Do CEO's traits matter in innovation outcomes?

Nadia Loukil, Ouidad Yousfi

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Abstract

The study investigates the influence of CEO attributes on innovation outcomes on all listed firms on the SBF120 index between 2001 and 2013. We provide the following results. First, business graduated CEOs are less prone to introduce new products while science educated CEOs are more likely to increase the number of patents in high-technology firms. Second, the longer is the CEO tenure, the lower are the innovation outcomes, specifically in high-technology firms. Third, CEO owners are likely to invest in long term profitable activities such as innovative projects, which increases all innovation outcomes. CEO founders, however, are more concerned about the implementation of new processes. Finally, robustness tests show that the number of patents decreases, on the long term, in the presence of female CEOs.

Keywords: CEO's attributes, product innovation, process innovation outcomes, patent, high-technology firms.

JEL Classification Codes: G30, O30, O31, M21

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Introduction

It is highly argued that CEOs are actively involved in shaping the performance and the strategy of their firms (Lee et al. 2016; Helft 2014; Chikh and Filbien 2011; Tang et al. 2011; Brown and Sarma 2007; Hambrick 2007, and Bertrand and Schoar 2003). The current financial literature analyzes how powerful CEOs could influence strategic decision-making (Faccio et al., 2016; and Farag and Mallin, 2018, Bach and Smith 2007, Brockmann et al. 2004, Hambrick and Mason, 1984, Miles and Cameron, 1982, Child 1972 and Finkelstein, 1992). When CEOs are also shareowners or chairs of their boards, or have many and powerful contacts in their address book, and strong and tied network, their influence could be strengthened. Furthermore, CEOs' decisions depend on their risk preferences: risk-takers CEOs are most often prone to undertake risky projects such as R&D projects while risk averse CEOs prefer more routine and less-risky investments (Lu and Wang, 2017).

In developed countries, CEOs tend to better accept changes and to undertake more risky projects which are necessary requirements to innovate (Francis and Smith, 1995). However, innovation investments could be undermined because of agency problems between managers and shareholders (Lu and Wang, 2017). The pressure for short-term results leads CEOs to be risk averse and to focus on projects with immediate returns (Kaplan and Minton, 2006, and Porter, 1992). Consequently, the threat of getting fired could dissuade managers from innovating.

Many theories support that top management's traits, such as CEO's traits, partially influence the firm performance and strategic decisions such as upper echelons theory, resource

dependence theory and human capital theory (Hambrick, 2007; Hambrick and Mason, 1984, Pfeffer and Salancik 1978; and Becker, 1964).

In upper echelons theory, the top management teams are characterized by bounded rationality. Their decisions are partly driven by their values, and social and psychological characteristics. In this sense, CEO's age, tenure and professional experience could be cognitive, psychological and social factors (Farag and Mallin, 2018; and Orens and Reheul, 2013). Several studies drawn on the upper echelons theory find evidence that some CEOs' demographic have effect on corporate cash holding (Orens and Reheul 2013); on takeover decisions (Li and Tang 2010); on R&D spending (Barker and Mueller 2002) and on financial disclosure (Bamber et al., 2010) and on corporate risk-taking (Farag and Mallin, 2018).

Also, the resource dependence theory links the company with its environment which could provide access to new resources (Pfeffer and Salancik, 1978). Carter et al. (2010), Adams et al. (2009) and Singh and Vinnicombe (2003) explore board diversity and how it could enhance several areas such as governance quality, information transparency, corporate disclosure and reputation. Appointing different board members enhances, therefore, the corporate reputation in the eyes of investors but also stakeholders, such as governments. This could favor access to external resources: Tang et al. (2015) provide evidence that hiring politically connected directors, in China, has a positive effect on firm valuation. Government-related business is positively associated with the number of politically connected directors (Agrawal and Knoeber, 2001). On the same vein, Appointing CEOs with different demographic traits could add new perspectives and bring more resources (Farag and Mallin, 2018, Faccio et al., 2016).

The human capital of Becker (1964) adds some insights on why more attention should be paid to the CEO traits. Hiring a top management with different experiences and backgrounds increases the human capital. It creates a favorable environment to produce new ideas and to see new perspectives. Therefore, the corporate is more likely and to improve the governance

quality to undertake more opportunities (Terjensen et al., 2009; Hillman and Dalziel, 2003; and Hillman et al., 2000). In the same vein, CEOs with different traits cloud have different opinions and experiences that could be valuable for the business.

Turning to studies on innovation provides evidence on how CEOs could favor or undermine innovation, most often without taking into account their individual characteristics. For instance, it has been argued that powerful CEOs are more prone to take decisions supporting exploratory innovations at the expense of exploitative innovation[3] (Sariol and Abebe, 2017) and could produce more diverse and original patents and citations than other CEOs[4] (Sheikh et al., 2018). CEOs seeking for new sensation and novel experience, such as pilot[1] CEOs, could improve innovation outcomes and its effectiveness (Sunder et al., 2017). Moreover, the presence of CEOs' incentive schemes and some CEOs attributes could favor innovation effort (R&D expenditure) and innovation outcomes (new product sales).

Recent studies have started exploring the influence of top management traits on strategic decisions such as innovation (Sheikh, 2018; Torchia et al., 2018; Pascal et al., 2017, Faccio et al. 2016; Lewis et al., 2014; Serfling, 2014; and Lin et al., 2011). They provide evidence that CEO education level, professional background and political connection are most often positively associated with risk tanking and innovation effort, specifically R&D expenditure (Farag and Mallin 2018; Lewis et al., 2014; Lin et al., 2011 and Slater and Dixon-Fowler; 2010). Most of these studies are conducted on global data while some are drawn on US and Asian data. European data, specifically French data, are not yet fully explored despite the huge number of initiatives and programs introduced to foster innovation (EUROPE2020, Horizon2020, Innovate Europe[5], Entrepreneurship and Innovation Program[6], the European

[3] Exploratory innovation is produced by research, experimentation, risk taking and discovery (while exploitative innovation meets the need of customers (March, 1991).

[4] Their result is true only in highly competitive markets.

[5] https://www.eppgroup.eu/newsroom/publications/innovate-europe-we-put-people-at-the-heart-of-innovation

Innovation Council EIC, and the EU Agency on disruptive innovation and Bpifrance in France). One explanation is the lack of data on top management traits. In the current paper, we contribute to this literature by shedding light on the French firms.

Furthermore, unlike previous studies, the current paper analyses how CEO' attributes could impact innovation outcomes such as the introduction of new products or processes and the number of patents. We take into account different CEO attributes: (1) CEO's demographic attributes (age, gender, education…) and CEO position's attributes (duality, ownership, tenure, business foundation…) to assess their effect on innovation outcomes. Innovation outcomes are measured by the ability to introduce a new or an improved product/process and the number of patents.

To the best of our knowledge, this is the first study to consider both categories of attributes drawn on a European data, i.e. the French market. The sample consists of all the listed firms on the SBF120 index between 2001 and 2013. To assess the level of innovation outcomes, we rely on the firm's ability to introduce new or improved products or processes and the number of filed patents. Findings highlight that CEO attributes differently influence innovation outcomes according to the innovation type and the technological intensity of the industries.

First, results show that the influence of the CEO's education background on innovation varies according to the type of academic degree: when a CEO has a science or technology or an engineering degree, he or she will be more inclined to increase the number of patents only in high-technology industries. In line with Bertrand and Schoar (2003), we show that business graduated CEO could undertake risky and aggressive strategies to increase the likelihood of introducing new products. However, when they are appointed to high technology firms, the number of patents decreases showing less ability to foster innovation.

[6] http://ec.europa.eu/cip/eip/index_en.htm

Second, our results support also the CEO entrenchment hypothesis (Fisman et al., 2014): CEO tenure decreases process innovation in all firms and reduces the number of patents in high-technology firms. In fact, long tenured CEOs are more likely to avoid risky and challenging decisions. They could have friendships with board members, which decreases the likelihood to appoint a new CEO (Miller, 1991).

Third, despite that we expect the CEO-owner to act as a conformist shareholder (Thornton, 2002, and Thornton and Ocasio, 1999), our results provide evidence that CEO ownership could favor both product and process innovations and increase the number of patents (Francis and Smith, 1995). One explanation is that CEO ownership could decrease agency costs and CEO risk averseness (Goel and Jong, 2017; Lerner and Wulf, 2007; and Coles et al., 2006.)

Fourth, in line with Lee et al. (2016), we show that founder-CEOs are more likely to introduce new organizational changes and to decrease raw patent counts. Furthermore, Boeker and Wiltbank (2005), and Boeker and Karichalil (2002) argue that founder CEOs might not have appropriate leadership skills to successfully manage large and established firms. They could also be more reluctant to change their leadership style to meet the business needs and produce innovative products.

Fifth, the test of long term effects of CEO attributes on high-technology firms shows that women CEOs are not concerned about the number of patents. In line with a large number studies on women risk averseness (Faccio et al., 2016 and Crosen and Gneezy, 2009), they are reluctant to promote innovation decisions, which decreases raw patent counts.

Finally, gender diversity in boardrooms could favor innovation outputs, particularly the introduction of a new or significantly improved product or a new process while the presence of independent directors is positively associated with the number of patents.

This research is structured as follows: the review of the literature and the hypotheses are presented in section (1). Section (2) presents the data, the variables and the methodology. Results are discussed in section (3). The robustness tests are in Section (4). The last section concludes the paper.

Literature Review and hypotheses

CEO demographic attributes

CEO's age has been analyzed to assess how it could influence corporate practices; specifically, the firm performance and the corporate governance quality (Amran et al., 2014; Serfling, 2014; Cronqvist et al., 2012; Malmendier and Nagel, 2011, and Jackling and Johl, 2009).

The empirical findings on the effects of CEO age are mixed. For instance, older executives have longer business experience and a better understanding of making decision than their younger counterparts. Managerial success is positively correlated with CEO's age (Amran et al., 2014; and Brockmann and Simmonds, 1997). Turning to their decision's choices, old CEOs are prone to take less-risky decisions (Brockmann and Simmonds, 1997; and Carlsson and Karlsson, 1970). Unlike old CEOs who have gained legitimacy in the eyes of stockholders and in the workplace, young CEOs are more concerned about their reputation and are less skillful, particularly in business decision-making. They prefer growth opportunities that are most often risky opportunities (Serfling, 2014).

As innovation activities are labeled very risky, we could argue that young CEOs will encourage R&D activities leading to the introduction of new products and processes.

In the light of these arguments, we state the following hypothesis:

Hypothesis1: The CEO's age is negatively associated with innovation outcomes.

Another CEO attribute is the educational background. Several studies focus on CEO's education (Lin et al., 2011 and Barker and Mueller, 2002). They show that highly-educated CEOs could better understand complex decisions and absorb new ideas and technology (Farag and Mallin, 2018; Kuo et al. 2018; Li et al., 2017; and Barker and Mueller, 2002). For instance, Lin et al. (2011) provide evidence that highly educated CEOs have a better understanding of complex decisions and new ideas and technology which could lead to the introduction of innovative products and processes.

According to these arguments, we state the following:

Hypothesis2: CEO's education level is positively associated with innovation outcomes.

Regarding the type of the academic degree, science educated CEOs, such as CEOs with Science and Engineering degrees have better skills when they have to take strategic risky decisions (Tyler and Steensma, 1998). They adopt a more transformational leadership: they are open to new ideas and less reluctant to introduce new changes. In the same vein, Barker and Mueller (2002) show that CEOs who have advanced science degrees significantly increase R&D expenditures.

Management and Business programs attract more risk-averse, conformist individuals, who are less likely to undertake innovative strategies (Hambrick and Mason, 1984). Business graduated CEOs are more concerned about short-term financial objectives (Pascal et al., 2017; Lewis et al., 2014; and Slater and Dixon-Fowler, 2010). They prefer short term profitable activities at the expense of risky and long term profitable activities such as innovation projects (Ghoshal, 2005). In fact they have business competences, specifically on finance and on accounting areas. They are appointed to CEO position because they are more skillful to achieve a better financial performance and to handle risks (Maraghni and Nekhili, 2014; Nekhili and Gatfaoui, 2013, and Gendron and Bedard, 2006). However empirical studies provide evidence that, in the presence of business educated CEOs, firms undertake aggressive strategies: they spend more on R&D expenditures, increase leverage, prefer more diversified

acquisitions and issue less dividends than firms with other CEO's profiles (Bertrand and Schoar, 2003).

Accordingly, we test the following:

Hypothesis3: CEO who has a management or corporate degree will hinder innovation outcomes.

Hypothesis 4: CEO who has a science, technology or engineering degree, is positively associated with innovation outcomes.

Another emerging attribute that attracts an increasing interest is gender diversity and how it influences corporate policies. Despite the fact that the differences between man and woman CEOs are not yet fully discussed, the booming number of studies on differences between women and men in terms of risk preferences provides some interesting perspectives.

Although women have been labeled as more risk averse than men and adopt a risk-avoidance behavior (Crosen and Gneezy, 2009; Jianakoplos and Bernasek, 1998, and Sundén and Surette, 1998), recent studies provide mixed findings (Faccio, et al. 2016; Berger et al., 2012; and Cosentino et al., 2012).

For instance, Faccio et al. (2016), and Weber and Zulehner (2010) point out that the presence of female CEOs in a large number of European privately-held and publicly traded firms is negatively (respectively positively) associated with leverage and volatile earnings (respectively the likelihood of survival, particularly in start-ups).

However, female members have non-significant effect on leverage and total risk in listed firms in several European countries (Cosentino et al., 2012). In the banking sector, Beck et al. (2012) and Agrawal and Wang (2009) find that the default rate decreases when loans originate from women, while Berger et al. (2012) show a positive association between risk-taking and a high representation of women on corporate boards.

In innovation, taking risky-decisions is a necessary requirement; we expect that women CEOs will avoid risky-decisions such as R&D projects and decrease innovation outcomes.

In the light of the previous arguments, we hypothesize the following:

Hypothesis 5: Female CEO is negatively associated with innovation outcomes.

CEO position' characteristics

The influence of CEO tenure on the corporate performance and strategies is not completely assessed. On the one side, tenure is a proxy for the CEOs' experience and their influence on strategic decisions (Ryan and Wiggins, 2004; Vafeas, 2003; and Goyal and Park, 2002) and could lead to the introduction of more organizational innovations (Torchia et al., 2018). Lin et al. (2011) provide evidence that CEO tenure has positive and significant effect on the likelihood of R&D investment. On the other side, the longer is the tenure, the more entrenched could be the CEO. Under asymmetric information and when the board' monitoring is non-effective, entrenched CEOs pursue personal gains or their private agenda at the expense of shareholders. They are more concerned about their reputation on the workplace (Fisman et al., 2014).They pursue short-term-objectives and marginalize long-term projects (Hirshleifer, 1993). Accordingly, they are reluctant to undertake uncertain projects and introduce new changes. They could, therefore, lose touch with the firm's challenges menacing the firm's competitiveness and diminish innovation outcomes (Miller, 1991).

In the light of the previous discussion, we state:

Hypothesis 6: The CEO's tenure level is negatively associated with innovation outcomes.

Hypothesis 7: The CEO's tenure level is positively associated with innovation outcomes.

The influence of duality versus non-duality structure on the firm performance has been extensively discussed (Tang, 2017; Dalton and Dalton, 2011; Finkelstein et al., 2009; Dalton et al., 2007; and Fama, 1980). A large number of studies have long called for the separation

between the management and control functions to have an effective monitoring (Finkelstein et al., 2009). Nevertheless, some recent studies highlight the benefits of the CEO-chair structure (Dalton et al., 2007; Finkelstein and D'Aveni, 1994), such as the unity of command in complex environments (Boyd, 1995) and in turnaround situations (Mueller and Barker, 1997). In fact, the duality structure strengthens the CEO power (Bach and Smith 2007, Brockmann et al. 2004, Hambrick and Mason, 1984, Miles and Cameron, 1982, Child 1972 and Finkelstein, 1992) and increases the CEO influence over the decision-making process (Sheikh, 2018).

Nevertheless, the influence of the CEO-chair structure on innovation is ambiguous. In a recent study, Goel and Jong (2017) find positive moderating effects of CEO duality on the associations between the corporate risk-taking and innovation and between prior innovations and the performance in IT companies. This moderated effect is due to effective and strong CEO incentives. We expect that CEO-chair structure could increase risk taking and could lead therefore to more innovative products and processes.

Accordingly, we test the following hypothesis:

Hypothesis 8: CEO duality increases innovation outcomes.

Another attribute is the influence of the founder-CEO. It is extensively argued that founder-CEO increases the firm performance (Cohen et al., 2013; Adams et al., 2009; Fahlenbrach, 2009; and Willard et al., 1992). The management of the firm by the founders leads to a better monitoring (Li and Srinivasan, 2011) and increases the CEO power (Fahlenbbrach, 2009; Finkelstein, 1992; and Donaldson, 1983).

Although entrepreneurs' role on the introduction of changes and innovations is well documented (Christensen, 2013; Agarwal et al., 2004; Tripsas, 1997; and Christensen and Bower, 1996), the role of founders as managers in large companies is still puzzled. In a recent study, Lee et al. (2016) show that founder-CEOs are likely to introduce new changes and are

more effective and efficient innovators than professional CEOs: they increase raw patent counts, citations per issued patent, and R&D intensity. This effect is stronger in competitive markets.

Accordingly, we address the following:

Hypothesis 9: The founder-CEO introduces more innovation outcomes.

Managerial ownership on innovation has a puzzling effect on innovation. On the one hand, CEO-ownership could have a positive effect on innovative activities and on the firm performance (Francis and Smith, 1995; Baysinger et al., 1991; and Hill and Snell, 1989) through the decrease of agency costs and CEOs' risk averseness (Goel and Jong, 2017; Lerner and Wulf, 2007; Coles et al., 2006; and Balkin et al., 2000).On the other hand, the larger are the CEOs' share of capital, the more they are tempted to escape risky decisions to protect their private interests (Thornton, 2002, and Thornton and Ocasio, 1999). Francis and Smith (1995), however, point out that only when the CEO holds more than 30%, he or she could be tempted to invest in innovative projects while Czarnitzki and Kraff (2004) find that large CEO's ownership is positively associated with less successful innovation.

Hypothesis 10: CEO's ownership decreases innovation.

Hypothesis 11: CEO's ownership is positively associated with innovation.

Methods

Sample and data sources

The current study is drawn on all the French firms listed on the SBF120 index over the period 2001-2013: 153 firms and 1989 firm-year observations. Financial data are provided by several datasets FactSet-IODS[2] and Bloomberg. Governance and ownership data are hand-collected

from annual reports. Innovation data are provided by the surveys on Innovation conducted by the INSEE between 2001 and 2013.

[Insert table 0 here]

Measures

Dependent variables[7]

- PAT is the yearly number of patents filed during the year by the firm or its groups. The same patent can be the subject to many filings at the European Patent Office. In the current study, a patent can be counted only once.
- PROD is a dummy variable that is equal to 1 if the firm has introduced at least a new good/service or has significantly improved an existing good/service and 0 otherwise.
- PROC is a dummy variable that is equal to 1 if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise.

Independent variables

CEO attributes

- AGE is the CEO age
- TENURE is the CEO tenure. It is given by the number of years since the executive has been appointed to the CEO position.
- EDUC is a dummy variable equal to 1 is the CEO has a Master, MBA or PhD degree.
- SEDUC is a dummy variable equal to 1 is the CEO has a science or engineering degree.

[7]All innovation outcomes, in this section, are provided by the Surveys on Innovation conducted by the INSEE between 2001 and 2013 : http://www.enseignementsup-recherche.gouv.fr/cid88080/calendrier-2019-des-publications-statistiques-du-sies-1er-quadrimestre.html

- BEDUC is a dummy variable equal to 1 is the CEO has a business/management/ corporate law education.
- DUAL is a dummy variable equal to 1 if the CEO and Chairperson are the same person.
- FOUND is a dummy variable equal to 1 if the CEO is the business founder.
- GEND is a dummy variable equal to 1 if the CEO is a woman.
- CEO-OWN is the CEO share of capital

Board characteristics and ownership structure

- BSIZE is the number of directors in the boardrooms.
- PIND is the percentage of independent directors in the boardroom
- PFD is the percentage of female directors.
- S-OWN is the State share of capital.
- INS-OWN is the institutional investors' share of capital.
- F-OWN is the family share of capital.

Control variables

- R&D is the R&D expenses to total assets ratio.
- H-R&D is the average yearly number of hours per R&D team dedicated to R&D activities. It assesses the time spent on R&D activities by R&D team's members. Instead of taking into account the number of R&D researchers end of the fiscal year, as some researchers could join R&D project in the course of the year, we take into account the total number of hours they spend on R&D project.
- ROA is the return on asset ratio. It is highly argued that innovation and financial performance are positively associated (see Calabrese et al., 2013; Gronum et al., 2012; Rosenbusch et al., 2011, and Bae and Kim, 2003)

- F-AGE is the firm age.
- CF is the cash-flows to total assets ratio.
- LEV is the book value of debt to total assets ratio.
- USL is a dummy variable equal to 1 if the firm is listed on US markets and 0 otherwise.
- To control for industry sectors, we also introduce industry dummy variables.

Descriptive statistics (table 1) on CEOs attributes show that most often male are appointed to CEO positions (98.55%). The CEO is on average 55 years old, with an average tenure of almost 8 years and holds on average 2.23 % of the capital. 68.42% of CEOs are also the chair of the directors' board.

[Insert table 4 here]

Regarding their academic background, 87 % of CEOs have a high educational level (Master, MBA or PhD degree). 48.63% of CEOs have either business or management or corporate law degree while 42.88% have either science or technology or engineering degree.

Turning to the firms and the board characteristics, descriptive statistics show that the board of directors consists of almost 47.63 % independent directors and 11.64 % female directors.

Moreover, we notice that a large number of firms in our sample is also listed on US markets (60.27%). Among them 47.95% of total firms are operating in these sectors: ICT, industrial, health, medical, chemistry, and energy.

Statistics on innovation measures show that innovation effort (R&D spending and the number of researchers per R&D team) and innovation outcomes (product, process, and patent) significantly vary between firms. Specifically, there are 31.14 filling patents on average. When it comes to product and process innovations, only 14.68% firms were able to introduce a new or a significantly improved product or service and 15 % implemented a new process innovation.

Table (2) provides the value of the pairwise correlations between the variables used in the current analysis. The CEO attributes display mixed correlations with innovation measures.

[Insert table 2 here]

For instance, the CEO ownership is negatively and significantly correlated with innovation outcomes variables (PROD and PROC) at the 5 % level.

CEO age and FOUND are positively and significantly correlated with the introduction of new or significantly improved products or processes. However, FOUND and patents are negatively and significantly related.

Science graduated CEOs (SEDUC) have positive and significant correlations with all proxies for innovation effort (R&D, and H-R&D) and innovation outcomes (PROD, PROC, and PAT) at the 1% level.

However, business graduated CEOs (BEDUC) have negative and significant correlations with all innovation measures at the 1% level. Another interesting result is CEOs with longer tenure display negative and non-significant correlation with innovation proxies. Unexpectedly, DUAL displays a positive and significant correlation with both effort innovation and performance innovation. The presence of women CEOs is negatively and significantly correlated to product and process innovation at the 10% level.

We notice also that some correlations are exceeding 0.7. However, the Variance Inflation Factor (VIF) value, most often, does not exceed 3. Accordingly, we did not include SEDUC and BEDUC in the same models to avoid multicollinearity issues.

The table (3) presents mean difference tests between innovative firms and non-innovative ones. Statistics indicate that firms with patents are managed by older and less entrenched CEOs. Their boards are smaller and dominated by independents directors (51% on average). In addition, they are less levered, more profitable and older than non-innovative firms.

[Insert table 3 here]

Furthermore, State shareholding is more pronounced in firms which are able to introduce new products and processes while institutional investors are more attracted by firms with more innovative products.

In addition firms that have product and process innovations have larger boards and older CEOs.

Finally, CEO turnover seems to have a positive influence on the number of patents. Compared to firms with No-CEO turnover, firms with one and two CEO turnovers have more patents. However, when firms experience more than two turnovers, the number of patents decreases.

Model and results

$$INNOV_{i,t+1} = \delta + \sum \beta_i * CEO - Attributes + \sum \alpha_i * Firm - Characteristics + \varepsilon_{i,t} \quad (1)$$

where $INNOV_{i,t+1}$ is a measure of innovation outcomes (PROD, RPOC, PAT) of the firm i at the year t+1. CEO attributes and firms' characteristics are lagged by one year to assess the

relationship between CEO decisions and proxies for innovation (Cho and Kim, 2017; Balsmeier et al., 2014; and Choi et al., 2011).

For binary dependent variables such as PROD and PROC, we use Logit model.

CEO-Attributes are (1) demographic attributes, such as the CEO educational level EDUC, the CEO academic degree (SEDUC or BEDUC), the CEO gender (GEND), the CEO age (AGE), and (2) position's attributes, like for example the CEO tenure (TENURE); the capital share of the CEO (CEO-OWN); the CEO-chair structure of the board (DUAL) and when the CEO is the business founder (FOUND).

Firm-characteristics are the firm's age F-AGE, the ownership structure (F-OWN, S-OWN, INS-WN), the percentage of independent directors (PIND), and women directors (PFD), in addition to the financial variables such as cash-flows to total assets ratio (CF), leverage ratio (LEV), and return on assets ratio (ROA).

Table (4) provides the results of the estimation. The CEO age has no significant influence on all innovation measures, which leads to the rejection of H1.

[Insert table 4 here]

Regarding the demographic CEO attributes, findings reveal that educational level and the academic degrees (business, management, science, engineering…), have mixed effects. However, only business graduated CEOs have positive and significantly association with product innovation. Hence, we reject H2, H3, and H4. These results are not consistent with Pascal et al. (2017), Lewis et al. (2014), Lin et al. (2011), and Slater and Dixon-Fowler (2010), as we are focusing on well-established, large and listed companies on a developed country. Furthermore, more than 59% of the firms in our sample are implemented in competitive sectors such as industrials; consumer goods and financials sectors (table 0).

Almost 50% of them are technology firms (see table 5). They also operate in very competitive markets: 60 % are listed on US markets (table 1, panel B)

Furthermore, women CEOs have a negative and non-significant effect on the number of patents[3]. Accordingly, we cannot accept H5. Unlike Faccio et al. (2016), Weber and Zulehner (2010) and Crosen and Gneezy (2009), we cannot argue that women are risk averse, specifically in innovation projects. In fact, the percentage of female CEOs is too small 1.45% (table 1, panel B).

For CEO position's characteristics, findings show that the CEO tenure decreases all innovation outcomes measures: product innovation, process innovation and the number of patents. However, the decrease is significant only in process regression where the CEO tenure coefficient is significant at the 5% level. We cannot accept H6 and H7. This result is in line with the CEO's entrenchment hypothesis: long tenured CEOs could be more concerned about their own interests at the expense of the firm's ones. In fact, they have spent a long time in their positions and have been able to establish friendships with board members. They do not need any more to gain boardroom sympathy. Under asymmetric information and when the board' monitoring is non-effective, entrenched CEOs pursue personal gains or their private agenda at the expense of shareholders. They are more concerned about their reputation in the market (Fisman et al., 2014).They pursue short-term-objectives and marginalize long-term projects (Hirshleifer, 1993). Accordingly, they are reluctant to undertake uncertain projects and to introduce innovations, specifically when they cannot benefit them. They could, therefore, lose touch with the firm's challenges menacing the firm's competitiveness and diminish innovation outcomes (Miller, 1991).

Besides, the dual structure has no significant influence on all innovation measures. Despite the fact that duality structure is a specific dimension of CEO power (Finkelstein, 1992), gives the CEOs more influence and control over strategic decision-making (Sheikh, 2018) and

could lead him to actively shape the organizational development and firm's strategies such as in R&D projects (Goel and Jong, 2017, and Lin et al. 2011), it does not lead to more innovation. Accordingly, we reject H8. One explanation is due to stewardship theory. Donaldson and David (1991) argue that when the CEO is also the chair of the board. He or she could act like a steward, instead of self-serving decisions (as argued in agency theory); the CEO could take pro-organizational decisions in the best interest of the firm and its owners. Consequently, the CEO could marginalize risky and long term projects such as innovation projects.

When the CEO is the business founder or affiliated to the founder (for instance family-founder), the number of patents decreases significantly at the 10% level while the likelihood of implementing new processes increases significantly at 10% level. This result supports partially H9. In line with Lee et al. (2016), we show that founder-CEOs are more likely to introduce new organizational changes and to decrease raw patent counts.

Surprisingly, when the CEO is a shareholder, he or she is not acting like a conventional owner caring only about increasing the firm value and avoiding taking risks. In fact, estimates provide evidence that CEO ownership significantly increases the number of patents and the likelihood of introducing new products and/or processes which supports H11 and leads to the rejection of H10. This result is consistent with the assumption that managerial ownership could foster innovation activities (Czarnitzki and Kraff, 2004; Francis and Smith, 1995; Baysinger et al., 1991; and Hill and Snell, 1989). It is also consistent with Sheikh (2018) who argues that powerful CEOs are prone to produce more patents and citations relative to other CEOs. In fact CEO ownership is recognized as a specific dimension of CEO power in addition to other dimensions such as the structural power, the expert power and the prestige power (Finkelstein, 1992).

Turning to the firm's characteristics and board features reveals some interesting features. For instance, the presence of female directors PFD is positively and significantly associated with the introduction of product and process innovations: PROC and PROD coefficients are significant at the 1% level. Unexpectedly, estimates show that the presence of outside directors is positively associated with the number of patents: PIND coefficients are significant at the 1% level. This result is in line with Balsmeier et al. (2017).

The test of the ownership structure influence reveals only a positive and significant effect of family ownership on process innovation, at the 10% level. Also, the Cash-flows ratio CF reduces the number of patents and the likelihood of introducing a product or process innovation. However these results are non-significant.

Besides, the firm' leverage increases significantly the likelihood of product innovations (at the 10% level). Similarly, more profitable firms have larger number of patents: this result is significant at the 1% level. Finally, firms listed on US markets have more patents (significant at the 5% level). Listing on US markets seems also to favor other innovation outputs but not significantly.

Robustness checks

CEO attributes in high-Technology industries

According to Statistical classification of economic activities in the European Community (NACE) at 2-digit level, we distinguish three types of firms in our sample (Table 5): high-technology (42.4%), low-technology (10.2%) and non-technology firms (47.4%). This classification is based on technology intensity.

[Insert table 5 here]

We run regressions in two sub-samples: (1) non-technology low-technology firms and (2) high-technology firms. Results indicate that regressions on low and non-technological firms

are globally non-significant. Indeed, intuitively, non-technology firms do neither have product innovation, nor process innovation nor patents. For low-technology firms, they are less concerned about innovation compared to high-technology ones that must continuously innovate to survive in very competitive markets. Hence, we focus on the sample of high-technology firms (41 firms)

[Insert table 6 here]

Regressions (1) and (2), in table (6), reveal interesting findings[4]. The comparison of high-technology estimates with previous ones on the whole sample shows that some CEO' attributes have significant effects on innovation outcomes, in high-technology firms. For instance, the type of the academic degree is significantly associated with the number of patents in high-technology firms. Business graduated CEOs have a negative and significant effect on innovation (at the 10% level) while science educated CEOs have a positive and significant effect (at the 5% level). Hence, for high-technology firms, CEOs having business education marginalize innovation. One explanation is that she/he has short-term financial objectives while innovation is risky long-term investment (Ghoshal, 2005). Science graduated CEOs are more concerned about innovation outcomes, they could be better able to handle complex decisions and take into account the short-term and long-term projects.

Furthermore, in line with Faccio et al. (2016) and Crosen and Gneezy (2009) female CEOs seem to undertake less risky decisions and marginalize innovation decisions: the number of patents significantly decreases.

Turning to the remaining attributes, results provide evidence that CEO tenure and CEO ownership are significantly associated with innovation outcomes. The number of patents decreases with CEO tenure. In fact, entrenched CEOs are reluctant to undertake long-term projects and to introduce new changes. As expected, when the shareholder of the CEO increases, the number of patents significantly increases.

Furthermore, CEO duality and founder-CEO have negative but non-significant effects on the number of filed patents.

Finally, the number of patents decreases when State ownership increases (at the1% and 5% levels). It increases, however, with the institutional ownership (at the 1% level).

Hence, Sate is seen as a risk adverse investor. State ownership could discourage firms operating in high-technology industries to invest in innovation projects. However, institutional investors are risk takers and are more inclined to invest on innovation.

Long term effect of CEO's attributes on innovation outcomes

Results are presented in regressions (3) and (4) of the table (6). They show that women CEOs and founder-CEOs have long-term effect on the number of patents. Hence, founder-CEOs and women CEOs are risk adverse managers: they are less likely to undertake risky long-term decisions in order to achieve new innovations and new patents. Turning to the other CEO's attributes, results are not robust in the long term.

Conclusion

This study explores the influence of CEO's profile on innovation outcomes drawn on all the listed firms on the SFB120 index during the period 2001-2013.

Findings point out that the effects of CEO characteristics on innovation outcomes differ according to the proxy for innovation: process, product and patent. For instance, process innovations involves technical and operational changes, founder-CEOs and majority CEO shareholders are more involved in process innovations, while long tenured CEOs are less likely to undertake risky decisions leading to the introduction of new processes. Turning to product innovation, findings show that business graduated CEOs and majority CEO-shareholders are more likely to introduce new or significantly improved products. Finally, the number of patents increases when the share of capital hold by the CEO increases.

To better understand the relationship between CEO characteristics and innovation outcomes, we take into account the level of technology intensity. Our results show that CEO attributes have more pronounced effects on innovation outcomes in high-technology industries. For instance, unlike women CEOs and founder-CEOs, CEOs who are science graduated and less tenured, and who have large share of capital are more likely to invest in R&D projects and to achieve a large number of patents.

Our results provide support to the emerging literature on the influence of CEO attributes from different perspectives stemming from upper echelons theory, resource dependency theory and human capital theory where managerial background characteristics and connections mainly determine organizational strategic choices. It contributes to the debate on the broader concept of diversity exploring age, gender, professional experience, and academic background. It provides insights on how the choice of top executive management partially shapes strategic decisions such as innovation.

Finally, we tried to assess the effects of individual attributes on risky decisions such as undertaking innovation projects. However, we did not consider how external environment could interact with these effects, such as the CEO professional, political and social connections. We leave these issues for future development.

[1] Pilot CEOs have as a hobby of flying airplanes.

[2] This data access was funded by CTE-Gestion, University of Montpellier.

[3]The variable women CEO is dropped from regression of product and process innovations, because firms having innovation on product and/ or on process have no Woman CEO. Hence models cannot predict any relation between women CEO presence and the likelihood of innovation product and process.

[4] PROD and PROC regressions are non-significant. For the sake of space, we did not provide them. They are available upon request.

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Tables

Table 0. The sample composition

Sectors	Percentage (%)
Industrials	22.73
Consumer goods	22.47
Financial	16.12
Utilities	15.96
Technology	11.85
Health care	5.82
Oil and Gas	2.77
Basic Materials	2.29

Table 1. Descriptive statistics of variables

Panel A. Descriptive statistics of quantitative variables

Variables	N	Min	Max	Mean	Standard-deviation	Skeweness	Kurtosis
PAT	1415	0	2449	31.137	149.21	8.847	100.83
H-R&D	1534	**0**	97567	159.562	2532.394	37.197	1428.9
CEO-OWN	1431	0	80.92	2.223	10.974	5.476	33.06
AGE	1430	26	76	55.497	7.043	-.185	3.236
TENURE	1435	0	47	7.8515	8.481	1.741	6.194
PFD	1430	0	50	11.64	11.064	.759	2.799
INS-OWN	1275	0	98.5	23.012	23.392	.891	2.680
S-OWN	1273	0	89.2	2.685	11.339	5.358	33.814
F-OWN	1274	0	80.48	9.113	18.228	2.034	6.076
PIND	1305	0	100	47.633	20.748	.087	2.843
F-AGE	1506	1	348	67.492	61.611	1.580	6.362
ROA	1429	-43.01	55.49	3.899	6.5	.0721	16.153
CF	1186	7.91e-07	.2922	.00205	.0132	19.49	403.728
LEV	1392	-.25	2.021	.5784	.228	-.077	3.808

Legend: PAT: is the yearly number of patents filed; AGE: the CEO age; TENURE is the number of years since the executive has been appointed to the CEO position; CEO-OWN is the CEO share of capital; BSIZE is the number of directors; PIND is the percentage of independent directors; PFD is the percentage of female directors; S-OWN is the State share of capital; INS-OWN is the institutional investors' share of capital; F-OWN is the family share of capital; R&D is the R&D expenses to total assets ratio; H-R&D is the average yearly number of hours per R&D team dedicated to R&D activities; ROA is the return on asset ratio; F-AGE is the firm age; CF is the cash-flows to total assets ratio; LEV is the book value of debt to total assets ratio.

Panel B. Descriptive statistics of qualitative variables: table of frequencies

Variables		Percentage
USL	0	(39.72%)
	1	(60.27%)
TECH	0	(47.95%)
	1	(52.05%)
GEND	0	(98.55%)
	1	(1.45%)
Dum-PAT	0	(74.28%)
	1	(25.72%)
DUAL	0	(31.58%)
	1	(68.42%)
BEDUC	0	(51.37%)
	1	(48.63%)
SEDUC	0	(57.12%)
	1	(42.88%)
EDUC	0	(13%)
	1	(87%)
PROD	0	(85.32%)
	1	(14.68%)
PROC[5]	0	(85%)
	1	(15%)

Dum-PAT: is a dummy variable that is equal to 1 if the firm filled a patent and 0 otherwise; PROD is a dummy variable that is equal to 1 if the firm has introduced at least a new good/service or has significantly improved an existing good/service and 0 otherwise; PROC is a dummy variable that is equal to 1 if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise; EDUC is a dummy variable equal to 1 is the CEO has a Master, MBA or PhD degree; SEDUC is a dummy variable equal to 1 is the CEO has a science or an engineering degree; BEDUC is a dummy variable equal to 1 is the CEO has a business/management/ corporate law education; DUAL is a dummy variable equal to 1 if the CEO and Chairperson are the same person; FOUND is a dummy variable equal to 1 if the CEO is the business founder; GEND is a dummy variable equal to 1 if the CEO is a woman; USL is a dummy variable equal to 1 if the firm is listed on US markets and 0 otherwise. *, and ** significant respectively at the5%, and 1% levels.

Table 2.Pairwise Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12
1	PROD	1.000											
2	PROC	.912**	1.000										
3	PAT	.320**	.301**	1.000									
4	DUM-PAT	.309**	.290**	.986**	1.000								
5	H-R&D	.205**	.215**	.457**	.444**	1.000							
6	CEO-OWN	-.055*	-.064*	-.016	-.021	-.067*	1.000						
7	GEND	-.050	-.051	.001	.002	.048	-.035	1.000					
8	AGE	.057*	.056*	-.051	-.048	.005	.014	-.061*	1.000				
9	TENURE	-.006	-.006	-.052	-.049	-.050	.284**	.005	.359**	1.000			
10	DUAL	.112**	.116**	.072**	.066*	.083**	.157**	-.093**	.126**	.118**	1.000		
11	SEDUC	.075**	.092**	.085**	.074**	.108**	.007	.023	.025	-.001	.031	1.000	
12	EDUC	.000	-.010	.050	.055*	.041	-.070**	-.028	-.161**	-.155**	-.080**	.237**	1.000
13	BEDUC	-.117**	-.141**	-.103**	-.105**	-.146**	-.077**	-.052	-.114**	-.092**	-.125**	-.741**	-.069**
14	FOUND	.088**	.099**	-.088**	-.065*	.005	.205**	-.037	0.014	.370**	.092**	-.103**	-.143**
15	F-OWN	0.040	0.032	-.062*	-.040	.013	.168**	-.024	0.050	.161**	-.071*	.010	-.068*
16	INS-OWN	.110**	.075*	-.010	-.013	-.044	-.146**	-.070*	-0.039	-.083**	-.079**	-0.021	.062*
17	S-OWN	.094**	.089**	-.033	-.021	.021	-.110**	.174**	0.036	-.119**	.024	.025	.117**
18	BSIZE	.062*	.100**	-.059*	-.051	-.053*	-.245**	.052	.123**	-.138**	.161**	0.035	.043
19	PFD	.038	.040	-.020	-.004	-.008	.001	-.002	.097**	.087**	.011	-.078**	-.080**
20	PIND	-.005	.035	.116**	.109**	.117**	.006	-.080**	-.035	-.048	-.116**	0.004	.122**
21	USL	.003	-.001	.142**	.133**	.109**	-.145**	.044	.002	-.099**	-.038	.087**	-.008

22	LEV	.012	.005	-.091**	-.087**	-.037	-.137**	-.094**	-0.003	-.128**	-.022	.046	.168**
23	ROA	.070*	.069*	.096**	.096**	.033	-.106**	-.034	.102**	.162**	-.091**	-.051	-.028
24	CF	-.010	-.052	.032	.035	.021	.152**	-.082**	-0.056	.186**	-.012	-.125**	-.046
25	F-AGE	.010	-.006	.049	.063*	.073**	-.226**	-.099**	.073**	-.096**	-.118**	-.065*	-.016

PAT: is the yearly number of patents filed during the; Dum-PAT: is a dummy variable that is equal to 1 if the firm filled a patent and 0 otherwise PROD is a dummy variable that is equal to 1 if the firm has introduced at least a new good/service or has significantly improved an existing good/service and 0 otherwise; PROC is a dummy variable that is equal to 1 if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise; AGE: the CEO age; TENURE is the number of years since the executive has been appointed to the CEO position; EDUC is a dummy variable equal to 1 is the CEO has a Master, MBA or PhD degree; SEDUC is a dummy variable equal to 1 is the CEO has a science or an engineering degree; BEDUC is a dummy variable equal to 1 is the CEO has a business/management/ corporate law education; DUAL is a dummy variable equal to 1 if the CEO and Chairperson are the same person; FOUND is a dummy variable equal to 1 if the CEO is the business founder; GEND is a dummy variable equal to 1 if the CEO is a woman; CEO-OWN is the CEO share of capital; BSIZE is the number of directors; PIND is the percentage of independent directors; PFD is the percentage of female directors; S-OWN is the State share of capital; INS-OWN is the institutional investors' share of capital; F-OWN is the family share of capital; R&D is the R&D expenses to total assets ratio; H-R&D is the average yearly number of hours per R&D team dedicated to R&D activities; ROA is the return on asset ratio; F-AGE is the firm age; CF is the cash-flows to total assets ratio; LEV is the book value of debt to total assets ratio; and USL is a dummy variable equal to 1 if the firm is listed on US markets and 0 otherwise. *, and ** significant respectively at the5%, and 1% levels.

Table 2.Pairwise Correlation Matrix (continued)

		13	14	15	16	17	18	19	20	21	22	23	24	25
13	BEDUC	1.000												
14	FOUND	-.029	1.000											
15	F-OWN	-.043	.411**	1.000										
16	INS-OWN	.109**	-.112**	-.196**	1.000									
17	S-OWN	.006	.059*	-.164**	-.028	1.000								
18	BSIZE	.010	-.108**	-.149**	.149**	.373**	1.000							
19	PFD	-.006	.037	.118**	.137**	-.014	.022	1.000						

20	PIND	.066*	-.146**	-.198**	.075**	-.213**	-.088**	.017	1.000					
21	USL	-.027	-.221**	.007	.096**	.008	.096**	.012	.131**	1.000				
22	LEV	-.002	-.032	-.040	.201**	.050	.206**	.060*	-.092**	.095**	1.000			
23	ROA	.017	.013	.100**	-.034	-.123**	-.086**	.005	-.022	-.007	-.276**	1.000		
24	CF	.086**	.174**	.219**	-.137**	-.299**	-.548**	-.094**	-0.051	-.178**	-.201**	.259**	1.000	
25	F-AGE	.104**	-.021	.073**	.114**	-.111**	.111**	.054*	.070*	-.016	.020	.145**	.083**	1.000

Table 3. Mean difference tests MDT

Panel A: MDT between firms with at least one innovation and firms without innovation

	PAT(t+1)			PROD(t+1)			PROC(t+1)		
Variables	0	1	MDT	0	1	MDT	0	1	MDT
F-OWN	9.342	8.702	0.639	9.241	8.802	0.439	9.201	9.038	0.163
INS-OWN	21.814	20.039	1.775	20.486	26.416	(-5.93)***	20.818	24.402	-3.584
S-OWN	2.493	3.032	-0.539	1.939	6.703	(-4.764)***	1.947	6.548	(-4.601)***
PIND	45.460	51.225	(-5.764)***	46.838	47.822	-0.984	46.438	50.049	-3.611
PFD	10.341	10.333	0.008	10.232	10.954	-0.722	10.230	10.954	-0.724
H-R&D	45.5082	501.8007	(-456.292)*	81.239	613.219	-531.980	81.378	612.431	-531.053
LEV	0.587	0.546	0.040***	0.576	0.574	0.002	0.577	0.571	0.006
CEO-OWN	2.477	1.455	1.022	2.261	1.948	0.313	2.250	2.016	0.234
AGE	55.553	54.760	0.792*	55.126	56.644	(-1.517)***	55.138	56.545	(-1.407)***
TENURE	8.223	6.758	1.465***	7.800	8.098	-0.298	7.814	8.010	-0.196
F-AGE	65.083	72.991	(-7.908)**	67.305	65.284	2.021	67.781	62.583	5.198
ROA	3.778	4.614	(-0.835)**	3.940	4.270	-0.330	3.934	4.294	-0.359
CF	0.002	0.003	-0.001	0.002	0.002	0.001	0.002	0.001	0.001
BSIZE	12.11	11.62	0.486**	11.88	12.61	(-0.727)**	11.809	12.980	(-1.171)***

PAT: is the yearly number of patents filed during the; PROD is a dummy variable that is equal to 1 if the firm has introduced at least a new good/service or has significantly improved an existing good/service and 0 otherwise; PROC is a dummy variable that is equal to 1 if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise; AGE: the CEO age; TENURE is the number of years since the executive has been appointed to the CEO position; CEO-OWN is the CEO share of capital; BSIZE is the number of directors; PIND is the percentage of independent directors; PFD is the percentage of female directors; S-OWN is the State share of capital; INS-OWN is the institutional investors' share of capital; F-OWN is the family share of capital; R&D is the R&D expenses to total assets ratio; H-R&D is the average yearly number of hours per

R&D team dedicated to R&D activities; ROA is the return on asset ratio; F-AGE is the firm age; CF is the cash-flows to total assets ratio; LEV is the book value of debt to total assets ratio. *, and ** significant respectively at the5%, and 1% levels.

Panel B: MDT between firms with at least one CEO turnover and firms without CEO turnover

	No CEO Turnover	One CEO Turnover	Two CEO-Turnover	Three CEO-Turnover	More than 4 CEO-Turnover	DIFF	DIFF	DIFF	DIFF	DIFF	DIFF
	A	B	C	D	E	A-B	B-C	A-C	C-D	A-D	A-E
PATENT	19.14	41.13	50.76	10.77	9.21	-21.9***	-9.63	-31.61**	39.99***	8.371*	9.931***

*, and ** significant respectively at the5%, and 1% levels.

Table 4. Estimation Results

		(1)	(2)	(3)	(4)	(5)	(6)
		PAT(t+ 1)	PAT(t+1)	PROD(t+1)	PROD(t+1)	PROC(t+1)	PROC(t+1)
CEO demographic attributes	AGE	-0.001	-0.001	0.060	0.048	-0.002	0.023
	BEDUC	-0.103			1.965*		0.345
	SEDUC		0.126	-1.628		-1.326	
	EDUC	-0.194	-0.224	-0.270	-0.625	2.573	2.180
	GEND	-0.120	-0.101				
CEO position's characteristics	TENURE	-0.002	-0.003	-0.095	-0.066	-0.176**	-0.173**
	DUAL	0.122	0.130	-0.087	-0.233	-0.033	-0.085
	FOUND	-0.491*	-0.472	0.347	0.534	3.170*	3.510*
	CEO-OWN	0.012*	0.013**	0.169*	0.177**	0.176	0.168*
	H-R&D	0.117***	0.120***	-0.219	-0.219	0.0354	0.0506
	F-AGE	0.001	0.001	-0.008	-0.010	-0.012	-0.010
	ROA	0.035***	0.035***	0.016	0.011	0.007	0.003
	PIND	0.009**	0.009**	-0.004	-0.0010	0.028	0.020
	BSIZE	-0.012	-0.012	-0.448**	-0.390*	-0.190	-0.112
	PFD	-0.006	-0.005	0.140***	0.151***	0.121***	0.119***
	CF	-0.073	-0.072	-0.485	-0.507	-0.477	-0.500*
	LEV	-0.214	-0.222	6.628*	6.642*	1.717	1.128
	S-OWN	0.0002	-3.42e-05	0.027	0.013	0.001	-0.019
	INS-OWN	0.002	0.002	0.012	0.012	-0.012	-0.0161
	F-OWN	0.001	0.0004	0.023	0.014	0.075**	0.078*
	USL	0.393**	0.383**	1.390	1.151	1.066	0.953
	Industry-effect	Yes	Yes	Yes	Yes	Yes	Yes
	Constant	0.348	0.255	-17.45***	-18.48***	-16.06***	-17.41***
	N	893	893	881	881	881	881
	R^2	0.126	0.127				
	Wald chi2			50.18	48.73	45.31	35.68
	Prob> chi2			0.003	0.004	0.011	0.098
	Number of firms	104	104	104	104	104	104

PAT: is the yearly number of patents filed during the; PROD is a dummy variable that is equal to 1 if the firm has introduced at least a new good/service or has significantly improved an existing good/service and 0 otherwise; PROC is a dummy variable that is equal to 1 if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise; AGE: the CEO age; TENURE is the number of years since the

executive has been appointed to the CEO position; EDUC is a dummy variable equal to 1 is the CEO has a Master, MBA or PhD degree; SEDUC is a dummy variable equal to 1 is the CEO has a science or an engineering degree; BEDUC is a dummy variable equal to 1 is the CEO has a business/management/ corporate law education; DUAL is a dummy variable equal to 1 if the CEO and Chairperson are the same person; FOUND is a dummy variable equal to 1 if the CEO is the business founder; GEND is a dummy variable equal to 1 if the CEO is a woman; CEO-OWN is the CEO share of capital; BSIZE is the number of directors; PIND is the percentage of independent directors; PFD is the percentage of female directors; S-OWN is the State share of capital; INS-OWN is the institutional investors' share of capital; F-OWN is the family share of capital; R&D is the R&D expenses to total assets ratio; H-R&D is the average yearly number of hours per R&D team dedicated to R&D activities; ROA is the return on asset ratio; F-AGE is the firm age; CF is the cash-flows to total assets ratio; LEV is the book value of debt to total assets ratio; and USL is a dummy variable equal to 1 if the firm is listed on US markets and 0 otherwise. *, and ** significant respectively at the5%, and 1% levels.

Table 5. Technology intensity' classification

Sectors	**Percentage (%)**
High techology firms	42,4%
Low technology firms	10,2%
Non-technololgy firms	47,4%
	100%

Table 6. Robustness checks on patent: High tech industries

		(1)	(2)	(3)	(4)
		PAT(t+1)	**PAT(t+1)**	**PAT(t+3)**	**PAT(t+3)**
CEO demographic attributes	**AGE**	0.031	0.033	0.031	0.030
	SEDUC	0.618**		0.267	
	BEDUC		-0.458*		-0.336
	EDUC	-0.104	-0.030	-0.213	-0.233
	GEND	-0.814	-0.716	-2.133**	-2.070**
CEO position' characteristics	**TENURE**	-0.045*	-0.041*	-0.027	-0.028
	DUAL	-0.033	-0.029	-0.100	-0.072
	FOUND	-0.422	-0.490	-1.085*	-1.091*
	CEO-OWN	0.314**	0.317**	0.186	0.186
	H-R&D	0.171***	0.155***	0.187***	0.183***
	F-AGE	-0.004	-0.004	-0.008**	-0.008**
	ROA	0.057***	0.056***	-0.022	-0.023
	PIND	0.010	0.010	0.008	0.010
	BSIZE	0.011	-0.002	0.035	0.034
	PFD	-0.001	-0.004	-0.010	-0.009
	CF	-0.224**	-0.232**	-0.212	-0.208
	LEV	0.103	0.117	-0.050	0.001
	S-OWN	-0.063***	-0.056**	-0.054**	-0.053**
	INS-OWN	0.0194***	0.0196***	0.0170*	0.0175**
	F-OWN	0.003	0.004	0.007	0.007
	USL	0.576*	0.559*	0.454	0.439
	Constant	-3.193**	-2.769**	-2.006	-1.712
	N	364	364	294	294
	R^2	0.225	0.215	0.189	0.190
	Number of firms	41	41	40	40

PAT: is the yearly number of patents filed during the; PROD is a dummy variable that is equal to 1 if the firm has introduced at least a new good/service or has significantly improved an existing good/service and 0 otherwise; PROC is a dummy variable that is equal to 1 if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise; AGE: the CEO age; TENURE is the number of years since the executive has been appointed to the CEO position; EDUC is a dummy variable equal to 1 is the CEO has a

Master, MBA or PhD degree; SEDUC is a dummy variable equal to 1 is the CEO has a science or an engineering degree; BEDUC is a dummy variable equal to 1 is the CEO has a business/management/ corporate law education; DUAL is a dummy variable equal to 1 if the CEO and Chairperson are the same person; FOUND is a dummy variable equal to 1 if the CEO is the business founder; GEND is a dummy variable equal to 1 if the CEO is a woman; CEO-OWN is the CEO share of capital; BSIZE is the number of directors; PIND is the percentage of independent directors; PFD is the percentage of female directors; S-OWN is the State share of capital; INS-OWN is the institutional investors' share of capital; F-OWN is the family share of capital; R&D is the R&D expenses to total assets ratio; H-R&D is the average yearly number of hours per R&D team dedicated to R&D activities; ROA is the return on asset ratio; F-AGE is the firm age; CF is the cash-flows to total assets ratio; LEV is the book value of debt to total assets ratio; and USL is a dummy variable equal to 1 if the firm is listed on US markets and 0 otherwise. *, and ** significant respectively at the5%, and 1% levels.