than for those firms belonging to other countries (β_2=0.0120) and, as with all other dummies in Table III.7, the difference is significant (t=-5.12). This supports Hypothesis 3d, and confirms our theory that monitoring management through several control mechanisms such as effective board structures, the market for corporate control and ownership concentration leads managers to take a longer view in their investment decisions.

III.4.5. Corporate Governance Aggregated Index

Finally, we test for the effect of corporate governance on the sensitivity of R&D to cash flow by using an aggregated index of corporate governance. As can be seen in Table III.8, the coefficient of the cash flow variable is significantly smaller for firms operating in countries with stronger corporate governance ($\beta_2+\alpha_1$=0.0122-0.0031=0.0091, t=20.09) than for those firms belonging to countries with weaker corporate governance (β_2=0.0122). Consequently, this result not only supports our Hypothesis 4, but also confirms the central hypothesis of the study.

Table III.8

The Effect of Corporate Governance on Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1990 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *DCG* takes the value of 1 when a firm has a corporate governance index value higher than the sample median, and 0 otherwise. The corporate governance index is defined as the average of the shareholder rights index *(DEP)*, the financial system development index *(DFSD)*, and control mechanisms index *(DCM)*.

Variable		**Test-Statistic**	
$(CF/K)_{i,t-1}$	0.01223* (0.00035)	**t**	20.09
$(R\&D/K)_{i,,t-1}$	0.78011* (0.00096)	**z_1**	1.0e+05 (8)
$(LTD/K)_{i,t-1}$	-0.00911* (0.00069)	**z_2**	579.96 (12)
$(DIV/K)_{i,t-1}$	-0.02799* (0.00037)	**z_3**	262.08 (9)
$(TAN/K)_{i,t-1}$	-0.01090* (0.00050)	**z_4**	622.41 (7)
$(SIZE)_{i,t-1}$	0.00009* (0.00003)	**m_1**	-3.50
$(MS)_{i,t-1}$	-0.66821* (0.03990)	**m_2**	0.44
$DCG_{it}\ (CF/K)_{i,t-1}$	-0.00314* (0.00055)	**Hansen**	373.65 (356)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. t is the t-statistic for the linear restriction test under the null hypothesis H0:$\beta_3+\alpha=0$. z1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as $\chi 2$ under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Overall, the evidence described in this section strongly indicates that corporate governance plays a key role in facilitating R&D investment, as shown in Table III.9 that presents the corporate governance index results.

Table III.9

The Effect of Corporate Governance on Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1990 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *DEP* is equal to 1 if the firm is domiciled in a country with investor protection stronger than the median and zero otherwise. *DFSD* is equal to 1 if the firm is domiciled in a country with financial system development above the median for the sample and zero otherwise. *DCM* takes a value of 1 for firms with a combined corporate control index above the sample median, and 0 otherwise. *DCG* takes the value of 1 when a firm has a corporate governance index value higher than the sample median, and 0 otherwise. The corporate governance index is defined as the average of the shareholder rights index *(DEP)*, the financial system development index *(DFSD)*, and control mechanisms index *(DCM)*. Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. *t* is the t-statistic for the linear restriction test under the null hypothesis $H_0:\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order *i* using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)
$(CF/K)_{i,t-1}$	0.01475*	0.01209*	0.01202*	0.01223*
	(0.00044)	(0.00047)	(0.00039)	(0.00035)
$(R\&D/K)_{i,,t-1}$	0.77388*	0.78240*	0.78173*	0.78011*
	(0.00116)	(0.00108)	(0.00101)	(0.00096)
$(LTD/K)_{i,t-1}$	-0.00762*	-0.01056*	-0.01025*	-0.00911*
	(0.00049)	(0.00080)	(0.00070)	(0.00069)
$(DIV/K)_{i,t-1}$	-0.02816*	-0.02579*	-0.02694*	-0.02799*
	(0.00041)	(0.00037)	(0.00039)	(0.00037)
$(TAN/K)_{i,t-1}$	-0.01073*	-0.00975*	-0.01156*	-0.01090*
	(0.00039)	(0.00043)	(0.00053)	(0.00050)
$(SIZE)_{i,t-1}$	0.00012*	0.00006	0.00004	0.00009*
	(0.00003)	(0.00003)	(0.00003)	(0.00003)
$(MS)_{i,t-1}$	-0.54928*	-0.61692*	-0.59031*	-0.66821*
	(0.03485)	(0.03557)	(0.03563)	(0.03990)
$DEP_{it}\ (CF/K)_{i,t-1}$	-0.00743*			
	(0.00045)			
$DFSD_{it}\ (CF/K)_{i,t-1}$		-0.00357*		
		(0.00067)		
$DCM_{it}\ (CF/K)_{i,t-1}$			-0.00256*	
			(0.00050)	
$DCG_{it}\ (CF/K)_{i,t-1}$				-0.00314*
				(0.00055)
t	26.63	15.63	23.01	20.09
z_1	93728.78 (8)	67031.56 (8)	94651.85 (8)	100,000 (8)
z_2	665.48 (12)	573.94 (12)	636.09 (12)	579.96 (12)
z_3	180.68 (9)	598.22 (9)	253.90 (9)	262.08 (9)
z_4	536.04 (7)	775.11 (7)	634.05 (7)	622.41 (7)
m_1	-3.50	-3.50	-3.50	-3.50
m_2	0.45	0.44	0.45	0.44
Hansen	378.20 (356)	371.20 (356)	381.73 (356)	373.65 (356)

II.5. Discussion and Comparative Analysis of Corporate Governance Factors

Until now we have shown that different corporate governance factors play an important role in explaining R&D investment. However, when a country wishes to boost its firms' R&D investment and improve its economic growth, it is of interest to know the most efficient drivers of R&D, especially in the current context of country level corporate governance.

Although the effect of each factor on R&D is computed in different regressions, we are able to use an elasticity index (EI) that allows us to compare all the factors from a homogenous base. To construct this index, we calculate the elasticities of the estimated corporate governance coefficients. Table III.10 presents the elasticities for the coefficients of each variable in the four models of Table III.9. Elasticities are computed using Equation (21).

$$h_k = b_k \frac{\overline{x_k}}{b'\overline{x}} \qquad (21)$$

where k represents each variable, 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. Unfortunately, elasticities from different models cannot be compared directly. Therefore, to perform a comparison across the different corporate governance factors, we compute an elasticity index, which measures the proportional power of each corporate governance factor, using Equation (22).

$$EI_f = \frac{h_{CF} + h_f}{\sum h} \qquad (22)$$

where h_{CF} is the elasticity of cash flow, h_f is the elasticity of the corporate governance factor, f, and $\sum h$ stands for the sum of the elasticity for the coefficients on all the explanatory variables. In this way, we capture the explanatory power of each corporate governance factor with respect to R&D investment. Furthermore, the larger the explanatory power of a factor the more this factor facilitates R&D investment.

As shown in column 3 of Table III.10, the highest explanatory power is found for the control mechanisms index (EI_{CM}=0.02489), which includes ownership concentration, board effectiveness and the market for corporate control. This is followed by investor protection, (EI_{EP}=0.02187), and then financial system development, (EI_{FSD}=0.01923). Finally, the aggregate index of corporate governance captures the combined impact of all the factors described above, and the elasticity index score is 0.02359, which is reflective of the weight of the different corporate governance factors.

According to these results, the main drivers of R&D investment at a country level are internal and external control mechanisms, followed by effective investor protection, and finally the orientation and development of the financial system.

Table III.10

Factor Elasticities

The sample is all firms in the Worldscope database with available *R&D* data between 1990 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *DEP* is equal to 1 if the firm is domiciled in a country with investor protection stronger than the median and zero otherwise. *DFSD* is equal to 1 if the firm is domiciled in a country with financial system development above the median for the sample and zero otherwise. *DCM* takes a value of 1 for firms with a corporate control mechanisms index above the sample median, and 0 otherwise. *DCG* takes the value of 1 when a firm has a corporate governance index value higher than the sample median, and 0 otherwise. The corporate governance index is defined as the average of the shareholder rights index *(DEP)*, the financial system development index *(DFSD)*, and corporate control mechanisms index (*DCM*).

	(1)	**(2)**	**(3)**	**(4)**
$(CF/K)_{i,t-1}$	0.02309	0.01891	0.01881	0.01881
$(R\&D/K)_{i,,t-1}$	0.79242	0.80076	0.80008	0.80008
$(LTD/K)_{i,t-1}$	-0.01518	-0.02101	-0.02040	-0.02040
$(DIV/K)_{i,t-1}$	-0.00960	-0.00879	-0.00918	-0.00918
$(TAN/K)_{i,t-1}$	-0.08388	-0.07618	-0.09031	-0.09031
$(SIZE)_{i,t-1}$	0.05182	0.02678	0.01755	0.01754
$(MS)_{i,t-1}$	-0.00933	-0.01047	-0.01002	-0.01002
$DEP_{it}\ (CF/K)_{i,t-1}$	-0.00519			
$DFSD_{it}\ (CF/K)_{i,t-1}$		-0.00366		
$DCM_{it}(CF/K)_{i,t-1}$			-0.0016	
$DCG_{it}\ (CF/K)_{i,t-1}$				-0.00157
EI	**0.02187**	**0.01923**	**0.02489**	**0.02359**

III.6. Conclusions

This work focuses on how corporate governance influences the efficiency of R&D investment. Taking cash flow as the main determinant of R&D expenditure, we derive an empirical model to explain the role of corporate governance in explaining the sensitivity of R&D investment to cash flow. As far as we are aware, this idea has not been addressed in prior studies.

Our results reveal that good corporate governance lessens the sensitivity of R&D to cash flow. Our evidence also provides empirical support for the importance of investor legal protection on R&D expenditure. R&D projects undertaken by firms operating in common law countries are less sensitive to cash flow fluctuations, since common law systems are more effective in the mitigation of asymmetric information than civil law societies. Specifically, strong minority shareholder protection lessens the sensitivity of R&D to cash flow; and more efficient law enforcement reduces the gap in information quality between insiders and outsiders, which consequently reduces the cost of external financing. Overall, the effectiveness of investor protection substantially reduces the sensitivity of R&D to cash flow.

With respect to the financial system, R&D investment is less dependent on cash flow constraints when firms operate in bank-based countries. The internal information channels between companies and banks help to lessen the asymmetric information problems between outside investors and the firm. In addition, in market-based systems, market pressure may lead managers to undertake myopic investment strategies in order to maintain short-term earnings growth.

Regarding control mechanisms, a high level of ownership concentration lessens R&D dependence on cash flow, suggesting that ownership plays an important role in resolving conflicts of interests between managers and shareholders. Additionally, an effective board and an active market for corporate control also facilitates R&D projects, suggesting that the fear of takeover may alleviate the opportunistic behaviour of directors and better align manager and shareholder objectives.

Overall, corporate governance exerts a positive influence on the development of R&D projects. This is an important issue for those agents that play a crucial role in setting the characteristics of a corporate governance system (mainly governments), because they are able to promote R&D projects and as a result economic growth and welfare for society.

CHAPTER IV

THE MARKET VALUATION OF RESEARCH AND DEVELOPMENT: THE MODERATING EFFECT OF CORPORATE GOVERNANCE

Introduction

A considerable number of studies has shown evidence of the positive response of a firm's market value to its research and development (R&D) investments. Some studies suggest that the magnitude of the market valuation of R&D investments depends on the firm-specific characteristics. In this sense, the second chapter of this study develops a method that accounts for the moderating role of several firm's characteristics in the relationship between R&D and its value. Their findings confirm the relevant role played by the firm's characteristics, such as size, growth, free cash flow, market share, external finance dependence, labour intensity and capital intensity, in moderating the market response to R&D investments.

However, the market valuation of R&D spending is not only affected by firm's characteristics. As shown by Booth et al. (2006), the financial environment also needs to be taken into account. Their findings suggest that a high portion of equity financing positively affects the relationship between R&D spending and a firm's market valuation. It is worth noting that a well-functioning financial system improves technological innovation by identifying and financing valuable projects (Schumpeter, 1911). Moreover, some growth models point to technological innovation as a channel through which the financial system affects economic growth (see, for example, Romer, 1990; Grossman and Helpman 1991; Aghion and Howitt, 1992).

Other corporate governance factors besides financial systems affect the magnitude of the market response to R&D investment. Some studies show evidence of the correlation between several corporate governance factors and corporate valuation. For instance, La Porta et al. (2002) find a higher Tobin's q for firms that belong to countries with common law system, than those operating in civil law countries. In addition, in accordance with La Porta et al. (2002), Alburquere and Wong (2008) predict a lower Tobin's q when the investor protection is weak. Gompers et al. (2003) find that the higher the level of shareholder rights, the higher the firm's value. These findings support the hypothesis that poor investor rights increase the conflict of interest between insiders and outsiders, since the ability of controlling shareholders to obtain private benefits is improved by inefficient investor protection.

From the agency perspective, managers could act in their benefits, seeking power, prestige, risk reduction and compensation at the cost of shareholder wealth. Several internal and external control mechanisms, namely ownership structure, board of directors and market for corporate control, can be put in place to align the interests of managers and shareholders. Jensen (1993) argues that internal corporate control has its origin in the board of directors, and the literature has pointed out the important role played by this mechanism in firms' decision-making (see for example, Fama and Jensen, 1983; Jensen 1993).

Although previous research has shown evidence of the important role played by the ownership structure to resolve the conflict of interests between shareholders and managers (Jensen and Meckling, 1976; Shleifer and Vishny, 1986), existing literature on the relationship between ownership and the value of the firm has provided competing hypotheses and conflicting evidence. In particular, for R&D investment, prior evidence regarding the importance of ownership in moderating the market valuation of R&D efforts is not unanimous. For example, Szewczyk et al. (1996) find a positive influence of institutional ownership on the market response to R&D announcements. Conversely, in Germany, France and Italy, Hall and Oriani (2006) find a negative effect of ownership concentration on the market valuation of R&D. However, Booth et al. (2006) do not find any support for ownership concentration effect.

As is well known, the primary function of the market for corporate control is to discipline management. Therefore, an active market for corporate control should enhance the firm's value by takeover threats that could lead managers to maximize its value (Brook et al., 1998).

Building upon the earlier studies that show evidence of the correlation between governance factors and corporate valuation, we develop this further by investigating the role played by several corporate governance factors in moderating the relationship between R&D and the value of the firm**.** Therefore, by considering legal protection indicators, financial system characteristics, ownership structure, board of directors and the markets for corporate control, we pose several hypotheses that allow us to analyze how these factors influence the relationship between R&D and the value of a firm.

It is worth noting that, following Mallin et al. (2006), we consider a wider definition of corporate governance that incorporates legal and financial characteristics, in addition to other control mechanisms. Note that this definition of corporate governance is in agreement with the Organization for Economic Cooperation and Development (OECD) principles on corporate governance.

Our study makes a significant contribution to the literature in at least three ways. First, by using a cross-country analysis, we offer evidence of the impact of several corporate governance factors in moderating the relationship between R&D and a firm's value.

Second, our research is able to differentiate between control mechanisms, and financial and legal systems that are not possible when examining one country alone. We are, therefore, able to provide significant insights on the importance of these factors in moderating the market response to R&D investments.

The third contribution refers, not only to the use of a robust econometric technique but also takes into account that R&D is linked to the strategy of the firm. We are able to consider this link in our study since panel data methodology allows us to incorporate the unobservable heterogeneity into the analysis through an individual effect. This captures characteristics related to the strategy of the firm, such as how it competes in the market, the propensity to innovate, and other unobservable characteristics. To control for endogeneity problems, the models have been estimated by using the Generalized Method of Moments (GMM), which embodies all the Instrumental Variable Methods.

Our results reveal that the positive relationship between the value of the firm and R&D spending is moderated by several corporate governance characteristics. Specifically, all the legal protection indices exert a positive effect. The reason is that investors lessen information asymmetry and, consequently, increase their ability to identify valuable R&D projects. A positive effect is also found for firms that are market-based, confirming the findings of Booth et al. (2006) that equity financing matters to market valuation of R&D spending. In contrast to Booth et al. (2006), our results support the financial system development hypothesis, consistent with the view that when firms are operating in countries with a higher level of financial development, they grow faster, especially when relying on external finance (Back and Levine, 2002). Regarding control mechanisms, an effective board and an active market for corporate control have a positive effect on the relationship between R&D and the firm's value. On the contrary, a high concentration of ownership negatively affects this relationship. The risk of expropriation of minority shareholders could be an explanation for this result. In this sense, in controlling for investor protection of minority shareholders, we find that firms with a high degree of ownership concentration operating in countries with a weak investor protection of minority shareholders have a lower market valuation than those ones with a high concentration of ownership belonging to countries with strong investor protection of minority shareholders.

The remainder of the chapter is organized as follows. In Section IV.1, we summarize the premise of the valuation model, which is a function of residual income and R&D spending. Section IV.2 explains the theoretical arguments behind our hypotheses. Section IV.3 describes our data set and the econometric method used to test our hypotheses. The results are discussed in Section IV.4, and the Section IV.5 presents the conclusions.

IV.1. Theory and Hypotheses

In this section, we rely on previous literature to derive our hypotheses about how several corporate governance factors influence the market response to the R&D effort.

IV.1.1.The Legal Protection of Investor

The relationship between investor protection and corporate finance has drawn attention in several strands of economic literature, such as financial system development, corporate ownership, economic growth and corporate valuation. The literature suggests that an efficient legal system contributes to reducing the magnitude of market imperfection caused by agency problems, and informational asymmetries between insiders and investors (Demirgüç-Kunt and Maksimovic, 1998). This benefit would be reflected on the level of investment, once strong investor protection affects investor willingness to provide external financing (La Porta et. al, 2002). Moreover, weak investor protection gives rise to incentive problems in that controlling shareholders may take the advantage of pursuing private benefits at the cost of outside shareholders (Albuquerue and Wong, 2008).

According to La Porta et al. (1997, 1998, 2000), common law countries protect investors better than civil law countries, which results in differences in the level of economic development, debt and equity market liquidity. Specifically, in the field of corporate valuation, the main aim of our work is to find a higher Tobin's q (La Porta et al., 2002) for firms that belong to countries with a common law system as compared to those operating in civil law countries.

Consistent with earlier studies, other authors have shown evidence regarding the importance of strong legal protection in firm performance. For instance, Gompers et al. (2003) construct a governance index to proxy for shareholder rights by combining several rules of governance. They investigate the relationship between shareholders' rights and corporate performance during the 1990s, and find that the higher the level of shareholder rights, the higher the firm's value. Moreover, this finding supports the hypothesis that poor investor rights increase the conflict of interest between insiders and outsiders, since the ability of controlling shareholders to obtain private benefits is improved by inefficient investor protection. On the contrary, strong investor protection grants investors the ability to assess manager actions, and consequently, protects them against expropriation from insiders.

Doidge et al. (2004) examine why shares are better valuated for foreign firms listed in the United States (US) than those non-listed firms operating in their country are. Taking, among others, country variables associated with legal origin, anti-director rights, and an index of judicial efficiency, they suggest that a US listing reduces the extent to which controlling shareholders can engage in expropriation. This advantage may improve the ability of firms to undertake valuable investments, which could be reflected in market valuation. Moreover, in accordance with La Porta et al. (2002), Alburquerue and Wong (2008) predict a lower Tobin's q when the investor protection is weak. They point to the extraction of private benefits by controlling shareholders and investment distortions as possible explanations. Similarly, other studies have shown the positive impact of investor protection on corporate valuation (for example, Claessens et al., 2002; Lee and Ng, 2003; Daouk et al., 2006; Hail and Leuz, 2006).

Relying on previous evidence, our objective is to study how the legal protection of investors moderates the relationship between R&D investment and a firm's value. Although the literature shows evidence of the important role played by the legal protection of investors to mitigate agency problem and informational opacity and, consequently, to impact the value of a firm, less attention has been devoted to the influence of investor protection on the relationship between R&D and a firm's value.[23] In this vein, Booth et al. (2006) use some indices associated with the legal system as control variables in order to investigate how the financial environment affects the stock market valuation of R&D spending. Their results do not show a significant influence of the legal protection in moderating the relationship among R&D, market valuation and financial environment.

Particularly for R&D, the market valuation should be favorable for R&D intensive-firms operating in countries with stronger investor protection, since 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 documented by John et al. (2008), the legal protection of the investor lowers the incentive problems. Given that insiders may choose conservative investment, stronger investor protection helps to reduce the magnitude of opportunistic behaviour, reflecting in a more positive net present value risky investment. They conclude that stronger shareholder protection is related to higher firm-level riskiness. Furthermore, Wurgler (2000) suggests that stronger legal protection of minority shareholders is related to more efficient capital allocation and, consequently, in locations with stronger investor protection, investment is likely to be more responsive to changes in positive value added. Consequently, we posit our first hypothesis:

Hypothesis 1a. Firms belonging to common law countries will exhibit a higher market valuation of their R&D investments than firms in civil law countries.

To test this hypothesis, we extend the model in Equation (14) of Chapter II by interacting R&D with a dummy variable that distinguishes between common law countries and civil law ones. The resultant model can be written as follows:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + (\beta_2 + \alpha_1 CL_{it})\left(\frac{RD}{K}\right)_{it} + e_{it} \qquad (23)$$

---

[23] Note that both market imperfections are strongly related to intangible assets, such as R&D.

where CL_{it} is a dummy variable equal to 1 if the firm belongs to a common law country, and 0 if the firm belongs to a civil law country. This classification is made following La Porta et al. (1997, 1998). According to this model, the coefficient of R&D under civil law is β_2 (since CL_{it} takes value 0), whereas $\beta_2+\alpha_1$ is the coefficient for common law (since CL_{it} takes value 1). In this last case, if both parameters are significant, a linear restriction test is needed in order to determine whether their sum ($\beta_2+\alpha_1$) is significantly different from zero. Hence, the null hypothesis of no significance is $H_0{:}\beta_2+\alpha_1=0$.

One of the most important legal indicators affecting R&D valuation is the protection of minority shareholders. In an environment with poor minority shareholder rights, markets may respond negatively to R&D (Hall and Oriani, 2006). Weak legal protection of minority shareholders may increase the probability that corporate insiders undertake investments that do not maximize value, since the minority shareholder rights are positively related to better capital allocation (La Porta et al., 1998; Wurgler, 2000). Accordingly, our next hypothesis is:

Hypothesis 1b. The protection of minority shareholder positively influences the market response to R&D investments.

La Porta et al. (1997, 1998) compute an index to proxy for the level of minority shareholder rights, which they term "Antidirector Rights."[24] We use this combined index to build a dummy variable, AR_{it}, which takes a value of 1 for firms that belong to a country with Antidirector Rights higher than the sample median, and 0 otherwise. We test this hypothesis by substituting the dummy variable in Equation (23) with the new dummy variable, AR_{it}.

To examine the influence of legal protection on the market valuation of R&D investment in depth, not only do the characteristics of the laws need to be taken into account but also the extent of their enforcement. Defond and Hung (2004) suggest that strong law enforcement is more efficient than extensive investor protection laws in improving corporate

[24] The index is constructed by combining the six indices (whether a proxy vote by mail is allowed; shares not blocked before annual general meeting; cumulative voting or proportional representation; oppressed minorities mechanism; pre-emptive rights; and percentage to call an extraordinary shareholders' meeting) into an aggregate score.

governance. Their findings point that Chief-Executive Officer (CEO) turnover is more likely to be associated with inefficient performance and poor stock returns because, under strong law enforcement, the stock prices are more informative about the firm's decisions. In addition, the capital should be more efficiently allocated where stock prices are more informative (Durnev et al., 2004). These earlier studies lead to the following hypothesis:

*Hypothesis 1c**.** Stronger law enforcement leads to a higher market valuation of R&D investment.*

To test Hypothesis 1c, we substitute the dummy variable in Equation (23) with another dummy variable, EF_{it}, which takes a value of 1 for firms belonging to a country with high levels of law enforcement, and 0 otherwise. La Porta et al. (1998) measures law enforcement using two indices: "Efficiency of the Judicial System" and "Law and Order." "Efficiency of the Judicial System" is based on data published by the Business International Corporation, and "Law and Order" relates to the country's law and order tradition collated from data created by International Country Risk, a country risk-rating agency. We combine these two indices to build, by aggregating them, a combined law enforcement index.

Overall, if we jointly consider the characteristics of a legal system and the level of enforcement, we can build an index that more fully captures the effective protection of investors. We would, therefore, expect that more effective investor protection increases the market valuation of R&D investments. Hence, a new hypothesis emerges:

Hypothesis 1d. Firms operating in countries with more effective investor protection have a higher market valuation of their R&D investments than those firms operating in countries with lower effective investor protection.

This hypothesis can similarly be tested by substituting the dummy variable in Equation (23) with another dummy variable, EP_{it}, which takes a value of 1 for firms belonging to a country with a high index of effective investor protection (above the median), and 0 otherwise.

IV.1.2.The Financial System

In 1911, Schumpeter pointed out that a well-functioning financial system fosters technological innovation by identifying and financing valuable projects. More recently, some growth models point to technological innovation as a channel through which the financial system's functions affect economic growth (Romer, 1990; Grossman and Helpman 1991; Aghion and Howitt, 1992).

Although a considerable number of theoretical studies have documented the importance of financial development to promote economic growth, it was only in the 1990s that empirical works began to attract a special attention. In their seminal work, King and Levine (1993) highlight that the level of financial development is likely to be a good predictor of capital accumulation, economic growth and technological change. By using country level data, they find a positive and strong correlation between financial system development and economic growth. At the microeconomic sphere and using industry indicators, Rajan and Zingales (1998) demonstrate that those industries more dependent on external finance grow faster in countries with more developed financial systems. One explanation for this evidence is that developed financial systems mitigate market imperfections and consequently, provide less costly external finance.

However, there are different opinions among scholars concerning the role played by the financial system and its structure to promote economic growth. Consequently, a growing body of studies has examined this issue trying to answer two main questions: i) Is there a relationship between financial system development and economic growth? and ii) Does financial system orientation (market-based versus bank-based) influence the cost of external financing? (Beck et al., 2000; Beck and Levine, 2002; Levine, 2002; Demirgüç-Kunt and Maksimovic, 2002; Beck et al., 2008)

Surprisingly, although the technological innovation is indicated as a channel through which financial system's functions affect economic growth, there is very little work (Hall and Oriani, 2006; Booth et al., 2006) empirically investigating whether the financial system matters to the market valuation of R&D investments. For instance, Hall and Oriani (2006) motive their study based on capital markets in continental European countries differing in several ways from the Anglo-Saxon ones. For instance, the lack of professional investors and weaker markets for corporate control may lead firms to have a higher propensity to undertake long-term investments compared to those firm operating in the United Kingdom (UK) and US. Here, the market pressure could motivate managers to undertake short-term investments in order to maintain short-term earnings. However, the results show a higher market valuation of R&D investments for firms belonging to Anglo-Saxon countries, especially the UK, than for those operating in Germany, France and Italy.

From the financing perspective, Booth et al. (2006) support the notion that the relative size of the equity and the private loan markets influence the way in which R&D is assessed. Specifically, they document that the greater portion of equity financing, the stronger market valuation of R&D spending. Their sample is comprised of all listed firms from Australia, Canada, Finland, France, Germany, Japan, Sweden, Switzerland, the UK and the US.

Following Hall and Oriani (2006), who provide evidence of the higher market valuation of R&D investment for firms operating in UK, we attempt to add further support to the view that the R&D investments undertaken by firms operating in countries with market-based financial systems are better assessed by capital markets, in which one of the main functions is to price efficiently investments. In addition, as above-mentioned, Booth et al. (2006) find a positive correlation between financing equity and the market response to R&D. Then, we posit our next hypothesis as follows:

Hypothesis 2a. Market-based financial systems lead to a higher market valuation of R&D investment.

We test this hypothesis by substituting the dummy variable in Equation (23) with another dummy variable, DMB_{it}, which takes the value 1 for firms operating in market-based systems and 0 otherwise. The data is drawn from Demirgüç-Kunt and Levine (2001), who document and detail those countries that have market-based and bank-based systems.

Moreover, we jointly consider the characteristics of bank-based and market-based systems, and build an index that more fully captures the financial system development. In addition to our arguments mentioned above, Beck and Levine (2002) find that the extent of external financing is greater in countries with a higher degree of financial system development. Their findings are consistent with the view that the financial system development mitigates the market imperfections and consequently, provides less costly external finance. It is important to note that Booth et al. (2006) do not find support for the importance of the level of financial system development in moderating the market valuation of R&D investment, since their sample is comprised of firms belonging to countries that have a similar level of financial development. Accordingly, we posit our next hypothesis:

*Hypothesis 2b***.** *A higher level of financial development leads to a higher market valuation of R&D investments.*

This hypothesis is tested by substituting the dummy variable in Equation (23) with another dummy variable, FSD_{it}, which takes the value of 1 for firms belonging to a country with a high index of financial system development, and 0 otherwise. The construction of this measure of financial system development is based on indicators of banking development and market development.[25]

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[25]The index of market development is defined as the average of two measures: market capitalization to Gross Domestic Product (GDP) and Total Value Traded to GDP. The index of banking development is the average of three variables: bank liquid liabilities, bank assets and deposit bank domestic, all standardized by GDP.

IV.1.3. Control Mechanisms

As documented by the literature, ownership structure can be characterized as concentrated or diffused.[26] The capital markets in the US and UK are characterized by stock ownership diffused among institutional investors, individuals and other minority investors. On the other hand, Continental Europe and Japan are characterized as having a concentrated ownership by family business, banks and governments. An explanation for these cross-country differences is the extent of investor protection (La Porta et al., 1998, 2000). Under strong investor protection, the larger shareholders have less incentive to purse private benefits at the cost of the minority investor, increasing the willingness of small shareholders to invest.

Research has shown evidence of the important role played by ownership structures to resolve the conflict of interests between shareholders and managers (Jensen and Meckling, 1976; Shleifer and Vishny, 1986), as well as its importance in mitigating informational asymmetries, which are particularly severe for R&D investments (Leland and Pyle, 1977). However, existing literature on the relationship between ownership and a firm's value has provided competing hypotheses and conflicting evidence. A positive effect could be a result of large shareholders with high cash flow rights which confer on them the incentives and capacity to monitor managers (Lemmon and Lins 2003; Claessens et al, 2002; La Porta et al., 2002). On the contrary, a high level of ownership concentration, which confers voting powers that exceed the level of cash flow rights, may lead majority owners to expropriate the wealth of minority shareholders (see, Claessens et al., 2002; Gompers et al., 2004). The non-systematic evidence generally comes from American and British firms. For instance, Kvist et al. (2006) find non-significant correlation between blockholder ownership and a firm's value in the US and UK; in contrast their findings suggest a negative impact of concentrated ownership on a firm's value for Continental European firms.

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[26] See, for instance, Becht and Mayer (2001); Moerland (1995); Franks and Mayer (1997); Kaplan (1997); Gedajlovic and Shapiro (1998); Mayer and Sussman (2001); Faccio and Lang (2002).
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Regarding R&D investment, the evidence of the importance of ownership in moderating the market valuation of R&D efforts is not unanimous. For example, Szewczyk et al. (1996) find a positive influence of institutional ownership on the market response to R&D announcements. Hall and Oriani (2006) investigated, among other things, the impact of large shareholders on the market value of R&D investment in Germany, France and Italy. For German firms, one of their specific estimations indicates a substantial reduction of market valuation when a firm has a majority shareholder. With respect to France and Italy, the evidence is interesting. Using both methods, the results reveal that for those French and Italian firms having a single shareholder with a more than 33% share, the R&D investment is not valued by the market. However, Booth et al. (2006) do not find support this for ownership concentration.

It is worth noting that Hall and Oriani (2006) suggest that, in an environment with weak minority shareholder rights, markets may respond negatively to R&D. As shown by La Porta et al. (1998), corporate ownership is more concentrated in countries with poor investor protection.

In this context, the evidence provided by Hall and Oriani (2006), who find that the concentrated higher level of ownership is negatively related to the market valuation of R&D for firms operating in countries with poor investor protection, such as Italy and France, leads us to formulate our next hypotheses. In short, in this environment, controlling shareholders are more likely to seek private benefits at the expense of minority shareholders; as a result, the capital could be allocated inefficiently.

Hypothesis 3a. The higher the level of ownership concentration, the lower the market valuation of R&D investment.

Hypothesis 3b. The impact of ownership concentration on the market response to R&D investment is moderated by the level of legal protection of minority shareholders.

To test Hypothesis 3a, we substitute the dummy variable in Equation (23) with the dummy variable, DOC_{it}, which takes a value of 1 for firms with high levels of ownership concentration[27] and 0 otherwise. Following La Porta et al. (1998), we construct an index measuring Ownership Concentration.[28]

To test Hythesis 3b, we extend equation (14) by interacting the R&D variable with dummy variables, OC_{it}, and AR_{it}. The resultant model can be written as:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + (\beta_2 + \alpha_1 OC_{it} + \alpha_2 AR_{it})\left(\frac{RD}{K}\right)_{it} + e_{it} \tag{24}$$

In this case, the coefficient of RD_{it} could be: i.) β_2 (OC_{it} and AR_{it} take the value 0) for firms with a lower level of ownership concentration, and who operate in countries with weak protection of minority shareholders; ii.) ($\beta_2+\alpha_1$) if the firms have a higher level of ownership concentration and are operating under weak protection of minority shareholders (OC_{it} takes value 1 and AR_{it} takes the value 0); iii.) ($\beta_2+\alpha_2$) if firms have a lower level of ownership concentration and are operating in countries with strong shareholder protection (OC_{it} takes the value 0 and AR_{it} takes the value 1); and iv.) ($\beta_2+\alpha_1+\alpha_2$) if the level of ownership concentration is high and firms are operating in countries with strong shareholder protection (OC_{it} *and* AR_{it} both take the value 1).

The two main functions of board of directors are to advise and monitor management (Lehn, et al., 2003). Jensen (1993) argued that internal corporate control has its origin in the board of directors, and the literature has pointed out the important role played by the board of directors in a firm's decision-making (Fama and Jensen, 1983; Jensen 1993).

As is well known, dominant board structures are unitary and two-tier. The unitary board structure is prevalent in Anglo-Saxon countries (specifically the US and UK: Hopt and Leyens, 2004; Dargenidou, et al., 2007), Japan (Jackson and Moerke, 2005), and European

[27] Higher than the median percentage of ownership by the three largest shareholders in the ten largest non-financial, privately owned domestic firms.
[28] Some papers, such as Carlin and Mayer (2003) and Leuz et al. (2003), also use the same index.

countries except for Germany, the Netherlands and Austria (Maassen and van den Bosch, 1999; De Jong, et al., 2002), where the two-tier board has been adopted.

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 supervisory board, which reduces the power and control of the executive boards. The members of the supervisory board are elected by the shareholders. The supervisory board appoints and supervises the executive board (Kim et al., 2007; Jungmann, 2006); therefore, it may be easier to replace a director with poor performance or opportunistic behavior.

In Anglo-Saxon countries, such as the US and the UK, the predominant board system is the unitary board. Here, the boards include a higher proportion of non-executive directors, which confers on these boards a higher independence as compared to their continental European counterparts. From an agency perspective, an independent board is a mechanism to reduce informational opacity, given that executive and non-executive directors have access to the same information, as they are involved in the making-decision process. Moreover, resource dependence theory (Pfeffer and Salancik, 1978) suggests that firms with independent boards are better at interfacing with the external environment.

Particular for R&D investment, which is associated with high risk, long term in nature and has greater hidden information and actions, an effective board could lead managers to undertake valuable R&D projects instead of alternative investments that may be carried out with their private benefits and at the cost of shareholders. Accordingly, the effectiveness of the board may have a positive impact on the market valuation of R&D efforts, leading to the following hypothesis:

Hypothesis 3c. Firms with an effective board of directors have better valuation of their R&D projects.

This hypothesis can be tested by substituting the dummy variable in Equation (23) with another dummy variable, EB_{it}, which takes value 1 when the country operates a two-tier board structure or when non-executive directors represent a significant proportion on boards, and 0 otherwise. We define a dummy variable, EB_{it}, to proxy for board structure, and which takes the value of 1 when a country has a two-tier board structure or when non-executive directors represent a significant proportion (50% or more) on boards and 0 otherwise.

The strong correlation between managerial efficiency and the stock market value is the essential premise of the market for corporate control (Manne, 1965). The market for corporate control (hereafter MCC) mainly emerges with acquisitions and mergers. The threat of takeover especially helps to reduce agency costs. Jensen and Ruback (1983) have argued that a strong MCC checks managerial opportunism when asymmetries are severe. Thus, an active MCC should enhance the firm's value by increasing the available scale and scope economies from mergers, and by takeover threats that could lead managers to maximize a firm's value (Brook et al., 1998). Consistent with these previous studies, other authors have suggested that some antitakeover governance provisions negatively affect a firm's value (see, Gompers et al, 2003; Bebchuck and Cohen, 2005).

For R&D investment, in particular, Meulbroek et al. (1990) investigate the effect of antitakeover provisions on R&D. Their findings indicate that antitakeover protection may reduce the level of R&D intensity. Specifically, they find a decrease in the R&D/sales ratio after the implementation of takeover impediments. An explanation for this is that takeover defenses could facilitate the managers' entrenchment and support them against any MCC actions. Their study was motivated by Stein 1988, who in contrast to the above-mentioned studies, argued that antitakeover amendments benefit shareholders by leading managers to undertake valuable long-term projects, such as R&D investment.

One of the main differences across the financial system structures is the frequency of takeovers. The MCC is quite active in market-based systems (Jensen and Ruback, 1983;

Franks and Mayer, 1996). On the contrary, in bank-based systems, this type of activity is limited (Berglöf and Perotti, 1994; Franks and Mayer, 1998; Höpner and Jackson, 2001). The legal and regulatory impediments could be explanations for these differences. For instance, in Japan, the influence of banks and the strength of cross-shareholdings, typical of *keiretsus*, represent the main structural barriers to takeovers. In Germany, only three hostile takeovers took place from 1945 to 1995 (Franks and Mayer, 1998).

In this context, if the MCC plays an important role in disciplining management in countries with an active MCC, managers may be more encouraged to undertake profitable investments. This should be recognized by capital markets when assessing R&D projects. As a result, our next hypothesis would be as follows:

Hypothesis 3d. ***In countries with an active market for corporate control, the market valuation of R&D investments is higher than in those countries where the market for corporate control actions is limited.***

We test this hypothesis by substituting the dummy variable in Equation (23) with another dummy variable, MCC_{it}, which takes value 1 for firms operating in country with an active market for corporate control[29] and 0 otherwise.

In addition, to investigate how internal and external control mechanisms moderate the relationship between R&D and firm value when they are working together, we construct a combined index of control, CM_{it}, computed as the sum of ownership concentration, board effectiveness and market for corporate control. The CM_{it} takes a value of 1 for firms operating under a higher combined corporate control index, and 0 otherwise, leading to the next hypothesis:

Hypothesis 3e. *Firms operating under more effective control mechanisms have better market valuation of their R&D investment.*

IV.1.4. Corporate Governance Aggregated Effect

[29] Ireland, the Netherlands, the UK and US. The classification coincides with the market-based countries, with the exception of Ireland.

The above-mentioned corporate governance factors could interact. Hence, an interesting issue is to analyze the overall effect of corporate governance on the relationship of R&D investment and a firm's value. In fact, La Porta et al. (1997, 2000) show that investor protection facilitates the development of the financial system. Consistently with these previous studies, Kwok and Tadesse (2006) highlight the key role played by the legal systems in differentiating financial systems across countries. In addition, as suggested by Demirgüç-Kunt and Maksimovic (1998), both legal and financial systems reduce the magnitude of market imperfections caused by agency problems. Consequently, there is enough evidence to argue that the effect of corporate governance on the relationship of R&D and a firm's value arises from two sources. The first could either be the legal or financial system, in that both systems could interact to affect this relationship further. The second is drawn from the internal and external control mechanisms, as explained in the previous section.

Consequently, we posit that a good corporate governance system increases the market valuation of R&D investment. As a result, our last hypothesis would be as follows:

Hypothesis 4. *Good corporate governance increases the market valuation of R&D investment.*

We test this hypothesis by substituting the dummy variable in Equation (23) with another dummy variable, CG_{it}, which takes the value 1 when the index of corporate governance is higher than the median and 0 otherwise. Our corporate governance index is defined as the average of the effective investor protection index (*EP*), the financial system development index (*FSD*), and the control mechanisms index (*CM*).

IV.2. Data

Our initial sample consists of all listed companies in the European Union, US, and Japan included on the WorldScope database for the years 1986 to 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), companies from Luxembourg are removed because of the very low number of listed firms. Finnish and Portuguese companies had to be dropped because of a lack of R&D data for these countries. As a result, the sample comprises of companies from twelve countries: Austria, Belgium, France, Germany, Greece, Ireland, Italy, Spain, the Netherlands, the US, the UK and Japan. In addition, financial firms were removed because their corporate structure is fundamentally different from the rest of the sample. Table IV.1 provides the sample structure in terms of companies and number of observations per country. The distribution of firms used in this study mirror that of the whole sample of firms listed in each country.

Table IV.1

Breakdown of Samples by Country

This table presents a breakdown of sample companies into country of incorporation. To be included in the sample, there must be six consecutive years of financial information included R&D between 1986 and 2003. Financial firms were not included in the financial system because of the nature of their data. Financial information comes from WorldScope and economic data is taken from the OECD.

Country	*Number of companies*	*Percentage of companies*	*Number of observations*	*Percentage of observations*
Austria	14	1.16	107	1.73
Belgium	12	0.99	90	1.45
France	107	8.89	834	13.47
Spain	4	0.33	27	0.44
Germany	103	8.55	808	13.05
Greece	14	1.16	98	1.58
Ireland	33	2.74	266	4.30
Italy	48	3.99	369	5.96
Japan	336	27.91	1,344	21.71
Netherlands	25	2.08	215	3.47
UK	190	15.78	760	12.28
USA	318	26.42	1,272	20.56
Total	1,204	**100**	6,190	**100**

The data is an unbalanced panel, which comprises of 1,204 companies and 6,190 firm-year observations. An unbalanced panel was preferred to a balanced approach in order to mitigate survivorship bias problems. Table IV.2 presents the breakdown of the sample by economic sector. Companies are categorized according to their Economic Sector

Code, a classification system pertaining to nine different industry groupings (including financial firms).[30]

Table IV.2

Sample distribution by economic sector classification

The table presents a breakdown of the sample into industrial groups, classified using Compustat Economic Sector Codes. 1000 Materials includes all construction materials, chemicals, gasses and commodity firms. 2000 Consumer – Discretionary includes automobile manufacturers, homebuilders, hotels, casinos, retail, and electrical appliance firms. 3000 Consumer – Staples includes food and drug retail and brewers. 3500 Health Care includes health care, and pharmaceuticals. 4000 Energy includes all types of oil and gas firms. 6000 Industrials includes conglomerates, construction, aerospace and defence, heavy machinery, airlines, marine, trucking, railroads, and office services and supplies. 8000 Information Technology includes telecommunications, IT, software, electronics, and semiconductor firms. 9000 Utilities includes electric, gas, water, and shipping firms. Economic Sector Code 5000 Financial was not included in the sample research design.

Economic sector Code	Number of companies	% of companies	Number of observations	% of observations
1000 Materials	202	16.78	1,022	16.52
2000 Consumer – Discretionary	130	10.80	720	11.63
3000 Consumer – Staples	209	17.33	1,072	17.32
3500 Health Care	212	17.64	1,025	16.56
4000 Energy	26	2.17	171	2.77
6000 Industrials	253	20.98	1,282	20.71
8000 Information Technology	130	10.80	692	11.17
9000 Utilities	42	3.50	206	3.32
Total	**1,204**	**100**	**6,190**	**100**

The spread of firms across industries is balanced, with most companies listed within the 6000 Industrials grouping. As would be expected, the total number of firms in the 4000 Energy and 9000 Utilities industry groups is quite low, with 68 companies in total, less than 6% of the total sample. All the industries, with the exception of financial firms, are well represented in the sample, providing a strongly representative sample for testing our major hypotheses. Table IV.3 provides the summary statistics (mean, standard deviation, maximum and minimum).

[30] To avoid a large number of dummy variables in the model, we use the most general industrial classification system.

Table IV.3

Summary Statistics for Key Variables

(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 residual income scaled by the replacement value of total assets, and *(R&D/K)*$_{it}$ is research and development scaled by the replacement value of total assets.

Variable	Mean	Standard deviation	Minimum	Maximum
***(MV-BV)/K)*$_{it}$**	0.8787	2.3129	-30.9296	84.5471
***(R&D/K*$_{it}$**	0.04062	0.0708	0.0000	1.5725
***(RI/K)*$_{it}$**	-0.0175	0.3707	-15.9476	0.7139

IV.3. Model and Methodology

As we are interested in studying how the corporate governance impacts the market valuation of research and development, we use the model recently derived in the second chapter). This model is based on the capital market arbitrage condition that predicts that the net after-tax return for shareholders in firm *i* during period *t* is obtained from current dividends and capital appreciation. Accordingly, the shareholders will maintain their shares as long as the return is equal to their required after-tax return. This equilibrium could be expressed as following:

$$r_{it}V_{it} = (E_t V_{i,t+1} - V_{it}) + E_t D_{i,t+1} \quad \text{(A)}$$

where $D_{i,t+1}$ are the dividends paid by firm *i* at time *t+1*, r_{it} is the after-tax return required by shareholders, and E_t is the conditional expectation based on information known at moment *t*.

After several algebraic manipulations, the following basic model is obtained (see second Chapter):

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

It is important to note that this model has been derived under the assumption that we should use several lagged R&D values to estimate its current value. Consequently, we should use an instrumental variables method for estimating the study. Since the Generalized Method of Moments (GMM) is the method that embeds the other instrumental variables method as special cases (Ogaki, 1993), we have chosen it as the estimation method.

Our main econometric methodology draws on panel data techniques. As a result, all the models specified in this work have been estimated using the panel data methodology. Specifically, the estimation is carried out by GMM, because we need to use an instrumental variables method. Since R&D is strongly linked to the strategy of the firm, our methodology has to address the strong specificity of R&D investment. Similarly, unlike cross-sectional analysis, the panel data method allows us to control for individual heterogeneity. Therefore, to eliminate the risk of obtaining biased results, we have controlled for this heterogeneity by modeling it as an individual effect, η_i, which is then eliminated by taking the first differences of the variables. Consequently, the basic specification of our model would is as follows:

$$\frac{V_{it} - BV_{it}}{K_{it}} = \beta_1 \frac{RI_{it}}{K_{it}} + \beta_2 \frac{RD_{it}}{K_{it}} + \eta_i + d_t + c_i + i_i + v_{it} \qquad \text{(C)}$$

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 variables on R&D; c_i are country dummy variables representing country-specific effects; i_i are industry dummy variables standing for industry-specific effects, since R&D is strongly related to the kind of activity developed by the company; and v_{it} is the random disturbance term.

The analysis also faces the challenge of dealing with factor endogeneity. This is likely to arise since the dependent variable (a firm's value) may also explain the R&D value, since a higher value may encourage managers to undertake new R&D projects. Therefore, all models have been estimated using instruments. To be exact, we have used each right-hand-side variable in the models lagged one to three times as instruments in the difference equations and just once in the level equations, since we use the system GMM developed by Blundell and Bond (1998).

Finally, we check for any potential mis-specification of the models. First, we use the Hansen *J*-statistic of over-identifying restrictions in order to test for the absence of correlation between the instruments and the error term. Second, we use the m_2 statistic, developed by Arellano and Bond (1991), in order to test for the lack of second-order serial correlation in the first-difference residuals. Third, we carry out four Wald tests for linear restrictions. These are z_1, which is a test of the joint significance of the reported coefficients; z_2 is a test of the joint significance of the time dummies; z_3 is a test of the joint significance of the country dummies; and z_4 is a test of the joint significance of industry dummies.

IV.4. Results

In this section, we summarize the results obtained from our valuation model to capture the influence of corporate governance indicators in moderating the market valuation of R&D investments.

IV.4.1.The Legal Protection of Investors

Table IV.4 shows the impact of the legal system on the market valuation of R&D. In Column 1, we find that the R&D coefficient for firms belonging to common law countries ($\beta_2+\alpha_1$ = 3.6556 +7.1476 =10.8032, significantly different from zero, see t value) is greater than the coefficient for firms belonging to civil law countries (β_2=3.6556). This result supports Hypothesis 1a, and suggests that countries whose laws have a common origin benefit

R&D-intensive firms. That is, common law systems characteristic less information asymmetry and, consequently, investors are more prone to provide less costly external funds, resulting in abnormal return at the investment. Given that R&D projects are largely characterized by asymmetric information (Aboody and Lev, 2000), firms operating in countries with strong legal protection receive better valuation of their R&D efforts.

Table IV.4

The Effect of Legal Systems on the Market Valuation of Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1986 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *CL* equal to 1 if a firm is domiciled in a common law country and zero otherwise. *AR* is equal to 1 if the firm is domiciled in a country with anti-director rights above the median for the sample and zero otherwise. DEF is equal to 1 if the firm is domiciled in a country with legal enforcement stronger than the median country in the sample and zero otherwise. *EP* is equal to 1 if the firm is domiciled in a country with investor protection stronger than the median and zero otherwise.

	(1)	(2)	(3)	(4)
$(RI/K)_{i,t}$	0.21962*	0.25114*	0.10642*	1.09214*
	(0.02927)	(0.02749)	(0.02478)	(0.04689)
$(R\&D/K)_{i,t-}$	3.65557*	3.22125*	8.93987*	2.78310*
	(0.23718)	(0.21408)	(0.33381)	(0.20178)
CL_{it} $(R\&D/K)_{it}$	7.14763*			
	(0.44001)			
AR_{it} $(R\&D/K)_{it}$		9.07792*		
		(0.41730)		
EF_{it} $(R\&D/K)_{iit}$			3.063785*	
			.3338112	
EP_{it} $(R\&D/K)_{iit}$				12.36111*
				(0.40090)
T	16.01	15.87	26.98	17.97
z_1	314.74(3)	420.23(3)	784.96(3)	718.53(3)
z_2	385.79 (12)	544.42(12)	1465.38(12)	317.83(12)
z_3	42.13(8)	48.89(8)	188.87(8)	65.25(7)
z_4	27.85(7)	25.60(7)	27.67(7)	22.03(7)
m_1	-1.34	-1.34	-1.39	-1.00
m_2	-0.48	-0.50	-0.54	1.63
Hansen	313.56(185)	344.77(185)	333.59(192)	264.14(185)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. t is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

The greater R&D coefficient in Column 2 for firms belonging to countries with higher minority shareholder protection ($\beta_2+\alpha_1$ = 3.2213+9.0779=12.2992, significantly different from zero, see t value) also supports Hypothesis 1b. There is a positive correlation between the protection of minority shareholders and the R&D-firm value relation. In this sense, Hall and Oriani (2006) suggest that, in an environment with poor minority shareholder rights, markets may respond negatively to R&D. Moreover, Gompers et al. (2003) find that the higher the level of shareholder rights, the higher the firm value. This result is also in accordance with La Porta et al. (1998) and Wurgler (2000), in that strong legal protection of minority shareholders is related to more efficient capital allocation, and consequently, the capital markets should consider this when assessing R&D investment.

As shown in Column 3, R&D investments undertaken by firms belonging to countries with better levels of law enforcement ($\beta_2+\alpha_1$ =8.9399+3.06378=12.0036, significantly different from zero, see t value) are better valuated by capital markets. This result supports Hypothesis 1c, and is consistent with Defond and Hung (2004), who suggest that under strong law enforcement, the stock prices are more informative about firm performance. Hence, law enforcement plays an important role in mitigating asymmetric information, and consequently, helps to align the interests between insider and outsider. This then lessens the abilities of the manager and insider shareholder to take private benefits at cost of value-maximization.

Finally, Column 4 indicates that firms operating under more effective investor protection exhibit higher valuation of their R&D investments ($\beta_2+\alpha_1$=2.7831+12.3611=15.1442, significantly different from zero, see t value) than in other countries (β_2=2.7831). This result supports Hypothesis 1d, and shows strong evidence about the importance of the legal protection in moderating the market valuation of R&D.

IV.4.2. The Financial System

Table IV.5 presents the results regarding the role played by the financial system. Column 1 shows that market-based financial systems increase the market valuation of R&D

investment. Companies in bank-based systems have a lower valuation (β_2=3.1833) than firms operating in a market-based financial system ($\beta_1+\alpha_1$=3.1833+11.1728 =14.3561, significantly different from zero, see t value). This result not only supports Hypothesis 2a, but is also consistent with Hall and Oriani (2006) and Booth et al. (2006). Hall and Oriani (2006) find a higher market valuation of R&D investments for firms belonging to Anglo-Saxon countries, especially to the UK, while Booth et al. (2006) suggest that a higher portion of equity financing leads to a higher market valuation of R&D.

Table IV.5
The Effect of the Financial Systems on the Market Valuation of Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1986 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *MB* equal to 1 if a firm is domiciled in a market-based country and zero otherwise. *FSD* is equal to 1 if the firm is domiciled in a country with financial system development above the median for the sample and zero otherwise.

	(1)	**(2)**
$(RI/K)_{it}$	0.24386* (0.02892)	0.15351* (0.02603)
$(R\&D/K)_{it}$	3.18327* (0.21138)	3.95625* (0.11833)
MB_{it} $(R\&D/K)_{it}$	11.17281* (0.40638)	
FSD_{it} $(R\&D/K)_{it}$		7.80777* (0.38111)
t	16.12	32.76
z_1	766.81(3)	660.31(3)
z_2	123.19(12)	148.64(12)
z_3	36.24(7)	76.34(8)
z_4	16.10(7)	16.63(7)
m_1	-1.35	-1.35
m_2	-0.54	-0.51
Hansen	289.65(189)	269.28(193)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. *t* is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Column 2 shows that higher level development of financial system increases the market valuation of R&D. The coefficient for firms operating in countries with a more developed financial system is higher ($\beta_2+\alpha_1$=3.9563+7.8078=11.7641, significantly different from zero, see t value) than for those firms belonging to countries with less developed financial systems (β_2=3.9563). In contrast to Booth et al (2006), we find support for the financial system development hypothesis. It is important to note that our sample comprises of data from countries with different levels of financial system development, whereas Booth et al. (2006) used a sample of firm data from countries with similar level of financial system development.

IV.4.3. Control Mechanisms

In this section, the impact of ownership concentration on the market valuation of research and development is investigated. Column 1 of Table IV.6 shows that firms with higher ownership concentration have less valuation when undertaking R&D investment. Specifically, the R&D coefficient is smaller for firms with concentrated ownership ($\beta_2+\alpha_1$= 12.062-8.6525=3.41, significantly different from zero, see t value) than for widely held firms (β_2=12.062). This result supports Hypothesis 3a, and is consistent with Hall and Oriani (2006) who that the market response to R&D is favorable for firms with a lower level of ownership concentration in France, Germany and Italy.

Table IV.6

The Effect of the Corporate Control Mechanisms on the Market Valuation of Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1986 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. *OC* is equal to 1 if a firm has higher than the median percentage of ownership by three largest shareholders in the 10 largest non financial, privately owned domestic firms in the country and zero otherwise. *AR* is equal to 1 if the firm is domiciled in a country with anti-director rights above the median for the sample and zero otherwise.

	(1)	(2)
$(RI/K)_{it}$	0.12852 (0.02266)	0.24469 (0.02125)
$(R\&D/K)_{it}$	12.062 (0.28382)	5.22305 (0.13067)
OC_{it} $(R\&D/K)_{it}$	-8.65253 (0.36089)	-2.01274 0.24049
AR_{it} $(R\&D/K)_{it}$		7.67125 (0.26437)
T	42.80	40.45
z_1	642.60(3)	649.40(4)
z_2	176.72(12)	778.26(12)
z_3	69.31(8)	30.62(4)
z_4	45.36(7)	37.15(7)
m_1	-1.36	-1.34
m_2	-0.52	-0.51
Hansen	280.64(193)	393.11(245)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. t is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Consistent with the above-mentioned arguments about the relevance of the legal protection of investors to firm valuation, we find that a stronger protection of minority shareholders helps to reduce the negative impact of ownership concentration on the market valuation of R&D investment. Controlling for the legal protection of minority shareholders

(Column 2 of Table IV.6), the coefficient of R&D is higher ($\beta_2+\alpha_1+\alpha_2$=5.2231-2.0127+7.6713=10.8817) for firms with a higher level of ownership concentration but who operate in an environment with stronger protection for minority shareholders than for those with a higher level of ownership concentration and who operate in an environment with weaker protection for minority shareholders. As can be seen, there is an exception when firms are operating in countries with stronger shareholder rights and who have a lower level of ownership concentration, as the R&D coefficient is lower. In other environments: i) a higher level of ownership concentration and weak protection of minority shareholders, it takes a value 3.2104 ($\beta_2+\alpha_1$=5.2231-2.0127=3.2104); ii) a lower level of ownership concentration and weak protection of minority shareholders, it takes a value 5.2231 (β_2=5.2231); and iii) a stronger protection of minority shareholders and a lower level of ownership concentration, it takes value of 12.8941 ($\beta_2+\alpha_2$=5.2231+7.6713=12.8941). This result not only supports Hypothesis 3b but is consistent with the view that, under strong investor protection, the majority shareholders have less incentive to pursue private benefits at the cost of minority shareholders.

Consistent with the main argument in Hypothesis 3c, the coefficient of the board dummy variable in Column 1 of Table IV.7 suggests that an effective board increases the market valuation of R&D investment. The coefficient of R&D for firms with effective boards is higher ($\beta_2+\alpha_1$=3.1108+9.9535=13.0643, significantly different from zero, see t value) than for other firms (β_2=3.1108), highlighting the role of effective boards in encouraging managers to efficiently allocate capital.

Table IV.7

The Effect of Corporate Control Mechanisms on the Market Valuation of Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1986 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *EB* is equal to 1 if the firm is domiciled in a country with a two-tier board structure system or when non-executive directors represent a significant proportion (50% or more) on boards financial and zero otherwise. *MCC* is equal to 1 if the firm is domiciled in a country with an active market for corporate control and zero otherwise. *CM* takes a value of 1 for firms with a combined corporate control index above the sample median, and 0 otherwise.

	(1)	(2)	(3)
$(RI/K)_{it}$	0.90739*	1.11022*	0.95092*
	(0.04824)	(0.02624)	(0.03596)
$(R\&D/K)_{it}$	3.11078*	2.01099*	2.88592*
	(0.12613)	(0.17428)	(0.12394)
EB_{it} $(R\&D/K)_{it}$	9.95351*		
	(0.33679)		
MCC_{it} $(R\&D/K)_{it}$		13.94675*	
		(0.27694)	
CM_{it} $(R\&D/K)_{it}$			15.62339*
			(0.53820)
T	27.96	17.40	27.76
z_1	680.55(3)	3560.73(3)	905.58(3)
z_2	209.19(12)	2545.29(12)	168.04 (12)
z_3	103.43(7)	70.83(7)	86.20 (7)
z_4	28.19(7)	36.60(7)	16.91 (7)
m_1	-1.11	-0.96	-1.101
m_2	1.62	1.61	1.61
Hansen	260.23(193)	306.92	261.23 (193)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. *t* is the t-statistic for the linear restriction test under the null hypothesis H_0:$\beta_3+\alpha=0$. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Column 2 of Table IV.7 shows the effect of the market for corporate control on the market response to R&D. Our results indicate that firms in countries with an active market for corporate control have a higher coefficient of R&D ($\beta_2+\alpha_1$=2.0110+13.9468=15.9578, significantly different from zero, see t value) than those firms who operate in other countries (β_2=2.0110). This result is consistent with the view that the MCC plays a key role in disciplining management, and consequently, when there is an active MCC, managers are more encouraged to maximize the value of the firm by undertaking profitable investments (see, for instance, Meulbroek et al., 1990); Bebchuck and Cohen, 2005).

In Column 3 of Table IV.7, the coefficient for the aggregate impact of corporate control mechanisms on the market valuation of R&D investment is presented. The coefficient of R&D for firms operating in countries with a high level of corporate control is higher ($\beta_2+\alpha_1$=2.8859 +15.6234 =18.5093, significantly different from zero, see t value) than for those firms belonging to other countries (β_2=2.8859). This result, not only supports Hypothesis 3e, but also be interpreted as evidence that the negative impact of ownership concentrated on the market valuation of R&D investment could be mitigated when the internal and external control mechanisms are associated.

IV.4.4. Corporate Governance Aggregate Effect

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 can be seen in Table IV.8, the coefficient of the R&D variable is higher for firms operating in countries with stronger corporate governance ($\beta_2+\alpha_1$= 3.14515+8.69764=11.84279, significantly different from zero, see t value) than for those firms belonging to countries with weaker corporate governance (β_2=3.14515). Consequently, this result not only supports our Hypothesis 4, in that good corporate governance increases the market valuation of R&D projects, but also reveals the importance of the idea that motivates this study.

Table IV.8

The Effect of Corporate Governance Index on the Market Valuation of Research and Development

The sample is all firms in the Worldscope database with available *R&D* data between 1986 and 2003. The table presents parameter estimates from panel GMM regressions of Research and Development on several different specifications. The interpretation for each coefficient is the change in *R&D* associated with a one unit change in the determinant. Variable definitions are presented in the appendix 1. The dummy variables are as follows. *CG* takes the value of 1 when a firm has a corporate governance index value higher than the sample median, and 0 otherwise. The corporate governance index is defined as the average of the shareholder rights index *(EP)*, the financial system development index *(FSD)*, and control mechanisms index *(CM)*.

Variable		**Test-Statistic**	
$(RI/K)_{it}$	0.15518 (0.02604)	**T**	26.35
$(R\&D/K)_{it}$	3.14515 (0.12137)	**z_1**	540.37(3)
CG_{it} $(R\&D/K)_{it}$	8.69764 (0.37258)	**z_2**	188.57(12)
		z_3	83.69(7)
		z_4	23.15(7)
		m_1	-1.35
		m_2	-0.51
		Hansen	279.36(193)

Heteroskedasticity consistent asymptotic standard errors are in parentheses. * indicates significance at the 1% level. t is the t-statistic for the linear restriction test under the null hypothesis H0:$\beta3+\alpha=0$. z1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as $\chi2$ under the null of no relationship, degrees of freedom in parentheses. z_2 is a Wald test of the joint significance of the time dummy variables, 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 dummy variables, 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 the sector dummy variables, asymptotically distributed as χ^2 under the null of no relationship. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as N(0,1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null, degrees of freedom in parentheses.

Overall, the evidence described in this section corroborates that corporate governance plays a key role in moderating the market response to R&D projects.

IV.5. CONCLUSIONS

This study focuses on how corporate governance influences the magnitude of the market valuation of R&D investment. Taking our valuation model based on the well-known capital market arbitrage condition, we investigate how corporate governance moderates the relationship between R&D and the value of a firm by interacting R&D with several corporate governance factors.

Our results reveal that the environment in which firms are operating exerts an important influence on the relationship between R&D and its value. Consistent with the law and finance literature, all legal system indicators, namely, legal tradition, protection of minority shareholders, law enforcement and the index of effective protection of investor, positively affect the market response to R&D investments. The R&D projects undertaken by firms operating in common law countries are better valuated by capital markets. Since common law is more effective to mitigate asymmetric information than civil law, this advantage helps to align the interests between insiders and outsiders, and consequently, improves the ability of firms undertaking valuable R&D projects, reflected on the market valuation. The high level of minority shareholder protection is related to more efficient capital allocation. Under strong investors, protection investments are likely to respond more to change in value added. In an environment with better law enforcement, stock prices are more informative about corporate performance, given that law enforcement is one of the main mechanisms that contribute to mitigating the asymmetric information problem between insiders and outsiders. Overall, the effectiveness of the investor protection substantially increases the market valuation of R&D investments.

With respect to the financial system, the R&D investment is better assessed in market-based countries. An explanation for this is that financing equity matters to the market response to R&D, besides the evidence that the capital markets exert their function assessing investments. Additionally, our findings support the hypothesis that a developed financial system increases the market valuation of R&D investments.

Regarding control mechanisms, an effective board plays an important and positive role in moderating the market response to R&D. A similar effect is provided by the market for corporate control, suggesting that the fear of takeover may alleviate the opportunistic behaviors, and consequently, lead managers to promote value-maximization. In contrast, a higher level of ownership concentration negatively affects the market valuation of R&D spending. However, controlling for the legal protection of minority shareholders, we find that firms with a higher degree of ownership concentration who operate in countries with a stronger investor protection of minority shareholders have a better market valuation of their R&D investments than those belonging to countries with a weaker investor protection of minority shareholders. This finding corroborates the important role played by strong legal protection of investor to firm valuation.

Overall, in aggregated effect, corporate governance is positively related to the relationship between R&D and firm value, since the interaction among the different corporate governance indicators also increases the market valuation of the R&D investment. This idea should be taken into account by the politicians when determining the characteristics of the corporate governance system, since, in this way, they could facilitate the positive impact of R&D investment on the valuation of the companies.

CHAPTER V

CONCLUSIONS

This work aims to answer the following three research questions: i) how do several characteristics of a firm moderate the relationship between R&D spending and firm value; ii) do corporate governance factors help to reduce the sensitivity of the R&D investment to cash flow; and iii) do corporate governance factors influence the market valuation of R&D spending.

In doing so, this study makes a significant contribution to the literature in at least six ways. Taking the capital market arbitrage condition as our starting point, we derive a valuation model in which a firm's value depends on its residual income and R&D spending. Thus, our valuation model is perfect for capturing the impact of a firm's characteristics and governance features on the market valuation of R&D spending. As a result, the analytical derivation of a testable model is quite an important contribution, in that our study arises from a well-known equilibrium in the economic theory.

Second, we offer new evidence on how several characteristics of a firm influence the relationship between R&D investments and firm value in the Eurozone countries. As far as we know, this is the first time a study for these countries has been conducted, not only on the moderating effects analyzed here, but also on looking at the effect of R&D on a firm's value.

Third, we offer additional evidence on the determinants of R&D investment in a cross-country analysis. There is considerable work on the determinants of R&D; however, this tends to be based on just one country. Our research is able to differentiate between control mechanisms, and financial and legal systems that are not possible when examining one country alone. Therefore, we are able to provide significant insights on the importance of these factors on R&D.

Fourth, we present evidence for the first time on how corporate governance affects R&D investment sensitivity to cash flow. Our study is useful in characterizing the appropriate corporate governance systems in countries to promote and facilitate R&D, and consequently, for faster economic growth. To this end, it is worth noting that we extend our sample to include firm data from the US, UK and Japan. This is because the need for data from different corporate governance systems, given that the structure and the degree of development of corporate governance are extremely important to our study; as a result, our sample is comprised of firm data from Eurozone countries, the US, the UK and Japan.

Fifth, we provide new evidence about the impact of several corporate governance factors on the market valuation of R&D spending. To investigate this issue, we also use a sample comprised of firm data from Eurozone countries, the US, the UK and Japan due to the above-mentioned need.

The sixth contribution refers, not only to the use of a robust econometric technique, but also takes into account that R&D is linked to the strategy of the firm. We are able to consider this link since panel data methodology allows us to incorporate the unobservable heterogeneity into the analysis through an individual effect. This effect captures characteristics related to the strategy of the firm, such as how it competes in the market, the propensity to innovate, and other unobservable characteristics. To control for endogeneity problems, the models have been estimated using the Generalized Method of Moments, which embodies all the Instrumental Variable Methods.

Our results reveal that the firm's characteristics play an important role in moderating the relationship between its value and R&D. We find that size has a positive effect on the market response to R&D spending, since it provides economies of scale, access to capital markets and R&D cost spreading. The capital markets better assess the R&D projects undertaken by growing firms. An explanation for this is that firms with a high rate of growth make the most of their supra-normal profits arising from the R&D projects. With respect to market share, our results indicate a positive effect on the market valuation of R&D spending, rather than on firm value. This could be evidence on the dependence of the supra-normal profits of R&D on the amount of R&D spending. On the contrary, free cash flow has a negative effect on the relationship between R&D and firm value, suggesting that firms with high free cash flow may be tempted to undertake negative net present value R&D projects. The dependence on external financing negatively affects the market response to R&D efforts. The higher information asymmetry related to R&D increases the cost of external funds, and consequently, reduces the benefits of R&D projects. Labor-intensive firms also have a lower market valuation of their R&D spending, given that the supra-normal profits obtained with R&D projects are diluted among employees. Capital intensity also negatively affects the market response to R&D spending because of the greater financial constraints faced by capital-intensive firms.

Regarding the impact of corporate governance on the sensitivity of R&D to cash flow, our results reveal that several factors, namely, legal protection of investor, financial systems and control mechanisms (ownership concentration, effectiveness of the board of directors, and market for corporate control) lessen the dependence of R&D on cash flow. The R&D projects undertaken by firms belonging to common law countries are less sensitive to cash flow fluctuations. An explanation for this result is that the market imperfections are less severe in common law countries; consequently, the cost of external funds will be lower. The high level of minority shareholders protection lessens the sensitivity of R&D to cash flow. A better law enforcement contributes to mitigating the asymmetric information problem between insiders and outsiders, thus reducing the cost of external finance, and as a result, lessens the sensitivity of R&D to cash flow. Overall, an effective protection of investors substantially reduces the sensitivity of R&D to cash flow. With respect to the financial system, the R&D investment is less dependent on the cash flow fluctuation when the firm operates in bank-based countries. The explanation for this result is that the internal channel between the firm and the bank contributes to reducing the asymmetric information problems between the firm and its investors. Additionally, a developed financial system also lessens the sensitivity of R&D to cash flow, and consequently, facilitates R&D activities. Similarly, the presence of control mechanisms facilitates R&D projects, since investors may be more confident about manager actions and, thus, the external finance could be less costly. Overall, the aggregated effect of corporate governance is positive for undertaking R&D projects, since the interaction among the different corporate governance factors also leads to a positive outcome for R&D.

Furthermore, we find strong evidence of the importance of corporate governance for the market valuation of R&D spending. First, a strong legal protection of investors positively impacts the market response to R&D investments. When a firm operates in a country with a common law tradition, its R&D efforts are better assessed by the capital market, suggesting that common law is more effective for mitigating information problems. This, in turn, contributes to reducing opportunistic behaviors at the expense of firm value. Our results provide strong empirical evidence supporting the relevance of the legal protection of minority shareholders for the relationship between R&D and firm value. The market valuation of R&D is higher in countries with strong investor protection of minority shareholders. There are some explanations, such as a more efficient allocation of capital and less risk of expropriation in this environment. In addition, under stronger legal protection, minority shareholders are more confident to invest. Law enforcement also has a positive effect on the relationship between R&D and a firm's value, since the stock prices are more informative in countries with a higher level of law enforcement. Overall, stronger investor protection substantially increases the market valuation of R&D investments. Second, with respect to the financial system, firms operating in market-based countries have a higher valuation of their R&D investments. This result suggests that financing equity matters to the market response to R&D. Additionally, our findings support the hypothesis that a developed financial system increases the market valuation of R&D investments. Third, regarding control mechanisms, an effective board has a positive effect on the relationship between R&D and firm value, given that it mitigates the agency and information problems; consequently, leading managers to promote value-creation. The market for corporate control also increases the market valuation of R&D, since the fear of takeover contributes to aligning the interests between mangers and shareholders. On the contrary, a high concentration of ownership negatively affects the market response to R&D spending. The risk of expropriation of minority shareholders could be an explanation for this result. Controlling for investor protection of minority shareholders, we find that firms with a higher degree of ownership concentration operating in countries with weaker investor protection of minority shareholders have a lower market valuation than those ones with higher concentration of ownership belonging to countries with stronger investor protection of minority shareholders.

Finally, this study provides interesting ideas to be taken into account when making decisions at the firm level and to attain more effective R&D spending, since the R&D intensity strongly depends on the firm's characteristics and corporate governance factors. Several characteristics and corporate governance features moderate the market valuation of R&D spending. Therefore, corporate governance should be taken into account by the policy decision makers, whereas a firm's characteristics should be accounted for by shareholders and managers. In doing so, both types of decision makers would substantially increase the effectiveness of R&D spending; consequently, fostering economic growth.

To sum up, the thesis proved in this work is as follows: *"The positive effect of R&D on a firm's value is moderated by its characteristics and the corporate governance factors, which mitigate the sensitivity of R&D to cash flow."*

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Appendix 1

In this Appendix we present the definition and calculation of the variables used in our analysis, when necessary. Except for the items we point out that come from the *Main Economic Indicators* published by the Organization for Economic Cooperation and Development (OECD), the remaining items have been extracted from Worldscope.

Firm value

This variable is a derivation of our valuation model. According to Equation (14), our dependent variable is computed as follows:

$$\frac{V_{it} - BV_{it}}{K_{it}}$$

where V_{it} is the market value of equity and BV_{it} is its book value. K_{it} stands for the replacement value of total assets computed as follows:

$$K_{it} = RF_{it} + \left(TA_{it} - BF_{it}\right)$$

where RF_{it} is the replacement value of tangible fixed assets, TA_{it} is the book value of total assets, and BF_{it} is the book value of tangible fixed assets. The latter two have been obtained from the firm's balance sheet and the first one has been calculated according to the proposals by Perfect and Wiles (1994):

$$RF_{it} = RF_{it-1}\left[\frac{1+\phi_t}{1+\delta_{it}}\right] + I_{it}$$

for t>t_0 and $RF_{it0}=BF_{it0}$, where t_0 is the first year of the chosen period, in our case 1986. On the other hand $\delta_{it}=D_{it}/BF_{it}$ and $\phi_t=(GCGP_t-GCGP_{t-1})/GCGP_{t-1}$, where $GCGP_t$ is the growth of capital goods prices extracted from the *Main Economic Indicators*.

Residual income

As expressed in Equation (7), this variable is defined as:

$$RI_{it} = \pi_{it} - \kappa_{it} BV_{i,t-1}$$

where π_{it} stands for the net income and K_{it} denotes the cost of capital. For each firm and time period the cost of capital has been calculated by using the Capital Asset Pricing Model (CAPM):

$$\kappa_{it} = rf_{it} + (E(rm_{it}) - rf_{it})\beta_{it}$$

where rf_{it} is the risk-free rate extracted from the *Main Economic Indicators* for each country and time period. The market return (rm_{it}) was computed by using the market price of all the companies listed in each country regardless of whether or not they provide research and development information. The sample used for computing the market return comprises 3,147 companies and 21,072 observations[31]. The company's beta (β_i) was also computed by using the market price and the same sample mentioned above to compute the market return item.

Research and development

This variable (RD_{it}) was extracted from Worldscope and represents all direct and indirect costs related to the creation and development of new processes, techniques, applications and products with commercial possibilities.

Market share

This variable is computed as follows:

$$MS_{it} = \frac{NS_{it}}{\sum_{i=1}^{n} NS_{it}}$$

where NS_{it} denotes the net sales of firm i, and $\sum_{i=1}^{n} NS_{it}$ stands for the total net sales of its

[31] The distribution of this sample across countries and industries will be provided by authors upon request.

industry. To compute the net sales of the industry, we have used the sample comprising 3,147 companies and 21,072 observations.

Long term debt

The market value of long term debt, $MVLTD_{it}$, is obtained from the following formula:

$$MVLTD_{it} = \left[\frac{1+l_{it}}{1+i_l}\right] BVLTD_{it}$$

where $BVLTD_{it}$ is the book value of the long term debt, i_l is the rate of interest of the long term debt reported in the *Main Economic Indicators* and l_{it} is the average cost of long term debt that is defined as $l_{it}=(IPLTD_{it}/BVLTD_{it})$, where $IPLTD_{it}$ is the interest payable on the long term debt, which has been obtained by distributing the interest payable between the short and long term debt depending on the interest rates. That is:

$$IPLTD_{it} = \frac{i_l \, BVLTD_{it}}{i_s \, BVSTD_{it} + i_l \, BVLTD_{it}} IP_{it}$$

where IP_{it} is the interest payable, i_s stands for the rate of interest of the short term debt, also reported in the *Main Economic Indicators*, and $BVSTD_{it}$ is the book value of the short term debt.

Size dummy

This dummy variable, DS_{it}, is equal to 1 if the firm size is larger than the sample mean, and 0 otherwise. The firm size is calculated as the natural logarithm of the replacement value of total assets.

Growth dummy

This dummy variable, DGR_{it}, takes value 1 for firms whose rate of growth is larger than the sample mean, and 0 otherwise. The rate of growth for each firm is calculated as follows:

$$GR_{it} = \frac{NS_{it} - NS_{i,t-1}}{NS_{i,t-1}}$$

where NS_{it} denotes the net sales.

Free cash flow dummy

This dummy variable, $DFCF_{it}$ takes value 1 for firms whose free cash flow level is higher than the sample mean, and 0 otherwise. Following Miguel and Pindado (2001), we constructed a free cash flow variable as the interaction between the firm's cash flow and the inverse of its investment opportunities.

$$FCF_{it} = CF_{it}\left(\frac{1}{Q_{it}}\right)$$

We compute a firm's cash flow as $CF_{it} = NIAPD_{it} + DEP_{it}$, where $NIAPD_{it}$ denotes net income after preferred dividends, and DEP_{it} stands for the book depreciation expense.

Tobin's q is calculated as follows:

$$Q_{it} = \frac{V_{it} + PS_{it} + MVLTD_{it} + BVSTD_{it}}{K_{it}}$$

where PS_{it} is the value of the firm's outstanding preferred stock.

Market share dummy

This dummy variable, $DMS_{it,}$ takes value 1 for firms whose market share level is larger than the sample mean, and 0 otherwise.

External finance dependence dummy

This dummy variable, $DEFD_{it,}$ takes value 1 for firms whose external finance dependence level is larger than the sample mean, and 0 otherwise. The external finance dependence is calculated as follows:

$$EFD_{it} = \frac{I_{it} - CF_{it}}{K_{it}}$$

where I_{it} denotes investment, calculated according to the proposal by Lewellen and Badrinath (1997):

$I_{it}=NF_{it}-NF_{it-1}+BD_{it}$

where[32] NF_{it} denotes net fixed assets and BD_{it} is the book depreciation expense.

Labour intensity dummy

This dummy variable, DLI_{it}, takes value 1 for firms whose labour intensity level is higher than the sample mean, and 0 otherwise. The labour intensity is calculated as follows.

$$LI_{it} = \frac{NE_{it}}{NS_{it}}$$

where NE_{it} denotes the number of employees.

Capital intensity dummy

This dummy variable, DC_{it}, takes value 1 for firms whose capital intensity level is larger than the sample mean, and 0 otherwise. The capital intensity is calculated as follows:

$$CI_{it} = \frac{RF_{it}}{NS_{it}}$$

Dividends

The dividends are computed as the dividends paid based on the current year's net income scaled by the replacement value of total assets.

Tangible fixed assets

The tangible fixed assets are computed as the net book value of property plant and equipment, scaled by the replacement value of total assets.

Appendix 2 (referred to in footnote 6): algebraic manipulation

$$V_{it} = E_t \sum_{j=1}^{\infty} \frac{(BV_{i,t+j-1} + \pi_{i,t+j} - BV_{i,t+j})}{(1+r_{it})^j} =$$

$$\frac{E_t(BV_{it})}{(1+r)} + \frac{E_t(\pi_{i,t+1})}{(1+r)} - \frac{E(BV_{i,t+1})}{(1+r)} + \frac{E(BV_{i,t+1})}{(1+r)^2} + \frac{E_t(\pi_{i,t+2})}{(1+r)^2} - \frac{E_t(BV_{i,t+2})}{(1+r)^2} + \ldots + \frac{E_t(BV_{i,t+\infty-1})}{(1+r)^{\infty}} + \frac{E_t(\pi_{i,t+\infty})}{(1+r)^{\infty}} - \frac{(BV_{i,t+\infty})}{(1+r)^{\infty}} .$$

(A.1)

Note that for each j there are three components. For instance, for j=1 we have

[32] The details on the derivation process of this formula will be provided by appendix 3.

$$\frac{E_t(BV_{it})}{(1+r)} + \frac{E_t\,(\pi_{i,t+1})}{(1+r)} - \frac{E(BV_{i,t+1})}{(1+r)}.$$

Then, we sum the last component of each j with the first two components of the next j in Equation (A.1). For instance, for j=1 we have

$$-\frac{E(BV_{i,t+1})}{(1+r)} + \frac{E(BV_{i,t+1})}{(1+r)^2} + \frac{E_t(\pi_{i,t+2})}{(1+r)^2} =$$

$$\frac{-E(BV_{i,t+1}) - rE(BV_{i,t+1}) + E(BV_{i,t+1}) + E(\pi_{i,t+2})}{(1+r)^2} =$$

$$\frac{E(\pi_{i,t+2}) - rE(BV_{i,t+1})}{(1+r)^2}. \text{ (A.2)}$$

The same applies for the remaining j to infinity.

$$\frac{E_t(BV_{it})}{(1+r)} + \frac{E_t\,(\pi_{i,t+1})}{(1+r)} + \frac{E(\pi_{i,t+2}) - rE(BV_{i,t+1})}{(1+r)^2} + \ldots + \frac{E(\pi_{i,t+\infty}) - rE(BV_{i,t+\infty})}{(1+r)^{i\infty}} - \frac{(BV_{i,t+\infty})}{(1+r)^{\infty}} \text{ (A.3)}$$

As a result of this process, we have Equation (A.3). As can be seen in this Equation, all the terms follow the pattern in Equation (A.2), which varies in j, except for the first two, and the last components. The first two components can be written in a similar way, as follows

$$BV_{it} - BV_{it} + \frac{E_t(BV_{it})}{(1+r)} + \frac{E_t\,(\pi_{i,t+1})}{(1+r)} =$$

$$BV_{it} + \frac{-BV_{it} - rBV_{it} + E_t(BV_{it}) + E_t(\pi_{i,t+1})}{(1+r)} \text{ (A.4)}$$

Since we are at moment t, $E_t\,(BV_{i,t+1}) = BV_{it}$, and Equation (A.4) is

$$BV_{it} + \frac{E_t\,(\pi_{i,t+1}) - rBV_{it}}{(1+r)}.$$

Substituting this result in the Equation (A.3) above, we have

$$BV_{it} + \frac{E_t\,(\pi_{i,t+1}) - rBV_{it}}{(1+r)} + \frac{E(\pi_{i,t+2}) - rE(BV_{i,t+1})}{(1+r)^2} + \ldots + \frac{E(\pi_{i,t+\infty}) - rE(BV_{i,t+\infty})}{(1+r)^{i\infty}} - \frac{(BV_{i,t+\infty})}{(1+r)^{\infty}}.$$

Note that all terms follow the same pattern, except for the first and last, hence we can write the previous formula as follows

$$V_{it} = BV_{it} + E_t \sum_{j=1}^{\infty} \frac{(\pi_{i,t+j} - rBV_{i,t+j-1})}{(1+r)^j} - \frac{E_t(BV_{i,t+\infty})}{(1+r)^{\infty}}.$$

This is the equivalent to Equation (6) in the paper.

Appendix 3 (referred to in footnote 34): construction of the investment variable.

Investment is calculated according to the proposal by Lewellen and Badrinath (1997) as follows:

$FA_{it}=FA_{it-1}+I_{it}-R_{it}$ (B.1)

$ABD_{it}=ABD_{it-1}+BD_{it}-R_{it}$. (B.2)

Where FAit is the gross book value of the tangible fixed assets of the period *t*, *Rit* the gross book value of the old assets retired during the year *t, ABDit* the accumulated book depreciation for the year *t,* and *BDit* the book depreciation expense corresponding to year *t*. solving Eq. B.2 for R_{it} and substitute it into *Eq*. A.1, we obtain B.3,

$FA_{it}=FA_{it-1}+I_{it}+ABD_{it}-ABD_{it-1}-BD_{it}$. (B.3)

Realigning terms, Eq. A.3 is transformed into expression B.4,

$FA_{it}-ABD_{it}=FA_{it-1}-ABD_{it-1}+I_{it}-BD_{it}$. (B.4)

As for $FA_{it}-ABD_{it}=NF_{it}$, the net fixed assets, the former equation can be rewritten as in Eq. B.5,

$NF_{it}=NF_{it-1}+I_{it}-BD_{it}$, (B.5)

from which we obtain the value of investment

$I_{it}=NF_{it}-NF_{it-1}+BD_{it}$. (B.6)