HOW CEO ATTRIBUTES AFFECT FIRM R&D SPENDING? NEW EVIDENCE FROM A PANEL OF FRENCH FIRMS

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Résumé :

Cette étude examine empiriquement la relation entre les attributs du dirigeant et les dépenses de R&D. Les résultats obtenus sur un échantillon d'entreprises françaises cotées sur Euronext Paris, montrent une relation en U inversé entre les dépenses de R&D et à la fois l'ancienneté et l'âge du dirigeant attestant ainsi l'existence d'un optimum d'âge et d'ancienneté du dirigeant au-delà duquel le dirigeant a tendance à diminuer la prise du risque dans les stratégies choisies et à réduire notamment les dépenses de R&D. En outre, les résultats montrent une relation curvilinéaire en U entre les dépenses de R&D et la part du capital détenu par le dirigeant. Le niveau des dépenses de R&D est négativement (positivement) associé à la part de propriété du dirigeant à des niveaux faibles (élevés) de propriété. Ce résultat implique qu'à des niveaux faibles de propriété du dirigeant, une augmentation de cette part a pour effet d'aggraver la myopie managériale et le problème de sous-investissement dans les activités de R&D. Toutefois, en détenant une part élevée du capital, le dirigeant devient motivé à investir dans des projets de R&D risqués et à long terme reflétant ainsi un alignement des intérêts des dirigeants avec ceux des actionnaires.

Mots-clés: Dépenses de R&D, attributs du dirigeant, théorie de l'agence, upper-echelons perspective

Abstract :

This study investigates empirically the relationship between CEO attributes and R&D spending. Using a sample of French firms listed on Euronext Paris, the empirical results indicate an inverted U-shaped relationship between R&D spending and both CEO's tenure and age suggesting the existence of a critical CEO age and a critical point in time over CEO tenure at a firm before which CEO increases the amount spent in R&D activities and after which CEO begins to exhibit investment myopia by gradually reducing the amount spent in R&D activities. Furthermore, we find a U-shaped relationship between R&D spending and CEO ownership; R&D spending is negatively (positively) associated with CEO ownership at low (high) levels of CEO stockholding. This result implies that at low levels of CEO ownership, an increase in CEO ownership exacerbates CEO myopia and the under-investment problem with regard to R&D activities. However, at high levels of CEO ownership, CEO becomes more willing to invest in risky R&D projects which may reflect a closer alignment of managers' and shareholders' interests.

Keywords: R&D spending, CEO attributes, agency theory, upper-echelons perspective

Introduction

Over the last two decades, the academic literature has provided evidence on the crucial role played by research and development (hereafter R&D) activities in enhancing firm performance, gaining and sustaining a competitive advantage (Scherer, 1984; Ettlie, 1998; O'Brien, 2003; Kor, 2006), particularly in firms operating in the technology and science-based industries (Chang *et al.*, 2006). Recognition of the increasing importance of R&D activities to firm growth and prosperity has fuelled a debate about the factors that influence firm's commitment to these activities. There are a handful of empirical studies that have examined the effects of firm industry (e.g. Scherer, 1984; Sujit and Mukherjee, 2005), corporate diversification strategy (e.g. Hoskisson and Hitt, 1988; Baysinger and Hoskisson, 1989; Lopez-Sanchez *et al*., 2006), ownership structure (e.g. Lee and O'Neill, 2003; Ortega-Argilés *et al*., 2005; Chen and Hsu, 2009), institutional ownership (e.g. Graves, 1988; Bushee, 1998; David *et al.*, 2001), board of directors (e.g. Baysinger *et al*., 1991; Osma, 2008; Chen and Hsu, 2009), compensation policy (e.g. Cheng, 2004), among other factors, on R&D spending. As seen, these studies, however, almost consistently emphasize on firm, board or ownership characteristics as determinants of corporate R&D spending while overlooking the attributes of the top managers involved in strategic decision making. Then, in this research we change the earlier studies focus by investigating empirically how might Chief Executive Officer (hereafter CEO) attributes affect strategic decision making with regard to commitment in R&D activities?

By answering to this question we will contribute to the existing literature in two aspects. First, this study set out to shed light on the relationship between R&D spending and CEO characteristics, which is still rarely explored, from a cross-functional perspective that includes upper-echelons perspective and agency theory. In fact, many previous studies have investigated the issue of R&D investment decision, primarily from the perspective of agency and corporate governance theories. However, a firm's corporate strategy, such as investment decisions, is developed by top managers, whose preferences and attitudes may exert a great influence on the strategy adopted. According to the upper-echelon perspective organizational outcomes -strategic choices and performance levels- are reflections of the values and cognitive bases of top managers (Hambrick and Mason, 1984). Differences in observable and psychological characteristics of managers lead to different executive behaviors and strategic choices (Finkelstein and Hambrick, 1996). Then, integrating the upper-echelons perspective

into the issue of R&D strategy enables us to discover that CEOs attributes may affect a firm's risk propensity in strategy-making and thereby commitment in R&D activities. We believe that is substantially beneficial for the scholars by expanding their attention from environmental and organizational determinants of firms' decisions to include the characteristics of the decision makers, in particular the top managers of companies involved in R&D activities. Second, by undertaking this study we hope to add to the innovation literature that aims to determine the profiles of top executives at innovative firms (Chaganti and Sambharya, 1987). This is particularly useful for both those responsible for selecting and developing top executives and for the strategists who is trying to predict the competitor's R&D spending level. Therefore, given that R&D investment is important for firm's performance and competitiveness, namely for those operating in high-technology industries, it could be considerably important for boards to select and develop appropriate person for top management positions who will make value-maximizing decisions in the best interests of shareholders. For instance, boards may need to appoint younger persons to the top positions since they are more willing to develop a strategy more conducive to risk taking and innovation (Carlsson and Karlsson, 1970). Furthermore, given our findings, strategic decision makers could predict a competitor's R&D spending level based on the specific characteristics of its CEOs, namely, CEOs' tenure, age and stock ownership. For example, light has been shed on the tendencies of companies led by older or/and longer-tenured CEOs to pursue short-term and low risk strategies. Therefore, a firm entering a market where many of the incumbent firms have older or/and longer-tenured CEOs may be able to predict the future R&D spending behaviour of their new rivals better, ceteris paribus (Barker and Muller, 2002).

Using data from a sample of French firms listed on Euronext Paris for the period 2001–2006, this paper provides evidence that CEO's characteristics, namely CEO's age, tenure and stockholding, exert considerable influence on firm strategic decisions regarding R&D activities. The empirical results indicate an inverted U-shaped relationship between R&D spending and both CEOs' age and tenure, suggesting the existence of a critical CEOs age and a critical point in time over their tenure at a firm after which CEOs begin to exhibit investment myopia by gradually reducing the amount spent in R&D activities. These results suggest that older or/and longer-tenured CEOs are conservative and tend to avoid risk in decision making leading them to under-invest in risky R&D projects. However, younger and/or shorter-tenured CEOs, given that their career and financial security concerns have a longer time horizon, are willing to develop strategies more conducive to risk taking such as

commitment in R&D activities. Furthermore, in this study we find a U-shaped relationship between R&D spending and CEO ownership; R&D spending is negatively (positively) related with ownership at low (high) levels of CEO ownership. This result implies that increasing ownership at low levels of CEO ownership exacerbates CEO myopia and the under-investment problem with regard to R&D activities, because CEO has preference for low-risk strategies that stems from the lack of diversification of its wealth portfolio. However, at high levels of CEO ownership, CEO becomes more willing to invest in risky projects such as R&D investments which may reflect a closer alignment of managers' and shareholders' interests.

The remainder of this paper proceeds as follows. First, we begin with an overview of the literature on R&D spending and CEO attributes relationship as well as the testable hypothesis. The third section describes the research design and outlines data sources and sample selection procedure. The empirical analysis and results are presented in the fourth section. Finally, the fifth and the sixth sections conclude the paper by presenting the discussions, implications for theory and practice, limitations and some directions for future research.

1. Literature review and hypothesis development

Despite the importance of R&D investment for firms' prosperity and competitiveness, agency theorists argue that R&D investment may not be primarily targeted by managers toward improving the long-term value of the firm (Jensen, 1993). In fact, the separation of ownership and control has induced potential conflicts between the interests of managers and stockholders (Berle and Means, 1932). This conflict of interests is more acute in decision regarding corporate R&D investment due to its long-term horizon and its high degree of uncertainty. Managers and shareholders often diverge in their temporal preferences and in their attitudes toward risk (David *et al*., 2001). Indeed, given that their wealth is tied to the firm performance over their limited predictable tenure, managers have a preference to make investment decision that maximize firm short-term earnings and consequently enabling them to increase their compensation, which is generally based on short-term accounting measures (Jensen, 1986), and to enhance their reputation more rapidly in the job market (Narayanan, 1985; Hirshleifer, 1993). As a result, managers are motivated to under-invest in R&D activities since that the long-term effects of this strategy might only be manifested after they have already left the firm (Rumelt, 1987). In contrast, shareholders search for long-term profitability maximization as their wealth is tied to the expected firm performance over a generally unbounded time

period. Furthermore, shareholders and managers have different degrees of risk aversion. . Since the payoffs of R&D projects are excessively uncertain, managers whose human capital is difficult to diversify tend to avoid such risky projects (Hirshleifer and Thakor, 1992) that their failure during their career can be harmful implying an immediate employment risk (Alchian and Demsetz, 1972). However, shareholders favour risky projects such as R&D projects because they are able to diversify the inherent R&D risk by holding diversified portfolios (Hay and Morris, 1979). From the above, as the decision making is in the responsibility of top managers we assume that involvement in R&D activities is a decision that top managers have the discretion to control (e.g. Green, 1995) and to adjust the amount spent in these activities level based on their preferences (Barker and Mueller, 2002). Risk aversion and short sightedness of managers may lead them to reduce R&D spending to serve their own interests at the expense of shareholder wealth. This managerial behaviour may generate problems regarding the efficient allocation of firm resources (Jensen and Meckling, 1976).

At this stage, a main question arise, since that the strategic choices in the organization such as innovation is mainly determined by its top managers (Bantel and Jackson, 1989), how might the characteristics of top managers, and specifically CEOs, affect corporate R&D strategy?

The upper-echelons perspective establishes a connection between managers' decision making style and their characteristics and suggests that certain managers' observable demographic characteristics such as age tenure, education, functional backgrounds among others can be used as determinants of strategic choices and through these choices, of organizational performance (Hambrick and Mason, 1984).

Using insights from upper-echelons perspective, we assume that CEOs characteristics may influence the strategic decision making with regard to commitment in R&D activities. We limit our focus on the CEO rather than top management team, since that several studies have proved the importance of the role played by CEO as a central actor in designing the composition of the top management team (Zahra and Pearce, 1989) and in conducting the strategic decision making (Goodstein and Boeker, 1991). In fact, as suggested by Daellenbach *et al*. (1999), a top management team would be more open to innovation based on their demographic characteristics may not approve budgets supporting a commitment to innovation if the CEO does not favour this orientation.

Below, this paper adopts Hambrick and Mason's (1984) upper-echelons perspective and considers four visible characteristics of CEO, including CEO age, tenure, stock ownership and duality in order to explore whether and how CEO characteristics affect strategic decision making toward R&D activities.

1.1. CEO age

Eaton and Rosen (1983) argue that the age of the managers reflects their degree of risk aversion and that as managers' age increases, they become more inclined to adopt less risky decisions in order to safe their career. Marshall *et al.* (2006) suggest that as managers grow older, they become more reliant on their own sources of information for making decisions, more conservative and less likely to take risks. Risk aversion and myopia is likely to become more intense when the CEOs' age is close to retirement age given that their limited horizon and weakened career concerns. In fact, previous studies have shown that as CEOs near retirement age, they exhibit growing aversion to risk (Matta and Beamish, 2008), they become more oriented toward short-term investment strategies (Gibbons and Murphy, 1992a) and hence they tend to reduce R&D spending in the years leading up to their exit (Dechow and Sloan, 1991).

Given that the payoffs from R&D projects are highly uncertain and occurs over the long term, older CEOs, having only a few years before retirement, may not personally benefit from these payoffs in the form of higher short-term salary and bonuses (Barker and Muller, 2002). In fact, while such risky-long projects could provide rewards to shareholders and the CEOs' successors, they might jeopardize current returns and adversely affect the present CEO's wealth (Murphy and Zimmerman, 1993; Berger *et al.* 1997), especially if the company adopts incentive compensation plans that pay CEOs based on current accounting earnings and treat R&D costs as expenses[1] in their accounting statements. Thus, older CEOs likely have stronger incentives to reduce R&D expenditures to boost up short-term earnings in order to maximize their compensation. In contrast, according to Gibbons and Murphy (1992b) CEOs who are far from retirement are willing to take more costly unobservable actions in an attempt to influence the market's belief about their abilities because they are more concerned about

[1] The accounting treatment of R&D costs is an area of divergence between U.S. Generally Accepted Accounting Standards (U.S. GAAP) and International Financial Reporting Standards (IFRS). Under U.S. GAAP, almost all R&D expenditures are recognized as expenses when incurred. IAS/IFRS standards require that R&D costs to be expensed as incurred. However, certain development costs must be capitalized if they meet the criteria for recognition as an asset fixed in IAS 38 "Intangible Assets".

their careers. Younger CEOs have consistently been found to be willing to develop a strategy more conducive to risk taking and innovation (Carlsson and Karlsson, 1970) and to foster firm growth (Child, 1974; Hambrick and Mason, 1984), as they may be more capable of learning and integrating information in making decisions, and thus may have more confidence mainly in risky decisions (Taylor, 1975). Also, younger CEOs can be more risk seeking through, for example, increasing R&D spending because their career and financial security concerns have a longer time horizon (Barker and Muller, 2002). Based on this reasoning, we can predict the existence of a non-monotonic relationship between CEO age and R&D spending. These costs increase as the CEO age rises until a certain optimum age and then decrease as CEO age continue to rise and approaches the retirement age. This prediction has been well confirmed by the study of Ryan and Wiggins (2002), which certifies the existence of a non-linear inverted U shaped relationship between R&D spending and CEO age such that there exists a critical age before which R&D spending increases and after which begins to decrease as the CEO age increases. Thus, we hypothesize the following:

H_1: There is an inverted U-shaped relationship between CEO age and R&D spending.

1.2. CEO tenure

The main idea developed in upper-echelon theory regarding the CEO-tenure concept is based on the «seasons of a CEOs-tenure» model proposed by Hambrick and Fukutomi (1991). This model reveals the dynamics of the CEO's tenure in office in which there are discernible seasons[2] that give rise to distinct pattern of CEO attention, behavior, and, ultimately, organizational performance (Hambrick and Fukutomi, 1991). In the beginning of their career in a firm, CEOs are in a vulnerable position with relatively low power and low levels of task knowledge and thereby are less likely to pursue personal interests at the expense of shareholders' interests. After an initial period of learning, CEOs become more open-minded, initiate experimenting and increase commitment. As tenure lengthens, CEOs accumulate more power and gain the confidence of shareholders and various firm's partners. "They become committed to their psychological paradigms that worked best in the past and therefore narrow down their information sources. Moreover, they feel less challenged, and tend to become inert to changes happening in the firm's environment" (Gils *et al.*, 2008). Longer-tenured CEOs tend to slow their knowledge, growth and development (Audia *et al.*, 2000;

[2]The five seasons delineated by Hambrick and Fukutomi (1991) are (1) response to mandate, (2) experimentation, (3) selection of an enduring theme, (4) convergence, and (5) dysfunction.

Hambrick and Fukutomi, 1991; Kroll *et al*., 2000), decrease their commitment to learning, narrow their information search (Finkelstein and Hambrick, 1996) and then may lose contact with their organizations' environments (Miller, 1991). Previous studies have shown that longer-tenured CEOs are inclined to become more risk-averse and to limit strategic changes and commitment in innovation (Grimm and Smith, 1991; Hambrick *et al*., 1999; Zahra, 2005). Furthermore, Chaganti and Sambharya (1987) and Thomas et al (1991), found that firms following prospector strategies emphasizing product-market innovations were lead by shorter-tenured CEOs. In contrast, firms following "defender" strategies emphasizing efficiency were lead by longer-tenured CEOs. As a result, longer-tenured CEOs may have little interest in pursuing strategies of innovation through higher R&D spending, preferring instead to emphasize stability and efficiency (Barker and Muller, 2002).

Based on the foregoing, we anticipate a non-monotonic relationship between CEOs tenure and R&D spending. At the beginning of their career in a firm, CEOs have low power and their concern is to prevail the confidence of shareholders and to build their reputation on the labor market. As a result, there is in their interests to pursue strategies conform to shareholders' interests such as R&D investment that enhance future firm performance, given that they have ample time to realize the benefits from future expected returns. As tenure rises from negligible to moderate levels, CEOs' increased task knowledge, confidence, and familiarity with prominent elements of the competitive situation should enhance their ability to pursue beneficial R&D strategies such as R&D activities. At this stage, although power increases over time, they are less likely to have enough power than long-tenured CEOs, and may be less likely in a position to pursue strategies benefiting themselves more than shareholders (Walters *et al*., 2007). As tenure rises from moderate to substantial levels, longer-tenured CEOs may gain sufficient power vis-à-vis the board and develop personal relationships with directors (Westphal and Zajac, 1995) and subsequently, directors may come to trust them implicitly (Shen, 2003; Westphal and Zajac, 1996). Such a power shift may facilitate CEOs' commitment in strategies in their favour over the shareholders' interests. Furthermore, longer-tenured CEOs may lose interest in making strategic changes and investment decisions that could keep the firm progressing over time (Miller, 1991; Barker and Mueller, 2002). Then, they may be more willing to engage in opportunistic myopic behavior and consequently to reduce the amount spent in R&D activities. This myopia is more intense if the CEOs retirement at the firm coincides with their retirement from their career, so that

they become less worried about being punished by the managerial labor markets for bad performance (Waisman *et al*., 2005).

From the above, and cconsistent with the findings of Waisman *et al*. (2005) we anticipate an inverted U-shaped relationship between CEO tenure and R&D spending such that at some point during their tenure, CEOs gradually start to decrease the amount of money spent in R&D investments. Then, we hypothesize the following:

H_2: There is an inverted U-shaped relationship between CEO tenure and R&D spending.

1.3. CEO ownership

Jensen and Meckling (1976) argue that an important managerial ownership helps to align managers' interests with those of shareholders (the assumption of "the convergence of the interests"). According to these authors, if the managers hold a significant portion of the firm's equity, they may become reluctant to take advantage of their position, to consume perquisites, to expropriate the wealth of shareholders and to engage in pursuing non-value-maximizing objectives. Also, Cho (1992) affirms that if the managers assume a major ownership share in the firm's equity the conflict of interests between managers and shareholders may be alleviated because the managers also bear the consequences of actions deviating from the shareholders' interests. In fact, any attempt by managers of mismanagement of firm's resources can undermine the performance of the firm and jeopardize the portion of their wealth tied strongly to the firm value. Then, a higher level of managers' stockholdings could align managerial objectives and shareholder objectives (Chen and Huang, 2006) and motive managers to undertake risky investments (Wright *et al*., 2007) According to the incentive alignment argument, we presume that in firms with high managerial ownership, managers are more likely to commit in R&D activities aimed at maximizing shareholders' wealth. This presumption has been supported by Barker and Mueller (2002) and Nam *et al*. (2003) who found a positive relationship between the CEOs' stockholdings and R&D spending.

However, The assumption of "the convergence of the interests" has been criticized by Fama and Jensen (1983a) who affirm that managerial ownership may have adverse effects on the agency relationship between managers and shareholders given that high managerial ownership may engender significant agency costs. They argue that instead of reducing the agency problems, the managerial ownership may entrench the current managers, increase their ability to neutralize the mechanisms controls and then exacerbate managerial opportunism.

Morck *et al.* (1988) affirm that a high managerial ownership enlarge the capacity of the managers to escape from control and to make decisions that maximize their wealth at the expense of other shareholders without endangering their employment and salaries (the assumption of 'the managerial entrenchment'). In particular, with significant voting power and influence, it becomes more difficult to control managerial behaviour, resulting in fewer constraints on managers' ability to adjust R&D investment level to their own self-interests. Based on the entrenchment assumption, the relationship between managerial ownership and R&D spending will be negative as confirmed by Chen et al (2006).

From the above, the expected effects of managerial ownership on R&D seem to be ambiguous, reflecting the net effect of benefits and burdens of managerial ownership. This ambiguity has been confirmed empirically, since some studies have concluded the existence of a nonlinear relationship between managerial ownership and R&D spending (Cho, 1998; Abdullah et al., 2002; Ghosh *et al*., 2007) although the actual nature of this nonlinearity differs across studies.

Ghosh et al (2007) found a non-linear association between R&D spending and CEO stock ownership. R&D spending increases as CEO ownership rises from 0 to 5%, declines across increasing levels of CEO ownership (between 5% and 25%) and then increases again for CEO ownership greater than 25%. The relation between CEO ownership and R&D spending is significant for CEO ownership levels between 0% and 25%, but is insignificant for levels above 25%. These results suggest that at low ownership levels (0-5%), CEOs are willing to invest in high-risk R&D projects reflecting better alignment of managers' interests with those of the other shareholders. However, when CEOs ownership levels are high (5%-25%) the risk aversion and the under-investment problem associated with R&D activities are exacerbated and CEOs with higher stock ownership become more reluctant to commit in R&D activities to limit their exposure to high risks since they are more likely to have an under-diversified personal wealth portfolio Ghosh et al (2007). But, at very high levels of CEOs stockholdings (up to 25%), CEOs ownership has no influence on R&D expenditures.

Similarly to the Ghosh et al (2007) study's findings, Cho (1998) find also a non-monotonic relationship between insider ownership and R&D expenditures. He estimates a piecewise linear regression of investment on insider ownership, imposing the breakpoints of 7% and 38% found in the value-ownership relation. The results show that the level of R&D investment rises as insider ownership increases up to 7% and it decreases as insider ownership rises from 7% to 38%, not being affected by insider ownership beyond 38%.

Abdullah et al (2002) confirm also the non-linear relationship between managerial holdings and R&D expenditures however the nature of this non linearity differs from the previous studies findings (Ghosh et al, 2007; Cho, 1998) since they find a W shaped relationship. Specifically, R&D spending decreases as managerial ownership increases from 0 to 5%. It increases slightly as managerial ownership rises from 5% to 10%, but decreases again when managerial stockholding rises from 10% to 15% levels. However, as managerial ownership increases beyond the 15% level, R&D spending increases sharply. These results indicate that at relatively low levels of managerial holdings (between 0 and 5%) managers are more focused on achieving short-term benefits leading them to reduce R&D spending. As managerial ownership increases (from 5% to 10%), managers become more long-term oriented and interested with commitment in R&D activities. However, at medium levels of ownership (between 10% and 15%) managers appear to become "entrenched" and may indulge in non-value-maximizing behavior leading them to lower R&D spending. But, higher levels of managerial holdings (up to 15%) seem to provide a strong incentive for managers to increase R&D expenditures and a strong concern for the future growth of the firm reflecting the convergence of managers' interests with those of shareholders.

From the foregoing, we conclude that depending upon the level of managerial holdings, either 'the convergence of interests' or 'managerial entrenchment' hypothesis will prevail, and, consequently the relation of CEOs ownership with R&D spending will be non-monotonic. As Ghosh *et al.* (2007), we expect that R&D expenditures increase (decrease) with increasing CEO stock ownership at low (high) levels of ownership. Then, we hypothesize that:

H_3: There is an inverted U-shaped relationship between CEO ownership and R&D spending.

1.4. CEO/Chairman duality

Many scholars argue that consolidating the positions of CEO and chairman of the board in one person impairs the monitoring function of a board and his effectiveness (Fama and Jensen, 1983b; Jensen, 1993; Lehn and Zhao, 2006). In fact, when the CEO also chairs the board of directors, decision-making and the monitoring of those decisions resides with the same person and then the CEO dominates the board and can challenge the board's independence and ability to effectively monitor and discipline management (Mallette and Fowler, 1992). Consequently, the dominating role of the CEOs allows the managers to defend easily the projects they prefer even if they are against shareholders' interests. In light of these

arguments, it is presumed that a separation of chairman of the board and the CEO duties is favourable to enhance the independence of the board, to limit the managers' opportunism and therefore to facilitate commitment in R&D activities which lead to superior future firm performance. Then, we hypothesize that:

H_4: There is a negative relationship between CEO/Chairman duality and R&D spending.

2. Research methodology

2.1. Sample selection

The sample consists of French firms listed on Euronext Paris during the period 2001-2006. We eliminate financial firms because they present a specific financial structure. Similarly, foreign firms subject to specific regulations and those having undergone a merger during the study period were excluded. Among the remaining firms, we drop firms that not undertake R&D activities and those that not report the annual amount of R&D expenditures. In addition, we exclude all firm-year observations with missing data needed to calculate independent and control variables. Finally, we eliminate observations called "outliers"[3] suspected of disrupting the quality of our econometric results. The final sample size consists of 103 firms observed over a period of 5 years, then 515 firm-year observations. Table 1 provides the sample distribution by industry classification.

Table 1: *Sample distribution by industry*

Industries	***Number of firms***	***Percent of sample***
Oil & Gas	2	1.9%
Basic Materials	7	6.8%
Industrials	21	20.4%
Consumer Goods	22	21.4%
Health Care	9	8.7%
Telecommunications	2	1.9%
Utilities	3	2.9%
Consumer services	5	4.9%
Technology	32	31.1%
Total	**103**	**100%**

[3] For the identification of outliers, we used the studentized residuals and Cook's distance.

2.2. Data collection

To determine annual R&D expenditures, we have combined the data available in Worldscope and Extel databases with those contained in the firms' annual reports. Data on CEO attributes were hand collected from firm's annual reports. These data were completed using the following databases: Diane, Dafsalien and Worldscope. We also consulted the website: www.topmanagement.net to complete data on CEO age. We extract all other financial variables from Worldscope database.

2.3. Measurement of variables

Dependent variable

R&D intensity is defined as firm's annual R&D expenditures divided by total assets (Ryan and Wiggins, 2002; Cui and Mak, 2002; Nam *et al*., 2003; Chen *et al*., 2006).

Independent variables

CEO age was measured in years (Barker and Mueller, 2002; Ghosh *et al*., 2007). CEO tenure is the number of years since being appointed CEO (Ryan and Wiggins, 2002; Barker and Mueller, 2002). CEO/Chairman duality is a dummy variable that equals one if the CEO is also serves as the board chairman and 0 if not (Chen and Hsu, 2009). We measure CEO ownership as the shares owned by the CEO divided by the total shares outstanding (Cho, 1992; Cui and Mak, 2002; Ryan and Wiggins, 2002; Nam *et al*., 2003, Ghosh *et al*., 2007).

Control variables

A series of control variables were integrated in the research model to account for alternative determinants of R&D expenditures. These included leverage, firm size, growth opportunities, past firm performance and industry and year indicator variables. For each of the control variables listed below, we briefly discuss the theory suggesting its inclusion and how it is measured for this study.

Leverage

A common assertion throughout prior studies is that leverage discourages managers from investing in long-term projects such as R&D projects for the sake of increasing current cash flow for debt service (Barker and Muller, 2002). Long and Malitz (1985) argue that R&D

investment creates intangible assets that are less able for supporting debt because these assets are largely non-tradable and cannot be used as good collateral for borrowing. In this vein, numerous researchers have found a negative association between firm's debt level and R&D spending (Baysinger and Hoskisson, 1989; Bhagat and Welch, 1995; Nam *et al*., 2003, Chen and Hsu, 2009). In this study, leverage was measured as total debt divided by total assets (Kochhar and David, 1996; Barker and Muller, 2002; Lee and O'Neill, 2003).

Firm Size

Large firms may have greater resources and incentives to develop sustained R&D programs and new products and exploit innovations (Schumpeter, 1942; Scherer, 1984). Then, it is widely believed that a major proportion of R&D expenditures is undertaken by large firms. Supporting this view, several empirical studies have found a positive relationship between firm size and R&D spending (Baysinger and Hoskisson, 1989; Baysinger *et al*., 1991; Chen and Hsu, 2009). In this study, total sales were included as measure of firm size (Baysinger *et al*., 1991)

Growth opportunities

Firms characterized by high-growth opportunities gain a larger percentage of their value from cash flows that arise from assets not yet in place. This idea suggests that high-growth firms have the incentives to invest more in R&D activities to develop these opportunities. Supporting this idea, Lee and O'Neill, (2003) and Ghosh *et al*. (2007) found a positive association between investment opportunity and R&D investment. Following Cho (1998) and Lee and O'Neill, (2003), we measured growth opportunities using the market-to-book ratio, calculating it as the market value of equity at the end of a year plus the book value of debt divided by the book value of total assets.

Past firm performance

Hundley *et al*. (1996) found that US firms were inclined to reduce their R&D spending when they are unprofitable. This finding suggests that profitability gives managers confidence to invest in more risky long-term projects and then to commit in R&D activities (Barker and Muller, 2002). For this study, past firm performance was measured as a firm's return on assets lagged by one year (Chen and Hsu, 2009; Barker and Muller, 2002).

Industry

Variations in the amount spent in R&D activities across firms may be associated with the industry of the firms involved (Andras and Srinivasan, 2003). Therefore, it would be appropriate to examine the effect of the industry on R&D spending. To control for unobserved heterogeneity in R&D spending across industries, we introduced a set of industry dummy variables identifying firm's industry based on Euronext industry classification benchmark. The industries are: oil and gas, basic materials, industrials, consumer goods, health care, telecommunications, utilities, technology, consumer services. The industry dummies obtain the value of 1 for the firm's industry and 0 otherwise. The omitted industry was consumer services.

Year effect

Market condition and the general economic environment can vary over time, making it more or less attractive to introduce new products (Katila and Ahuja, 2002) and then firms may change their preferences for R&D investment level. To control this potential time effect, this study included a series of year dummies. The omitted year was the year 2006.

The measurement and definition for each of the included variables in the study are summarised in Table 2 below.

Table 2: *Variables definitions and measurement*

Variable label	Variable	Variable definition	Predicted sign
Dependent variable			
RD	R&D intensity	Annual R&D expenditures ÷ total assets	
Independent variables			
CEO_AGE	CEO age	CEO age in years	+, -
CEO_TENURE	CEO tenure	Number of years served as CEO	+, -
CEO_OWN	CEO ownership	The percentage of common shares owned by the CEO	+, -
DUALITY	CEO-Chairman duality	1 if CEO acts as Chairman and 0 if not	-
Control variables			
DEBT	Debt ratio	Total Debt ÷ total assets	-
SIZE	Firm size	Total sales	+
GROWTH	Growth Opportunities	Market value of equity plus book value of debt ÷ book value of total assets	+
ROA	Return on assets	Earnings Before Interest and Taxes ÷ total assets	+
INDUSTRY	Industry dummies	OIL, MATERIALS, INDUSTRIALS, GOODS, HEALTH, TELECOM, UTILITIES, TECH, take the value 1 if the firm belongs respectively to the following industries: oil and gas, basic materials, industrials, consumer goods, health care, telecommunications, utilities, technology, and 0 otherwise. The omitted industry was consumer services	?
YEAR	Year dummies	Dummies: YEAR02: 1 if the observation year is 2002 and 0 otherwise; YEAR03: 1 if the observation year is 2003 and 0 otherwise…The omitted year was the year 2006.	?

2.4. Research model

To meet our research objective, the basic version of our model is set out below:

$$RD_{it} = \beta_0 + \beta_1 CEO\_AGE_{it-1} + \beta_2 CEO\_AGE^2_{it-1} + \beta_3 CEO\_TENURE_{it-1} + \beta_4 CEO\_TENURE^2_{it-1} + \beta_5 CEO\_OWN_{it-1} + \beta_6 CEO\_OWN^2_{it-1} + \beta_7 DUALITY_{it-1} + \beta_8 DEBT_{it-1} + \beta_9 SIZE_{it-1} + \beta_{10} GROWTH_{it-1} + \beta_{11} ROA_{it-1} + \sum \beta \beta_{11+J} INDUSTRY_{it} + \sum \beta \beta_{19+k} YEAR_{it} + \varepsilon_{it}$$

$$j=1 \rightarrow 8 \quad et \quad k=1 \rightarrow 4$$

***RD**: R&D expenditures divided by total assets*
***CEO_AGE**: CEO age in years*
***CEO_TENURE**: Number of years served as CEO*
***CEO_OWN**: The ratio of shares held by CEO to total shares outstanding*
***DUALITY**: 1 if CEO acts as Chairman and 0 if not*
***DEBT**: Total Debt divided by total assets*
***SIZE**: Total sales*
***GROWTH:** The sum of market value of equity and book value of debt, scaled by book value of total assets*
***ROA**: Earnings Before Interest and Taxes divided by total assets*
***INDUSTRY**: Dummies: OIL, MATERIALS, INDUSTRIALS, GOODS, HEALTH, TELECOM, UTILITIES, TECH, take the value 1 if the firm belongs respectively to the following industries: oil and gas, basic materials, industrials, consumer goods, health care, telecommunications, utilities, technology, and 0 otherwise. The omitted industry was consumer services.*
***YEAR**: Dummies: YEAR02: 1 if the observation year is 2002 and 0 otherwise; YEAR03: 1 if the observation year is 2003 and 0 otherwise…The omitted year was the year 2006.*
***ε:** Residual term*

To account for the non-linear relationship between R&D spending and CEO's age, tenure and ownership, we introduce in the model both CEO_AGE, CEO_TENURE and CEO_OWN variables and, their squares.

It should be noted that all independent and control variables were lagged by one year behind the dependent variable. This avoided the biases from reverse causality (Lee and Park, 2008; Ghosh *et al*., 2007) and allowed time for the CEO attributes and firm characteristics to reveal their impacts on strategic choices.

3. Analysis and Empirical Results

3.1. Descriptive analysis

Table 3 summarises the descriptive statistics for all the variables included in the study. The average R&D ratio is 5.293 in percent of total assets. CEOs in the sample range in age from 26 to 80 years. The mean CEO age is approximately 54 years. The CEOs in the sample serve

as chief executive for an average of about 10 years. The longest serving CEO has been in office for 38 years, and the shortest less than one year. CEO stock ownership ranges from 0 to 85.02% of outstanding shares. Average CEO ownership is 17.96%. Approximately 70% of the firms in our sample have a Chairman who is also the CEO. Debt ratio, return on assets and market-to-book ratio means were respectively 23.04%, 1.85% and 2.27% of total assets. Average firm's total sales were about 6237.44 million Euros.

Table 3: *Descriptive Statistics*

Variables	Minimum	Maximum	Mean	Median	Standard Deviation
RD	0.041	35.39	5.293	2.615	6.233
CEO_AGE	26.00	80.00	53.77	53.00	8.230
CEO_TENURE	0.000	38.00	9.830	8.000	7.159
CEO_OWN	0.000	85.02	17.96	5.010	23.65
DUALITY	0.000	1.000	0.700	1.000	0.459
DEBT	0.000	82.91	23.04	23.15	15.49
SIZE	0.000	117057	6237.44	284.3	15515.3
GROWTH	-15.00	16.00	2.270	1.820	2.212
ROA	-64.99	33.62	1.851	4.010	11.31

3.2. *Multivariate Analysis*

The Pearson correlations among the variables are presented in table 4. The correlation matrix shows that all correlation coefficients are below 0.9, which corresponds to the limit from which multicollinearity problem is detected (Gujarati, 1995). Furthermore, all Variance Inflation Factors "VIF" (table 4) calculated for independent and control variables were less than 10 *(*Gujarati, 1995*).* This leads us to conclude that multicollinearity is not likely to present an issue in the statistical analysis.

Table 4: *Pearson correlation coefficients and VIF*

	VIF	1	2	3	4	5	6	7	8	9
1.RD		1	-0.291**	-0.044	-0.043	-0.016	-0.409**	-0.219**	0.273**	-0.287**
2.CEO_AGE	1.56		1	0.302**	0.087*	0.127**	0.097*	0.101*	-0.084	0.257**
3.CEO_TENURE	1.39			1	0.255**	0.229**	-0.017	-0.063	0.128**	0.146**
4.CEO_OWN	1.26				1	0.147**	-0.123**	-0.252**	0.007	0.067
5.DUALITY	1.14					1	-0.030	0.051	0.040	-0.012
6.DEBT	1.49						1	0.222**	-0.214**	-0.108*
7.SIZE	1.58							1	-0.026	0.071
8.GROWTH	1.17								1	0.145**
9.ROA	1.22									1

Notes: Number of observations= 515
**Correlation is significant at the 0.05 level of significance (2-tailed).*
***Correlation is significant at the 0.01 level of significance (2-tailed).*

Our study covers a sample of 103 French firms observed over a period of 5 years, which by definition leads to estimate regression models on panel data. Given the special nature of these data, it should be to follow the order of certain econometric steps. It has been noted that the

fixed effects model was rejected because the regression models include variables that may not vary over time. In fact, as the fixed-effects model captures all firm's specific factors that are constant over time, these models cannot produce stable estimates for some variables that may not vary over time (Johnson, 1995). We therefore perform the Breusch-Pagan Lagrangian multiplier test for random effects to determine which model to use: the "pooled" or random effects model. As illustrated in Table 5, the results of this test show a statistically significant chi-square (Prob> chi2 = 0.000) for all regression models and indicate that a random effects model is appropriate for models' estimation. To detect the presence of heteroskedasticity problem, we perform the Breusch-Pagan test and we conclude the presence of such problem since the Fisher statistic, as shown in table 5, is significant at the 0.01 level (pob>F = 0.000). Finally, we execute the Wooldridge test for autocorrelation and we conclude the absence of serial autocorrelation of errors in all models (Prob> F> 0.05). In summary, the results confirm the presence of heteroscedasticity problem but no autocorrelation problem. Then for the estimation of the different regression models we choose feasible generalized least squares *(*FGLS*)* estimation method[4] which allows the correction for heteroscedasticity problem.

In what follows, we present in table 5 the results of the FGLS estimates of the various regression models performed in a step-wise manner.

[4] For more details on this estimation method see Wooldridge JM. 2002. *Econometric analysis of cross section and panel data*, Mit Press.

Table 5: *FGLS regression results*

Cross-sectional time-series FGLS regression						
Coefficients: Generalized Least Squares		***Panels: Heteroskedastic***			***Correlation: No autocorrelation***	
Number of observations =515		***Number of groups=103***			***Time periods =5***	
Dependent variable RD						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables	Coef (Std Err)	Coef (Std Err)	Coef (Std Err)	Coef (Std Err)	Coef (Std Err)	Coef (Std Err)
Intercept	2.3562*** (0.3320)	-4.6466* (2.402)	2.0732 (0.3298)	2.5539*** (0.3604)	2.2632*** (0.3578)	-4.8097 (2.9469)
CEO_AGE		0.2948*** (0.0900)				0.2993*** (0.1098)
CEO_AGE²		-0.0030*** (0.0008)				-0.0032*** (0.0010)
CEO_TENURE			0.0693*** (0.0256)			0.0951*** (0.0277)
CEO_TENURE²			-0.0023*** (0.0009)			-0.0017* (0.0096)
CEO_OWN				-0.0452*** (0.0092)		-0.0691*** (0.0103)
CEO_OWN²				0.0005*** (0.0001)		0.0009*** (0.0002)
DUALITY					0.1884 (0.1399)	0.0530 (0.1457)
DEBT	-0.0622*** (0.0061)	-0.0586*** (0.0064)	-0.0632*** (0.0061)	-0.0629*** (0.0062)	-0.0619*** (0.0063)	-0.0608*** (0.0062)
SIZE	-6.62e-06* (3.54e-06)	-7.82e-06** (3.95e-06)	-9.12e-06** (3.66e-06)	-0.00001*** (4.20e-06)	-7.93e-06** (3.79e-06)	-0.00002*** (3.85e-06)
GROWTH	0.2918*** (0.0567)	0.2614*** (0.0594)	0.2991*** (0.0568)	0.3023*** (0.0559)	0.2852*** (0.0572)	0.2753*** (0.0604)
ROA	-0.1075*** (0.0128)	-0.1095*** (0.0131)	-0.1107*** (0.0129)	-0.1038*** (0.0122)	-0.1074*** (0.0129)	-0.1102*** (0.01263)
INDUSTRY (dummies)	yes	yes	yes	yes	yes	yes
YEAR (dummies)	yes	yes	yes	yes	yes	yes
Wald chi2	1730.70	1736.31	1831.60	1740.03	1641.55	1945.30
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-1110.986	-1121.924	-1112.667	-1115.371	-1112.901	-1109.81
Breusch-Pagan Lagrangian Multiplier Test for Random Effects						
Chi2	619.69	606.90	623.82	615.03	618.15	592.65
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000
Breusch-Pagan Test for Heteroskedasticity						
F-statistic	2589.37	1869.94	1729.28	2211.79	2316.34	1023.79
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000
Wooldridge Test for Autocorrelation						
F-statistic	2.008	2.004	1.964	1.999	1.992	1.936
Prob>F	0.1595	0.1599	0.1642	0.1604	0.1612	0.1672

Note: **p<0.10. **p<0.05. ***p<0.01.*
Standard errors are shown in the parentheses
All the results have been corrected for heteroskedasticity
Industry and year dummies are included in all regression models but their coefficients are not shown in this table

The model 1 includes only the control variables and shows that firm's specific characteristics have significant effects on R&D spending. In particular, leverage ($p<0.01$) is negatively associated with R&D investment level, thereby suggesting that highly leveraged firms are inclined to cut R&D investment to service their debt (Hansen and Hill, 1991). A smaller firm size ($p<0.10$) is associated with an increased R&D spending which is consistent with previous studies findings (Gamble, 2000; Barker and Muller, 2002). In this case, small firms have

greater incentives to support R&D activities to adapt to the rapid technology changes. Low past firm performance ($p<0.01$) is also associated with increased R&D investment as confirmed by Chen and Hsu, 2009). This may indicate that poor profitability increases managers' risk tolerance to address this problem (Greve, 2003) and urge firms to experiment with innovative activities (Cyert and March, 1963) such as commitment in R&D activities. As expected, we find a positive association between growth opportunity and R&D spending indicating that high-growth firms have the incentives to invest more in R&D activities to develop these future opportunities.

Model 2 in table 5 represents the regression model where CEO_AGE variable and its square are added. The results show the presence of an inverted U-shaped relationship between CEO age and R&D spending since that the coefficients on CEO_AGE and CEO_AGE² variables are respectively positive and negative and significant (both $p<0.01$). This concave relation suggests the existence of a critical age (around 49 years)[5] before which CEOs increase the amount spent in R&D activities and after which they tend to decrease R&D spending as their age rises and approaches to retirement age. This finding confirms the premise that younger CEOs, (as opposed to older CEOs) are willing to take more risks in their strategic decisions leading them to spend more in R&D activities since their career and their objectives have a longer time horizon. In contrast, older CEOs, who have limited employment horizons due to their impending retirement, tend to be risk averse and have the incentives to invest less in uncertain long-term projects and consequently to limit R&D spending. Such behavior is likely to be more pronounced by old CEOs nearing retirement since R&D projects will benefit their successors while penalize them especially if the company adopts incentive compensation plans that pay CEOs based on current accounting earnings and treat R&D costs as expenses in their accounting statements.

The estimation of the model 3 shows that the coefficient on CEO_TENURE variable is significantly positive ($p<0.01$) while the coefficient on its square is significantly negative ($p<0.01$). Consistently with our prediction, this result confirms that the relationship between CEO tenure and R&D is non-monotonic (inverted U-shaped). R&D spending increases as the CEO tenure rises until a certain peak tenure of about 15 years[6] after which CEOs begin to exhibit investment myopia by gradually reducing the amount spent in R&D activities over

[5] This corresponds to point inflection of the quadratic relationship between CEO age and R&D spending (model 2) and it is obtained by resolving the first derivative equal to zero.
[6] This corresponds to point inflection of the quadratic relationship between CEO tenure and R&D spending (model 3).

time. The rationale for this finding lies in the idea supporting that shorter-tenured CEOs may lack legitimacy in the eyes of shareholders (Miller, 1993) and are therefore more likely to take risks and invest heavily in R&D activities to serve shareholder interests in order to prove themselves as competent managers (Kor, 2006) and to gain the confidence of diverse partners' firm. Furthermore, shorter-tenured CEOs may be too concerned with long run performance since they will still be in charge of their companies in the future and they have ample time to profit from the expected pay-offs of long-term projects. However, longer-tenured CEOs facing a short career horizon, mainly when their tenure within the firm is nearing its end and coincides with their retirement, may have a more risk-averse approach in decision making and accordingly, they tend to under-invest in risky long-term R&D projects. Instead, they prefer investments with shorter time horizons where cash flows are more predictable in order to enhance their own wealth.

Model 4 in table 5 confirms that, contrary to our underlying assumption, there is a significant U-shaped relationship between CEO ownership and R&D investment level. R&D. R&D spending decreases as CEO ownership rises and it increases as CEO ownership rises up to 45.2%[7]. These results are consistent with agency theory arguments and suggest that, when the level of CEO share ownership is high (beyond 45.2%), an increase in CEO share ownership has the effect of aligning management and shareholders' interests resulting in a higher CEO's incentives to undertake R&D investments. However at low levels of CEO ownership, an increase in CEO ownership makes managers myopic and more reluctant to invest in risky projects leading them to reduce R&D spending.

Model 5 in table 5 reports that the association between CEO/chairman duality and R&D spending is not significant.

Finally, the model 6 (table 5) which includes all the variables at once shows that the results are qualitatively identical to those obtained when each explanatory variable is introduced alone.

4. Discussion and conclusion

Using data on French firms, this paper investigates the role played by CEO in determining the level spent in R&D activities with specific emphasis on CEO's attributes. This paper provides

[7] This corresponds to point inflection of the quadratic relationship between CEO ownership and R&D spending (model 4).

evidence that CEO's characteristics, namely CEO's age, tenure and stockholding, exert considerable influence on firm strategic decisions regarding R&D investment. The empirical results indicate an inverted U shaped relationship between R&D spending and CEOs' age and tenure, suggesting the existence of a critical CEOs age and a critical point in time over their tenure at a firm after which CEOs begin to exhibit investment myopia by gradually reducing the amount spent in R&D activities. These results suggest that longer-tenured or/and older CEOs are conservative and tend to avoid risk in decision making leading them to under-invest in risky R&D projects. However, shorter-tenured and/or younger CEOs, given that their career and financial security concerns have a longer time horizon, are willing to develop strategies more conducive to risk taking such as commitment in R&D activities. Furthermore, in this study we find a U-shaped relationship between R&D spending and CEO ownership; R&D spending is negatively (positively) related with ownership at low (high) levels of CEO ownership. This result implies that increasing ownership at low levels of CEO ownership exacerbates CEO myopia and the under-investment problem with regard to R&D activities, because CEOs have preference for low-risk strategies that stems from the lack of diversification of their wealth portfolio. However, at high levels of CEO ownership, CEO becomes more willing to invest in risky projects such as R&D investments which may reflect a closer alignment of managers' and shareholders' interests. This finding allows us to assert that, consistent with agency theory, higher ownership may be and effective incentive mechanism to mitigate managerial opportunism and to induce managers to make value-maximizing investment decisions. In sum, these results support the idea that CEO attributes matter in explaining corporate R&D investment level. CEO attributes, mainly CEO's age, tenure and stockholding, have a significant direct and modifying association with attitude toward risky strategies, specifically, R&D activities with the central tendency of CEOs to increase the amount spent in these activities when they are young, low tenured or have high stock ownership.

The empirical evidence of this study has several practical implications. First, the results suggest that, CEO characteristics exert considerable on CEO risk-taking propensity toward R&D strategy. Therefore, given that R&D investment is important for firm's performance and competitiveness, namely for those operating in high-technology industries, it could be considerably important for boards to select and develop appropriate person for top management positions who will make value-maximizing decisions in the best interests of shareholders. For instance, boards may need to appoint younger persons to the top positions

since they are more willing to develop a strategy more conducive to risk taking and innovation (Carlsson and Karlsson, 1970) and are more capable of learning and integrating information in making decisions, and thus may have more confidence mainly in risky decisions (Taylor, 1975).

Second, boards may need to monitor closely the investment decisions made by older and/or long-tenured CEOs which are more likely made in their benefits at the expense of shareholders' interests. Boards could encourage older or longer tenured managers to interact with customers, suppliers or competitors more frequently. This could help the managers to absorb new information and knowledge and to increase their connections with the external environment, which in turn may facilitate to alter managers' conservative approach and as result affects their risk-taking propensity toward R&D strategy. Additionally, our results suggest that boards wishing to encourage managers to commit in risky and long-term R&D strategies need to make, if necessary, appropriate adjustments to their incentives in a timely manner. As discussed earlier, higher CEOs stock ownership is one incentive that may mitigate managers' myopic behaviour and induce them to undertake R&D investments. Also, compensation contracts, namely for older CEOs, should not overemphasize on current firm performance[8], but should contain a schedule of stock grants for the CEOs in retirement. This strategy could discourage the CEOs to adopt a conservative approach in decision making and accordingly reduce their tendency to decrease R&D spending in the years heading into retirement. Existing literature also provides evidence that the board could counteract the horizon problem by using more stock-based compensation for older CEOs, who would thereby receive incentives to maximize firm value so long as they believe that investors capitalized the expected returns of new investments (He *et al*., 2003). In fact, Eaton and Rosen (1983) and Lewellen *et al.* (1987) find that the proportion of stock-based compensation in CEO total compensation increases with CEO age. Thus, unless firms offset these incentives by adjusting the proportion of cash bonuses and base salary to CEOs approaching retirement, those CEOs will focus on short term earinings and forgo profitable long term investment opportunities (Waisman *et al*., 2005).

Finally, given our findings, strategic decision makers could predict a competitor's R&D spending level based on the specific characteristics of its CEOs, namely, CEOs' tenure, age

[8] Shen (2003), Bloom and Milkovich (1998) and Gibbons and Murphy (1992b) find that CEOs nearing retirement receive, on average, a greater proportion of their compensation based on current firm performance. The adoption of this pay structure in the CEO's final years could increase the incentive to manage earnings upwards by cutting R&D spending.

and stock ownership. For instance, a firm entering a market where many of the incumbent firms have long-tenured CEOs may be able to predict the future R&D spending behaviour of their new rivals better, ceteris paribus (Barker and Muller, 2002).

5. limitations and future research

This study has some major limitations, that their overcoming would be a fruitful avenue for future research. First the nature of the present sample makes it difficult to generalise the results. In fact, the sample covers only the companies that disclose the amount of R&D spending in their financial statements creating then problem in sample selection, since that some firms could choose not to report R&D spending. Second, this study focuses on CEO rather than top management team. Upper echelon theory asserts that one has to look beyond the characteristics of the CEO alone and should also take the characteristics and functioning of other members of the top management team into account for appreciating firm performance (Hambrick and Mason, 1984). Strategic decisions are often made and implemented through dynamic processes where managers interact, consult and debate with each other (Kor, 2006). Drawing on this idea, we presume that, in the context of investment decision-making, looking at the characteristics of the whole group of top managers will allow to better prediction of firm investment strategy. Then, while our study focuses on the effects of only CEO's attributes on R&D investment, it will be of great interest to consider the effects of the characteristics of the entire top management team. This approach provides attractive research avenues for researchers to collect more complete and in-depth data about the attributes of all the top management team and to study their affects on R&D spending in order to obtain more complete and better results.

Third, in this study we emphasize on only few CEOs characteristics (tenure, age, stock ownership and duality) regarding their effects on R&D spending. Other CEO characteristics such as CEOs' education level, CEOs' education type, CEO's career and professional experience…may influence CEOs' strategic decision-making with regard to commitment in R&D activities. These demographic characteristics have been proposed as the primary determinants of each individual's base, values and biases (Hambrick and Mason, 1984). In fact Lu *et al*. (2006) found that the higher the educational level of its CEOs, the higher the growth rate of the firm's R&D activity. Further, Barker and Muller (2002) find that CEOs with graduate degrees in science and engineering are more likely to spend money on R&D

than those with legal degrees. Similarly, CEOs experienced in technical and marketing areas tend to favour commitment in R&D activities more than those who rise through the ranks of the legal, accounting or finance departments. Additionally, since that managers' cognitive style influences the perceptual process underlying decision making, as argued by Wiersema and Bantel, (1992) and Hambrick and Mason (1984), emphasis should also be placed on managers' psychological characteristics (e.g. cognitive base, values and biases, locus of control…) beside their demographic (age, tenure, financial position, type of education,..). In this line of spirit, Hambrick and Mason (1984) raised doubts if research on managers' characteristics can progress far without greater attention to relevant literature in related fields, especially psychology and social psychology (Pansiri, 2005). Accordingly, it will be interesting to explore this line of research in the future to more understand how both demographic and psychological CEOs' characteristics may affect R&D decisions.

Finally, this study focuses mainly on the inputs of innovation (i.e., R&D spending) and not on the outputs of innovation, such as the quality and quantity of new products, processes, technologies…We assume that the results could be more powerful if both sides were taken into consideration. Also, since it is likely that some R&D spending is unproductive and not taken in the best interest of the firm, it will be interesting to extend the present study by investigating the effects of CEOs' characteristics (or the characteristics of top management team at whole) on R&D effectiveness. One might suppose that is likely that CEOs with high stockholdings would not only be committed to R&D activities, but also would be able to maximize the benefits of R&D spending. The relationship between top management characteristics (age, tenure, ownership, education, experience…) and R&D effectiveness may prove to be stronger than the one found in this research given that it is important to know not only how much is spent in R&D activities but also how effectively firm resources are deployed in these activities (Ettlie, 1998). This relevant issue is worthy of our continued research.

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