Heliyon 6 (2020) e04980

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Board effects on innovation in family and non-family business

Juan Pablo Gonzales-Bustos [a], Ana Beatriz Hernández-Lara [b], Xiaoni Li [b,*]

[a] Universidad Internacional de la Rioja, Spain
[b] Business Management Department, Universitat Rovira i Virgili, Spain

ARTICLE INFO

Keywords:
Board of directors
Innovation
Family businesses
Gender
Duality
Independent directors
Corporate governance
Organizational theory
Management
Business management
Strategic management
Family business
Research and development

ABSTRACT

This paper contributes to the corporate governance and innovation literature by providing empirical evidence with respect to the influence of composition of the board and its leadership structure on innovation. Also, this study seeks to investigate if such influence differs when comparing family and non-family business. Data were collected from 86 Spanish companies of innovative sectors from 2003 to 2014. The results show that innovation is affected positively by board size, especially in the case of family businesses, and gender diversity, especially in non-family businesses. Similarly, findings also point out that duality is better than the independence of functions in the case of non-family businesses. Finally, obtained results support that independent directors have a negative impact on innovation and such negative influence is even stronger in family firms. These findings contribute to an inconclusive literature regarding board effects on innovation, highlighting different recommendations depending on whether the companies are family businesses or not.

1. Introduction

Innovation becomes a crucial tool not only for firms to develop and maintain the competitive advantages in the ongoing turbulent market (Becheikh et al., 2006; Gonzales-Bustos et al., 2017) but also a key for their success and survival (Kor, 2006; Torchia et al., 2011). There are both internal and external variables which may have an impact on firms' innovation process and strategy (Cassiman and Veugelers, 2006). Internally, corporate governance literature offers some useful insights into the innovative behavior of firms (Belloc, 2012). This literature suggests that firms are different in corporate governance structure and mechanism and these differences may partially explain the innovative behavior adopted (Barker and Mueller, 2002).

Research work with regards to the relationship between different aspects of corporate governance and innovation were initiated since decades ago (Goodstein and Boeker, 1991). Some studies in the literature have focused on innovation determinants (Drucker, 1985; Jansen et al., 2006; Berraies et al., 2015; Valenti and Horner., 2020; Iyengar and Sundararajan, 2019). However, very few research works are dedicated to the contribution of corporate governance to strategic resources development and innovation promotion (O'Sullivan, 2000; Lazonick, 2010; Shapiro et al., 2015; Berraies and Rejeb, 2019). The existing literature shows that studies exploring the relationship between corporate governance and innovation performance have yielded very mixed findings in terms of the board size, its gender diversity, and CEO's characteristics (Berraies and Rejeb, 2019; Principe, 2016; Jaskyte, 2012; Wincent et al., 2010).

Therefore, the objective of this study can be stated as twofold. First, it aims to contribute to the existing literature in determining how certain board of directors' characteristics, composition and leadership structure, can boost business innovation. Second, this study seeks to investigate if such influence differs when comparing family and non-family businesses. Upon these objectives, we aim to contribute to a body of knowledge that is inconclusive by analyzing the impact of the aforementioned characteristics, board independence and CEO duality on innovation, providing empirical evidence and insights of firms in innovative sectors in Spain. This research is particularly interesting as few studies have previously investigated this topic related to the impact of the board of directors on innovation activities, comparing the familiar nature of companies that strongly determine how the companies are managed and governed.

The rest of the paper is organized as follows. Section 2 presents the relevant literature and research hypotheses. Sample and data are shown in section 3. Section 4 describes the empirical analysis followed by discussions in section 5. Conclusions are presented in the last section.

* Corresponding author.
E-mail address: xiaoni.li@urv.cat (X. Li).

https://doi.org/10.1016/j.heliyon.2020.e04980
Received 7 May 2020; Received in revised form 16 July 2020; Accepted 16 September 2020

2. Board of directors and innovation: relevant literature and research hypotheses

The exploration for the main research topics on corporate governance highlights the effects of board of directors on innovation. These studies fundamentally analyze the structure and composition of the board (Van Essen et al., 2012). As argued by Jensen (1993), the board of directors has a crucial impact on firm's internal control system and a dysfunctional corporate internal control system may lead to the failure of the firm (Simpson and Gleason, 1999). Fama (1980) also agreed that the board of directors is the central internal control mechanism for supervising and monitoring managers. Changes in board composition may influence the relationship between top management and shareholders via board of directors (Baysinger and Hoskisson, 1990).

Moreover, it is worth mentioning that different types of companies (family business or non-family business) own boards with distinctive characteristics and may yield divergent results on innovation. In recent years there is an increasing number of studies that concretely analyze the influence that family ownership can have on innovation (De Massis et al., 2012). There are also indications that family ownership, as well as the participation of family members in the management board of the company, may influence innovation and R&D investment (De Massis et al., 2013).

There are different theoretical perspectives that academics have used to understand the effects that the companies' ownership and the composition of their boards can exert on their performance and innovation. Firstly, the Agency Theory assumes the self-serving behavior of agents so as to satisfy their own interests above all others (Eisenhardt, 1989; Ashwin et al., 2015, 2016; Blanco-Mazagatos et al., 2016). Secondly, the Stewardship Theory (Davis et al., 1997) assumes that agents are far from being "opportunistic shirker" and they would like to achieve good corporate performance so as to improve effectiveness and obtain superior returns to shareholders. Thirdly, the Resource Dependence Theory suggests (Pfeffer and Salancik, 1978) that a board of directors can help in the formulation and implementation of the firm strategy because a board linking a firm to its external environment can foster access to critical information and valuable resources that may reduce uncertainty for strategic actions (Haynes and Hillman, 2010; Kroll et al., 2007; Chen, 2014). Building on the Resource Dependence Theory, Hillman and Dalziel (2003) introduce the concept of board capital as the sum of individual directors' human and social capital and use board capital as a proxy for a board's ability to monitor, control (Hambrick et al., 2015; Withers et al., 2012) and provide resources for the firm strategy. Accordingly, board capital may also explain corporate decisions in innovation, which demand effective guidance and various resources.

As a result of these different theoretical perspectives, it is not surprising that this line of research has declared different proposals and finally reached distinctive conclusions about the effects of the company ownership and the composition of its board on innovation. In fact, the body of research that explores the link between corporate governance and innovation is not consistent in its conclusions, and offers mixed findings about the influence that board size, gender diversity, and the independence of directors and CEOs finally exert on innovation, especially considering and comparing different property structures like those determined by the familiar nature of the companies. The aforementioned highlights the necessity to continue the study on the influence of the board of directors on innovation, distinguishing different ownership structures, like those of family and non-family businesses. This study seeks to contribute to this research void.

2.1. Board size and innovation

Recent research has revealed the relationship between size of the board and innovation. Board size may influence the inclusion of a variety number of perspectives on corporate strategy (Pearce and Zahra, 1992; Goodstein et al., 1994). However, the results regarding the impact of board size are very disparate without reaching an agreement in the literature (Cheng, 2008).

Some authors suggest that large board size favors innovation (Zona et al., 2008), mainly on product, process and organizational innovation (Kwon and Shin, 2007), or intensity (Mezghanni, 2008) and investment in R&D (Ashwin et al., 2016). These studies shed light on the board's strategic and advisory role (Gonzales-Bustos et al., 2017). According to the Agency Theory, small boards may not have sufficient experience and skills for the effective control and evaluation of the initiatives, particularly those related to innovation (Gonzales-Bustos et al., 2017). This would make the board emphasize short-term goals and objectives, leaving aside long-term objectives such as those related to innovation (Zahra et al., 2000). According to the Resource Dependence Theory, small firms may have more difficulty gaining access to crucial resources and have fewer options for managing their resource dependencies (Pfeffer and Salancik, 1978; Perez-Calero et al., 2017), limiting its capacity for innovation.

However, others argue that an excessive board size can lead to dysfunctional allocation of board members' responsibilities (Golden and Zajac, 2001) which may have a negative impact on the motivation of the board members to participate in strategic decision making (Eisenberg et al., 1998), as innovation. This approach led some authors to suggest a negative association between board size and innovation (Cheng, 2008). The aforementioned arguments lead the authors to propose the hypotheses openly as:

Hypothesis 1a. Board size has a positive influence on innovation.

Hypothesis 1b. Board size has a negative influence on innovation.

In the context of the family business, the risk of opportunistic behavior on the part of the executive managers is low or null comparing to non-family business. Therefore, for family business, the board tends to focus more on advisory role instead of monitoring and controlling (Brunninge et al., 2007).

Echoed with the assumptions of the Stewardship Theory (Davis et al., 1997), some authors as Gubitta and Gianecchini (2002) suggest that in family business, board size is relatively smaller compared with non-family business. Given this particularity of family businesses, where boards tend to be small, their growth in terms of adding more directors may enhance their capacity for advice (Corbetta and Salvato, 2004a), which is expected to have positive influences on innovation. Other arguments point out that small boards may not have enough breadth, or the necessary competencies to render good judgment. More directors also imply more eyes capable of noticing problems and ensuring accountability, which are valuable especially if the starting point is a small board, like it is the case, frequently, in family businesses (Lane et al., 2006). Accordingly, the authors propose the following Hypothesis:

Hypothesis 1c. A larger board size has a stronger positive influence on innovation in family business than in non-family business.

2.2. Female directors and innovation

Gender diversity on companies' board of directors is a subject of debate in corporate governance studies (Terjesen et al., 2009). There are arguments emphasizing the importance of female board members, even if in most cases, their presence is still purely symbolic (Daily and Dalton, 2003; Terjesen et al., 2009; Gonzales-Bustos et al., 2017; Hernández-Lara and Gonzales-Bustos, 2020).

Some authors suggest that there may be a positive relationship between gender diversity and innovation (Østergaard et al., 2011), mainly on marketing innovation (Galia and Zenou, 2012), or on innovation opportunities. Based on the Resource Dependence Theory's view, the board's diversity emphasizes the breadth of the resources that directors bring to the board (Kim and Lin, 2010; Reeb and Zhao, 2009), which generates a wider range of perspectives for searching information and

assisting managerial decisions. Therefore, gender diversity creates a deeper and more productive discussion (Post and Byron, 2015).

Some explanations which are in favor of the positive relationship refer to the fact that female representations in top positions can contribute to new insights, divergent experiences, knowledge and skills which are especially beneficial for innovation (Galia and Zenou, 2012). This is principally due to their better understanding of consumer behavior, customer needs as well as that they could represent means and opportunities of companies to satisfy those necessities (Galia and Zenou, 2012).

Others argue that gender diversity can increase the possibility of intra-group conflict in the top management (Treichler, 1995). They have also pointed out that women were more risk-averse towards decision-making (Barsky et al., 1997), which could affect the allocation of resources of the organization to risky investments, such as investment in R&D and innovation. These negative arguments of the board's gender diversity on innovation are confirmed by Galia and Zenou (2012) and Cropley and Cropley (2017). These authors highlight the negative influence of gender diversity on product innovation. The inconsistency in the results of previous research shows the importance of further studies analyzing this impact. Therefore, the following open hypotheses are proposed:

Hypothesis 2a. Gender diversity in the board has a positive influence on innovation.

Hypothesis 2b. Gender diversity in the board has a negative influence on innovation.

In the case of family business, to the best of our knowledge, previous research has shown no particular interest regarding the analysis of impact that gender diversity in the board exert on innovation. The few studies on gender diversity in family firms have argued that female representations appointments in top company positions are greatly determined by family ties or by the controlling shareholder with the expectation that the appointed female members will support some important management decisions (Loukil and Yousfi, 2016; Nekhili and Gatfaoui, 2013). These authors found evidence that family ownership tends to favor the appointment of women, usually family members, to the board. In the latter case, the most common scenario is that the women named on the board are those who are able to adjust to the dominant norms of their male counterparts, who are usually also members of the family (Casey et al., 2011).

Given that most of the positive influence on innovation of gender diversity on board can only be guaranteed as long as women are independent (Terjesen et al., 2009), in the case of family businesses, where this independence could be jeopardized being the women appointed to the board under the influence of their family male counterparts, their power of influence in decision making can be perceived as having less impact on innovation (Hernández-Lara and Gonzales-Bustos, 2020). These arguments lead to the following Hypothesis:

Hypothesis 2c. Gender diversity on boards has less influence on innovation in family business than in non-family business.

2.3. Independent directors and innovation

The academic literature has not reached consensus on the true influence of external and/or independent directors on innovation. Some authors concluded that there may be a positive relationship (Aragón et al., 2007). According to these authors, the exchange of knowledge within the board can influence the ability of a company to innovate, supporting and inspiring new ideas that improve the competitiveness of societies. External and independent board members can "think more freely with regard to the firm's goals" and may enhance cognitive diversity for decision-making process (Forbes and Milliken, 1999), which promotes innovations (Van Essen et al., 2012). According to the approach of the Agency Theory, it could be argued that the presence of this type of board members is positively associated with innovation.

However, other studies have displayed that the cognitive diversity on boards occurs when the proportion of external and independent directors increases, which can be converted as a "double-edged sword" for a successful innovation strategy (Milliken and Martins, 1996). These authors consider that cognitive heterogeneity may cause a dysfunctional rivalry in top positions and a decrease in knowledge level (Michie et al., 2006). Therefore, it can be more complicated to reach consensus for certain complex strategies, such as innovation (Goodstein et al., 1994). Based on the aforementioned arguments and the Stewardship Theory, some authors suggest a negative association of this type of board members with innovation (Yoo and Sung, 2015; Zahra et al., 2000).

This negative relationship can be interpreted as the fact that external and independent directors do not have sufficient information about operating issues of the industry or technologies which are directly connected with the business of the company (Baysinger et al., 1991; Baysinger and Hoskisson, 1990). According to these assumptions, the advisory and control entrusted to external and independent directors are not always positive for innovation (Zahra et al., 2000) and investment in R&D (Yoo and Sung, 2015), and it may actually depend on the specific context of each company. What has been exposed so far leads to open hypotheses about the relationship between external and/or independent directors on innovation:

Hypothesis 3a. The ratio of external and/or independent directors is positively associated with innovation.

Hypothesis 3b. The ratio of external and/or independent directors is negatively associated with innovation.

In family businesses, different types of board members may also have distinctive impact on innovation and R&D investments (Corbetta and Salvato, 2004b), but such impact is not necessarily the same as it may have on non-family businesses. In the case of family businesses, some scholars consider that external and/or independent board directors may have a greater impact on innovation due to the moderating divergence of interests (Miller et al., 2005; Gonzales-Bustos et al., 2017) and the reduction in agency costs with regard to family altruism (Schulze et al., 2002).

However, few have been dedicated to analyzing the impact of this type of directors on innovation in family business. Some authors, based on the Agency Theory, have suggested that there may be a positive relationship between the proportion of external and/or independent board directors and innovation (Nahapiet and Ghoshal, 1998). According to these authors, the human and financial capacities of the external and/or independent directors allow the family business to be more capable and more willing to participate in innovative activities (Matzler et al., 2015), as well as to expand the innovation they have already carried out (Nahapiet and Ghoshal, 1998). Some possible explanations of these findings can be found in the fact that participation of this type of directors facilitates the exchange of knowledge within the family organization, which may influence the capacity of the company to innovate, especially in this type of organizations that tend to have more homogeneous advice and are dominated by certain thoughts of the family (Aragón et al., 2007). The aforementioned arguments lead to the following Hypothesis:

Hypothesis 3c. The ratio of external and/or independent directors has more positive influence on innovation in family business than in non-family business.

2.4. CEO duality and innovation

Few studies have focused on analyzing the impact of duality roles on innovation. Some exceptions are the studies by Kor (2006), Van Essen et al. (2012), Zahra et al. (2000) and Zona (2016). According to these

research works, CEO duality may have a positive impact on innovation (Chouaibi et al., 2010) and investment in R&D (Van Essen et al., 2012).

Some possible explanations for this positive association, based on arguments drawn from the Stewardship Theory, point out that CEO duality can eliminate ambiguity regarding the company's leadership and to increase the legitimacy of a strong leader, avoiding confusion about who wins the power of the company (Baliga et al., 1996). In these cases, if the leader is appealed to risk taking and is in favor of innovation strategies, this duality will have a positive influence on innovation and R&D investment.

However, some others, referring to Agency Theory assumptions, have pointed out that when there is duality, the board is in a weak position in relation to the company's managers, this fact may complicate in changing the status quo and introducing new ideas to the company which deteriorates innovation (Zahra et al., 2000). In this case, the centralization of powers in the top executive of the company generally impairs the adoption of strategies that involve certain risk (Chen and Hsu, 2009). Based on those previous arguments, open hypotheses can be proposed regarding the impact of duality on innovation:

Hypothesis 4a. The duality of functions has a positive influence on innovation.

Hypothesis 4b. The duality of functions has a negative influence on innovation.

In the case of the family business, duality is very widespread and its influence is likely to be greater (Zehir et al., 2011). The family-owned business may be more vulnerable to problems of auto-control (Chang et al., 2010), since frequently the same person in charge may act not only as executive of the company and chairman of the board, but also as the biggest shareholder of the firm.

Some authors, based mainly on the Agency Theory assumptions, stated a negative relationship between the CEO duality and innovation in the family business (Chin et al., 2009), providing evidence that innovation is lower for some family firms, where the controlling owner of the firm is also the chief executive officer or the chair of the board of directors.

Some possible explanations for this negative evidence may be found in the fact that family firms are described as more risk-averse (De Massis et al., 2013; Gómez-Mejía et al., 2007; Zehir et al., 2011). This aversion to risk could negatively influence the commitment to innovation (Perel, 2002). If the company is governed and managed by family members who are risk-averse, because of the diversification scarcity of their investment, it is logical to assume a negative influence on innovation so as to limit investment in R&D.

However, other authors who support the Stewardship Theory argued that the CEO duality can have a positive and significant influence on R&D investment in family firms (Ashwin et al., 2015). Some possible explanations can be found as that the objectives of owners and managers are aligned in family business (Davis et al., 1997), which as a consequence, the risk of opportunistic behavior is low or null (Davis et al., 1997). This can benefit innovation when firm shows a clear long-term orientation, growth and survival, even this involves risk taking (Baliga et al., 1996). The following Hypothesis is proposed considering the aforementioned arguments:

Hypothesis 4c. CEO duality has more positive influence on innovation in family business than in non-family business.

3. Sample and data

3.1. Sample collection and sources of information

This article examines the relationship between different characteristics of the structure and composition of the board of directors and innovation using a dataset of Spanish listed companies. We included companies that belonged to innovative sectors, according to the percentage of innovative companies in the sector (greater than 30%), the R&D intensity (above 1.5%), or the percentage of income due to new or improved products (above 10%). Considering these criteria, 44 sectors according to the Spanish National Classification of Economic Activities (CNAE, 2009) were included. In order to simplify and reduce the number of categories considered in this regard, we looked for the equivalence between the CNAE Classification and the Stock Market Sector Classification used by the Madrid Stock Exchange. Accordingly, five economic sectors were included: energy and water supply, extractives, construction, industry, and services.

The search of the Spanish-listed companies within the 44 selected sectors included in the SABI database in 2003 (initial year of this study) returned a total of 669 companies. However, after checking if the company's headquarters were in Spanish territory, the actual economic activity developed by the firm, and that the company was operational throughout at least 5 years within the period considered in this study, the size of the sample diminished. The final sample was an imbalanced panel data composed of 86 Spanish-listed companies during the period from 2003 to 2014 (both years included). We included a delay of one year between independent and dependent variables. This ensured that the direction of causality was from characteristics of the structure and composition of the board of directors to innovation instead of the reverse case. It also gives time for independent variables to have their impacts on the companies' decisions (Chen and Hsu, 2009). At the end, 898 usable observations were obtained.

The data were retrieved from the CNMV (National Stock Market Commission), the annual financial statements of every company, ESPACENET (European Network of Patent Databases), SABI, and Datastream.

3.2. Dependent variable: innovation

This study includes two innovation indicators. The first one is related to R&D expenses registered by each company every year. R&D spending has been determined through the number of monetary units that the organization destines to the exploitation, and scientific and technological experimentation that allows to discover new technologies, products and/or processes, or to improve substantially those existing ones (Hernández et al., 2010; Hitt et al., 1997). The second indicator refers to the existence of patenting activity in the company (PAT) (Liang et al., 2013). This indicator is directly related to inventiveness and has been used as the basis for the development of innovation indicators in many studies (Balsmeier et al., 2014). In the case of R&D, to avoid asymmetry problems in the distribution of the variable, we added a very small constant 0.001 (David et al., 2008) and transformed the variable by measuring its logarithm (Feng et al., 2014; Hernández-Lara and Gonzales-Bustos, 2019; Hernández-Lara et al., 2014). This transformation reduces asymmetries and standardizes the variable (Lin and Germain, 2003). As for patents (PAT), due to the high proportion of companies in our sample with zero patents (70.60% of the observations in the sample exhibit no patents), the addition of the small constant may influence the regression analysis and the logarithmic transformation may not solve problems of asymmetry. These reasons lead us to measure it creating a dichotomous categorical variable with two values, “yes” in case the company had patents and “no” otherwise.

3.3. Independent variables

Board size (BSIZE). Board size is measured by the total number of board members in this governing body (Pearce and Zahra, 1992).

Gender diversity (GEN). Gender diversity is measured as the Blau Heterogeneity Index (Blau, 1977). This index is frequently used in the research of diversity in demographic variables for categorical ones and is calculated as $B = [1-\Sigma(p_i^2)]$, where p_i is the percentage of individuals in *i*th category (Camelo-Ordaz et al., 2005). In the case of gender, there are two categories ($k = 2$). Thereby, the higher the Blau index, the greater gender diversity on the board, and due to the Blau index ranges between

0 and (k-1)/k, the highest diversity is achieved at 0.5, which means parity between men and women appointed to the board.

Percentage of total external directors, including proprietary and independent (OUT1). This variable was measured through the division of the total number of proprietary, independent and other external directors by the board size (Conthe Code, 2006). The typologies of directors are defined in the Spanish Law of Capital Companies (article number 529), which considers proprietary directors those with a significant participation in the company or in representation of significant shareholders but without management responsibilities in the firm, while independent and other external directors are those without any link with the company, who are appointed to the board due to their personal or professional features.

Percentage of independent directors (OUT2). This variable was calculated by dividing the total number of independent and external directors by the board size (Baysinger et al., 1991).

Duality (DUAL). Duality was considered as a dichotomous variable, which took the value "1" in the event that the chairman and CEO of the company were the same person, and "0" otherwise (Daily and Dalton, 1997).

Family firm (FAM). Family property is measured as a dichotomous variable that took the value of "1" if the company was family business, and "0" otherwise. To consider the company as a family business, three requirements were asked: 5% or more of the company's shares in the hands of a family (Villalonga and Amit, 2006); at least two family members in the board; and the chairman and/or CEO should be part also of the family (García-Ramos and García-Olalla, 2011).

3.4. Control variables

A variety of control variables were included to control for firm effects on innovation. The total number of employees (FSIZE), logged to correct for skewness, was used as a measure of firm size (Le et al., 2006); this variable refers to the resources and capabilities of companies, which may influence their capacity for innovating. Past firm performance was included as a factor that might influence the innovative activity of companies (Chen and Hsu, 2009), and was measured through return on assets (ROA). The possible industry effects are captured through the control variable sector (SECT), since the innovation strategy of companies could be strongly affected by the characteristics of the industry (Le et al., 2006). These industry effects are captured by a categorical variable with five levels, one for each of the economic sectors included in this study. The market value (MV) of the company is the share price multiplied by the number of ordinary shares outstanding. The MV has been identified in previous studies as a factor to control the size of the company (Chen and Zhou, 2007), as larger firms may have more leeway to invest in innovation (Zahra et al., 2004). Financial leverage (LEV) refers to the ratio of debt to equity invested and represents the proportion of the company that is financed by debt. Its inclusion as a control variable is due to its influence on the resources available to the company and therefore on the resources that can be dedicated to R&D and innovation (Van Essen et al., 2012). The last control variable refers to company volatility (VOL). VOL is a measure of the frequency and intensity of changes in the price of an asset, defined as the standard deviation of that change over a specific time horizon. VOL has been identified in previous studies as a determinant for risk investments (Lenard et al., 2014), as innovation.

4. Empirical analysis

4.1. Descriptive statistics

R, version 3.4.0. (R Core Team, 2017) was used to conduct the statistical analyses. The descriptive statistics for numeric variables are shown in Table 1, reflecting the structure and composition of the boards according to their size, gender diversity and directors' typology.

As it can be seen in Table 1, the average size of the boards was around 10 members, with a minimum of 1 and a maximum of 24 members. The Blau index for gender diversity was low, indicating the expected preponderance of the male gender on the boards. Likewise, there are large differences between the minimum and maximum value in terms of gender diversity, showing that there are companies with boards composed exclusively of men (0.00), as well as boards members are fairly distributed (0.50). Regarding the directors' typology, considering all external directors (OUT1), they represent almost 80% of the boards in innovative sectors in Spain. Considering only the independent and external directors (OUT2), their percentage is lower, around 35% out of the total. As for categorical variables, data in our sample show that duality is present in most boards, so that 55% of firms in the sample showed a coincidence in the person who occupied the position of chairman and general director of the company. With regard to family business, this represents 41.98% of the companies in the sample, compared to 58.02% of non-family business. The percentage of companies with patenting activity reaches 29.40%.

The correlation matrix for the numeric variables is shown in Table 2. The bivariate correlations between the explanatory and control variables are below the cut-off point of 0.50 (Hair et al., 2010), suggesting that multicollinearity is not a serious problem. Exceptions were only observed in two bivariate correlations, which are above the indicated cut-off point. Given the threat of multicollinearity, we decided to perform additional analyses, the VIF values (variance inflation factor) of all variables were calculated. For both models, all VIF values were below the threshold of 4 (O'Brien, 2003), being the highest value as 1.73. Therefore, we can discard any potential multicollinearity problem.

We also checked whether or not there are differences between the mean values of the dependent and independent variables, when the different categories of companies, family businesses and non-family businesses, are compared. The results for the numeric variables are displayed in Table 3 and show the differences between these different types of companies in terms of their innovation (measured as R&D), board size, gender diversity, and the proportion of external and independent directors.

Similar analyses were conducted for the categorical variables, patents and duality, using the Pearson Chi-square test. We observed significant differences in the binary variable patents (PAT) when family and non-family firms are compared ($X^2 = 4.67$, p-value < 0.05), but not in the case of duality ($X^2 = 1.09$, p-value $= 0.295$). Likewise, we compared the dependent variables related to innovation in the case of duality and non-duality. The results indicate that R&D and patents (PAT) are significantly different when there is duality in the board or not ($F = 39.17$, p-value < 0.001 for R&D and $X^2 = 36.44$, p-value < 0.001 for PAT).

4.2. Empirical analysis and test of Hypothesis

The empirical specifications proposed to respond to our hypotheses imply two regressions, one for the dependent variable R&D and the other for the dependent variable PAT, respectively. The specifications of the two models are as follows:

$$R\&D_{it} = \beta_{11}BZIZE_{it-1} + \beta_{12}GEN_{it-1} + \beta_{13}OUT1_{it-1} + \beta_{14}OUT2_{it-1} + \beta_{15}DUAL_{it-1} + \beta_{16}FAM_{it-1} + (\beta_{17}BSIZE_{it-1}:FAM_{it-1}) + (\beta_{18}GEN_{it-1}:FAM_{it-1}) + (\beta_{19}OUT1_{it-1}:FAM_{it-1}) + (\beta_{1\ 10}OUT2_{it-1}:FAM_{it-1}) + (\beta_{1\ 11}DUAL_{it-1}:FAM_{it-1}) + \beta_{1\ 12}FSIZE_{it-1} + \beta_{1\ 13}ROA_{it-1} + \beta_{1\ 14}SECT_{it-1} + \beta_{1\ 15}MV_{it-1} + \beta_{1\ 16}LEV_{it-1} + \beta_{1\ 17}VOL_{it-1} + \mu_i + \varepsilon_{it-1}$$

$$PAT_{it} = \beta_{21}BSIZE_{it-1} + \beta_{22}GEN_{it-1} + \beta_{23}OUT1_{it-1} + \beta_{24}OUT2_{it-1} + \beta_{25}DUAL_{it-1} + \beta_{26}FAM_{it-1} + (\beta_{27}BSIZE_{it-1}:FAM_{it-1}) + (\beta_{28}GEN_{it-1}:FAM_{it-1}) + (\beta_{29}OUT1_{it-1}:FAM_{it-1}) + (\beta_{2\ 10}OUT2_{it-1}:FAM_{it-1}) + (\beta_{2\ 11}DUAL_{it-1}:FAM_{it-1}) + \beta_{2\ 12}FSIZE_{it-1} + \beta_{2\ 13}ROA_{it-1} + \beta_{2\ 14}SECT_{it-1} + \beta_{2\ 15}MV_{it-1} + \beta_{2\ 16}LEV_{it-1} + \beta_{2\ 17}VOL_{it-1} + \mu_i + \varepsilon_{it-1}$$

Hausman tests were performed to determine the choice between OLS pooling, fixed or random effects. In our case, the random effects model was the best estimate (Croissant and Millo, 2008). We used the plm R package to conduct the random effect regression model with panel data

Table 1. Descriptive analysis of variables.

Statistics	No.	Mean	St. Dev.	Min	Max
R&D	818	2.57	7.23	-6.91	13.92
BSIZE	887	10.37	4.06	1	24
GEN	893	0.13	0.15	0.00	0.50
OUT1	887	0.80	0.16	0.00	1.01
OUT2	887	0.35	0.21	0.00	1.00
FSIZE	817	7.92	1.68	3.99	12.56
ROA	819	0.01	0.81	-22.46	2.16
MV	816	5.65	2.72	-6.91	11.56
LEV	817	4.13	0.40	1.88	7.66
VOL	817	2.61	2.73	-6.91	7.03

Table 2. Correlation matrix.

	R&D	BSIZE	GEN	OUT1	OUT2	FSIZE	ROA	MV	LEV	VOL
R&D	1									
BSIZE	0.11***	1								
GEN	0.02	-0.11**	1							
OUT1	0.05	0.36***	0.05	1						
OUT2	0.13***	0.03	0.14***	0.16***	1					
FSIZE	0.20***	0.48***	0.10**	-0.02	0.15***	1				
ROA	-0.05	0.08*	-0.05	0.10**	0.01	0.04	1			
MV	0.19***	0.48***	0.12***	0.24***	0.26***	0.64***	0.08*	1		
LEV	0.07*	0.12***	-0.10**	-0.09*	0.03	0.18***	-0.33***	0.00	1	
VOL	0.13***	0.44***	0.06†	0.31***	0.10**	0.34***	0.08*	0.68***	-0.08*	1

***p < 0.001; **p < 0.01; *p < 0.05; †p < 0.1.

Table 3. Mean differences of the numeric variables in family and non-family businesses.

Mean values	Family firms	Non-family firms	ANOVA F test
R&D	0.64	3.96	40.43***
BSIZE	9.33	11.13	41.93***
GEN	0.15	0.12	15.55***
OUT1	0.77	0.82	24.51***
OUT2	0.31	0.39	28.27***

Signif. Codes: '***' if p-value < 0.001.

to estimate the numeric dependent variable R&D (Croissant and Millo, 2008), and the pglm R package to estimate the random effect logistic model with panel data on the binary dependent variable PAT (Croissant, 2020).

The results of analysis of random effects regression are shown in Tables 4 and 5. Different stages developed in the regression are displayed. In order to control the effects of time on different models, dummy variables were introduced for each of the target years of the study (from 2004 to 2013), which have not been shown as significant in any of the models.

The results of Table 4 show that the X-square statistic is significant for all models. In model 1 only the variables FSIZE and LEV positively and negatively affect the R&D respectively ($\beta = 0.219$, $p < 0.01$; $\beta = -0.118$, $p < 0.05$), and were significant. The rest of the control variables do not have any statistically significant effect on this variable.

In Model 2, we introduced the independent variables to determine the effects of these variables on R&D. In this model, the GEN variable shows a positive and statistically significant effect on R&D ($\beta = 0.090$, $p < 0.01$) agreeing with the H2a Hypothesis that suggests a positive relationship between gender diversity and innovation. On the other hand, the variable OUT2 has a negative and statistically significant effect on R&D ($\beta = -0,200$, $p < 0.001$) supporting the H3b hypothesis regarding the negative association of the ratio of independent directors with innovation. It has also been demonstrated that duality exerts a positive influence on R&D ($\beta = 0.237$, $p < 0.01$), supporting hypothesis H4a. Finally, although we do not propose any hypothesis specifically, the results support that the fact of being a family business impairs innovation, measured through the R&D variable ($\beta = -0.208$, $p < 0.05$). The remaining independent and control variables have no statistically significant effect on R&D.

In Model 3, we introduced the moderation of being a family business or not. Table 4 shows two regressors for each variable, which refers to the family business and the non-family business. In this model, the variable GEN-NO:FAM shows a positive and statistically significant effect on R&D ($\beta = 0.092$, $p < 0.05$). However, the results were only significant for non-family businesses. In addition, we conducted a X-square test which verified that the difference between the beta coefficients obtained for family and non-family firms was not statistically significant ($X^2 = 1.0319$, $p > 0.10$), which implied the impossibility to assert that gender diversity had less influence on innovation in family than in non-family companies. In the case of the variable OUT2, the results confirm that in both cases the influence of this type of directors on R&D is negative and statistically significant ($\beta = -0.157$; $p < 0.01$ for the non-family business

Table 4. Results of panel data regression model for R&D determinants.

	Model 1 Control		Model 2 H1a, H2a, H3a, H4a H1b, H2b, H3b,H4b		Model 3 H1c, H2c, H3c, H4c	
	Estimate β	Std. Error	Estimate β	Std. Error	Estimate β	Std. Error
Step 1. Control Variables						
Intercept	-0.097	0.356	-0.256	0.353	-0.346	0.356
FSIZE	0.219	0.083**	0.114	0.086	0.134	0.086
ROA	-0.068	0.125	0.052	0.129	-0.009	0.132
S1	-0.141	0.706	0.162	0.694	0.138	0.706
S2	-0.286	0.741	0.105	0.726	-0.006	0.738
S3	0.056	0.392	0.143	0.383	0.117	0.389
S4	0.145	0.389	0.291	0.380	0.305	0.386
MV	-0.099	0.091	-0.055	0.091	-0.058	0.092
LEV	-0.118	0.046*	-0.061	0.046	-0.072	0.047
VOL	-0.012	0.041	0.027	0.042	0.010	0.042
Step 2. Mayor effects						
BSIZE			-0.026	0.054		
GEN			0.090	0.031**		
OUT1			-0.001	0.046		
OUT2			-0.200	0.043***		
DUAL-YES			0.237	0.076**		
FAM			-0.208	0.092*		
Step 3. Interactions						
BSIZE-NO:FAM					-0.093	0.062
BSIZE-YES:FAM					0.146	0.085
GEN-NO:FAM					0.092	0.037*
GEN-YES:FAM					0.042	0.051
OUT1-NO:FAM					0.060	0.060
OUT1-YES:FAM					-0.065	0.065
OUT2-NO:FAM					-0.157	0.056**
OUT2-YES:FAM					-0.262	0.056***
YES DUAL-NO:FAM					0.303	0.087***
YES DUAL-YES:FAM					0.179	0.099†
Test Hausman X^2 (p-value)	0.457 (0.993)		17.519 (0.734)		22.046 (0.735)	
Adjusted R^2 (%)	1.90%		7.34%		8.25%	
X-square	14.58†		52.27***		59.01***	

All coefficients are standardized beta weights. Signif. Codes: '***' if p-value < 0.001 ; '**' if p-value < 0.01 ; '*' if p-value < 0.05; '†' if p-value < 0.1.

and β = -0.262, p < 0.001 for the family business) rejecting the H3c Hypothesis that suggests that the proportion of external and/or independent directors has a more positive influence on innovation in the family business than non-family business. The findings also corroborate the positive and significant influence of duality on R&D, which is stronger in the case of non-family business (β = 0.303; p < 0.001 for the non-family business and β = 0.179, p < 0.1 for the family business), rejecting the hypothesis H4c.

Table 5 shows the models where the dependent binary variable is patents (PAT). We used the log-likelihood and AIC provided by the pglm package to compare the different models. Lower value of AIC suggests better model, favoring in this case, model 2, which means that the inclusion of the moderation of being a family business does not add explanatory power to the model. In model 1, where only the control variables were included, those with a positive and significant influence on PAT were FSIZE (β = 1.784, p < 0.001), and the fact of belonging to certain sectors. In other model also leverage seems to have a positive and significant influence on PAT (β = 0.503, p < 0.05).

Model 2 introduces the independent variables so as to determine the effects of these variables on PAT. In this model, BSIZE, GEN and DUAL-YES had a positive and statistically significant effect on PAT (β = 0.619, p < 0.01 for BSIZE; β = 0.373, p < 0.05 for GEN, and β = 0.985, p < 0.01 for DUAL-YES), confirming hypotheses H1a, H2a and H4a respectively. On the contrary, the variable OUT1 was negatively related to PAT (β = -0.336, p < 0.01), agreeing with Hypothesis H3b. Likewise, the fact of being a family business affects negatively PAT (β = -1.178, p < 0.01).

In Model 3, we introduced the moderation term of being a family business or not. Again, two regressors were considered for each variable, which referred to the family business and non-family business, respectively. The results obtained confirm Hypothesis H1c, which indicates that a larger board size has a positive influence on innovation, higher in family business than in non-family business (β = 0.554, p < 0.05 for BSIZE-NO:FAM; β = 1.092, p < 0.05 for BSIZE-YES:FAM). Besides, the X-square test confirmed the significant difference between both beta coefficients (X^2 = 3.6952, p < 0.1). Hypothesis H2c, on the contrary, was rejected as far as we did not obtain any significant effect of gender diversity on PAT, independently if the companies were family or non-family ones.

In the case of the variable OUT2, the results only confirm that the influence of this type of directors on PAT is negative and statistically significant for the non-family businesses (β = -0.750; p < 0.01) rejecting the H3c Hypothesis partially. Like in the results found for R&D, hypothesis H4c was also rejected when PAT is considered as the dependent variable, because we found positive and significant influence of duality on PAT, stronger in the case of non-family business (β = 1.632; p < 0.001

Table 5. Results of panel data regression logistic model for Patent determinants.

	Model 1 Control		Model 2 H1a, H2a, H3a, H4a H1b, H2b, H3b, H4b		Model 3 H1c, H2c, H3c, H4c	
	Estimate β	Std. Error	Estimate β	Std. Error	Estimate β	Std. Error
Step 1. Control Variables						
Intercept	-5.146	0.794***	-4.483	0.819***	-5.145	0.808***
FSIZE	1.784	0.303***	1.240	0.316***	1.362	0.280***
ROA	0.079	0.396	0.231	0.485	0.323	1.373
S1	2.691	0.846**	-1.346	0.985	9.784	1.604***
S2	-16.50	1549	-17.52	1926	-18.60	1998
S3	3.531	0.683***	3.544	0.818***	3.993	0.758***
S4	2.258	0.607***	0.794	0.661	0.918	0.615
MV	-0.156	0.254	-0.203	0.297	0.227	0.319
LEV	0.108	0.175	0.503	0.236*	0.366	0.232
VOL	-0.151	0.254	0.289	0.317	-0.014	0.323
Step 2. Mayor effects						
BSIZE			0.619	0.228**		
GEN			0.373	0.159*		
OUT1			-0.588	0.204**		
OUT2			-0.336	0.210		
DUAL-YES			0.985	0.363**		
FAM			-1.178	0.362**		
Step 3. Interactions						
BSIZE-NO:FAM					0.554	0.232*
BSIZE-YES:FAM					1.092	0.440*
GEN-NO:FAM					0.299	0.190
GEN-YES:FAM					0.372	0.263
OUT1-NO:FAM					-0.421	0.258
OUT1-YES:FAM					-0.377	0.322
OUT2-NO:FAM					-0.750	0.229**
OUT2-YES:FAM					0.157	0.325
YES DUAL-NO:FAM					1.632	0.386***
YES DUAL-YES:FAM					1.465	0.453**
Log-likelihood	-296.41		-282.43		-283.58	
AIC	614.82		598,87		608.57	

All coefficients are standardized beta weights. Signif. Codes: '***' if p-value < 0.001 ; '**' if p-value < 0.01 ; '*' if p-value < 0.05.

for the non-family business and $\beta = 1.465$, $p < 0.01$ for the family business).

In the following table (Table 6) we display a summary of the supported and rejected hypotheses.

5. Discussion

The results obtained regarding the relation of the size, directors' typology, gender diversity and leadership structure of the board on

Table 6. Supported and rejected hypotheses.

Hypotheses codes	Hypotheses	Results
H1a	Board size has a positive influence on innovation	Supported
H1b	Board size has a negative influence on innovation	Rejected
H1c	A larger board size has a stronger positive influence on innovation in family business than in non-family business	Supported
H2a	Gender diversity in the board has a positive influence on innovation	Supported
H2b	Gender diversity in the board has a negative influence on innovation	Rejected
H2c	Gender diversity on boards has less influence on innovation in family business than in non-family business	Rejected
H3a	The ratio of external and/or independent directors is positively associated with innovation	Rejected
H3b	The ratio of external and/or independent directors is negatively associated with innovation	Supported
H3c	The ratio of external and/or independent directors has more positive influence on innovation in family business than in non-family business	Rejected
H4a	The duality of functions has a positive influence on innovation	Supported
H4b	The duality of functions has a negative influence on innovation	Rejected
H4c	CEO duality has more positive influence on innovation in family business than in non-family business	Rejected

innovation, allow us to confirm totally or partially some hypotheses and to reject some others.

The findings show that the board size has a positive and statistically significant influence on the innovation measured by patents, thus supporting the H1a Hypothesis. This finding is in line with some previous studies (Ashwin et al., 2016; Kwon and Shin, 2007; Mezghanni, 2008; Zona et al., 2008) and supports the assumptions of the Agency Theory and the Resource Dependence Theory, that emphasize the richer resources, experiences and skills of larger boards, useful for a valuable control and evaluation of alternatives, that favor innovation.

The results also confirm that larger board size has a stronger positive influence on innovation in family business than in non-family business. It was demonstrated for patents, supporting Hypothesis H1c. This evidence agrees with the assumptions of the Stewardship Theory and with the arguments of some previous studies (Corbetta and Salvato, 2004a; Lane et al., 2006), which point out that frequently in family businesses the boards are small, and in this case, the addition of more directors favors innovation due to the incorporation of more and richer perspective and the improvement of the board's capacity for control and advice.

Regarding gender diversity, the findings corroborate the H2a Hypothesis that states the positive influence of gender diversity on innovation. The positive influence was obtained for both, R&D and patents. This result coincides with previous research, and supports the approach of the Agency Theory and the Resource Dependence Theory, which underline the benefits of greater gender diversity in the main management and control bodies of the company. This positive influence is explained by the fact that greater gender diversity on board achieves a better working environment, more participatory and process-oriented leadership, more access to a greater knowledge base than their male counterparts, new styles of work and decision-making, different experiences and points of view (Galia and Zenou, 2012; Torchia et al., 2011; Hernández-Lara and Gonzales Bustos, 2020).

When analysing the influence of gender diversity comparing between family and non-family business, the findings support that the positive influence of gender diversity on innovation, as measured by R&D, was lower in the case of family businesses. However, although there was a smaller regressor in the family businesses than the non-family companies, it was only statistically significant in the non-family companies, and the difference between them was not proved to be significant. What we contrast with data is that only for the non-family companies, gender diversity has positive and significant impacts on innovation. Our results are in line with the literature that establish that the most common scenario is that women appointed to the board are those who are able to adjust to the dominant norms of their male counterparts, usually also family members (Casey et al., 2011), thus avoiding the emergence of the positive benefits of gender diversity. Therefore, this influence probably will be more positive in non-family business rather than in family business. Nevertheless, more evidence would be necessary on this regard, because with our data the different impact of gender diversity on innovation for family and non-family companies was not confirmed, being possible only to assert that gender diversity exerts a positive influence on innovation in non-family businesses.

As for the third block of hypotheses, related to the influence of the ratio of external and/or independent directors on innovation, the results obtained suggest that the variables OUT1 and OUT2 have a negative and statistically significant effect on different innovation indicators, supporting the Hypothesis H3b. This finding is consistent with previous research and with the assumptions of the Stewardship Theory, that suggest that high proportion of independent advisors are negatively and significantly associated with innovation (Zahra et al., 2000), investment (Baysinger and Hoskisson, 1990) and R&D intensity (Yoo and Sung, 2015), or with the innovative performance of the company (Balsmeier et al., 2014), due to the cognitive heterogeneity and the dysfunctional rivalry in top positions provoked by this kind of directors that could jeopardize to reach the consensus needed to innovate.

When analysing the influence of this type of boards comparing family and non-family business, obtained results indicate that their influence is more negative in the case of family business than the non-family ones, rejecting the H3c which suggests that the ratio of external and independents boards has more positive influence on innovation in family business than in non-family business. This finding echoed with the Stewardship Theory, which indicates that the lack of detailed information about the company makes this type of advisers not able to understand the activity of the company well enough to make a significant contribution to favour innovation (Baysinger and Hoskisson, 1990), diminishing importance to the more general knowledge rather than to the more specific knowledge that can be provided by other types of boards having more relationship with the firm (Matzler et al., 2015; Nahapiet and Ghoshal, 1998). The results of this study contribute to previous research demonstrating that this negative effect is more evident in family businesses, where the specific knowledge on the company seems to be especially relevant for innovation.

Regarding the CEO duality, the outcome indicates its positive influence on innovation, measured through R&D and PAT, which provides support for the H4a Hypothesis. These findings agree with the Stewardship Theory and with previous research which states that duality of functions is positively and significantly associated with firm's level of innovation (Chouaibi et al., 2010), measured by investment in R&D (Van Essen et al., 2012). In contrary, it contradicts the findings of previous research which point out that the separation of functions is positively and significantly associated with innovation (Zahra et al., 2000) and with R&D investment (Kor, 2006). This outcome is explained by the lesser ambiguity and the greater legitimacy of leaders in case of duality, which if the leader is fond of risky strategies may favor innovation.

When analysing the influence of CEO duality comparing between family and non-family business, the outcome indicates that CEO duality is more positive for innovation in the case of non-family businesses. This finding leads the authors to reject the H4c Hypothesis which suggests that the duality of functions has a more positive influence on innovation in family business than in non-family business. This is a contribution of this study, because although its results suggest the benefits of duality for innovation in both types of companies, it seems that in a situation where duality is less widespread (Zehir et al., 2011), like in the case of non-family businesses, its influence is likely to be greater, making clearer that a strong leadership could be more beneficial for innovation.

6. Conclusions

This study contributes to the body of research testing empirically the board effects in advancing the strategic direction of the firm. Based on one of our previous descriptive studies (Gonzales-Bustos et al., 2017) in board composition and firm innovation, we have applied an explanatory approach to obtain new findings and insights through empirical evidence on the impact of board characteristics on innovation. First, it is confirmed that incorporating more members and especially women into the board can improve innovation. In the case of the family business, the positive influence of board size is even stronger, especially because in this type of companies the board size is normally small, so the benefits of adding new members are more evident than if the starting point was bigger boards. Regarding gender diversity, our finding echoes with the literature (Valenti and Horner, 2020) that gender diversity does matter since it may increase creativity and innovation, although these positive effects were stronger for non-family companies. The reasons of that were not proven in this research and will need undoubtedly additional research, although a possible reason could be the higher independence of female directors in this type of companies, when they are compared with female directors in family firms (Hernández-Lara and Gonzales-Bustos, 2020).

Another contribution lies on that the board independence has a negative impact on innovation, for both types of firms (family and non-family), although of different intensity depending on the type of company and of independence, measured through the type of directors and

duality. It indicates that the suitability of knowledge and information related to the company is crucial to promote innovation. We consider that this finding is novel given the context of family business innovation. In the specific case of duality, less widespread among non-family companies, its positive influence is even more evident.

All in all, with these results the present study contributes to an inconclusive literature regarding the board effects on innovation, highlighting different empirical insights depending on the familiar nature of the company. These results may have some meaningful implications. Academics can benefit from this study by further testing the board effects in different contexts categorized by family or non-family business so as to compare the results obtained. From an academic perspective also, different theoretical frameworks have been compared, demonstrating the suitability of them to explain the effects of the different variables, especially with regard to the Stewardship Theory, whose assumptions seems to be more appropriate to explain the influence of corporate governance within innovative sectors. From a practical perspective, corporate managers and leaders may adjust the board composition as suggested in the findings of this study upon the firms' type (family or non-family) to strategically boost and promote innovation process. Policies should be formulated to motivate the inclusion of more members in the boards, especially in family companies, and the participation of more female members to the board, especially for non-family business so as to enhance innovation. Also, policy makers may consider different recommendations towards corporate board monitoring for promoting innovation depending on the type of firms. CEO duality does favor innovation although this positive influence is stronger for non-family firms.

The findings of this study can be helpful for researchers, practitioners and policy makers in this area, but some limitations should be addressed. First, although we measure the degree of innovation by R&D expenses and patents, there can be many other measurements to be further analyzed. Second, our sample was restricted to Spanish firms (family and non-family). The factors that drive firms to innovate in Spain may not be generalizable to firms in other countries under different corporate governance mechanisms. Another limitation is related to the sample, composed only by listed companies, which exclude other kind of firms where the innovation component could be high and interesting to explore, like startups or small companies in high technology sectors. Also, the homogenous characteristics of the sample, composed of mature listed companies, make impossible to check the potential influence of some other features that could affect corporate governance attributes, like for example the life cycle of the companies.

Notwithstanding these caveats, this study makes an important contribution to the explanation of the effects of board characteristics, independence and CEO duality on innovation comparing family and non-family firms. We consider that no single piece of theory can tell the whole story regarding corporate governance and firm innovation. Instead, each theoretical perspective can be adopted in difference governance elements to contribute to the debate of board effects on innovation.

Declarations

Author contribution statement

J. P. Gonzales-Bustos, A. B. Hernãndez-Lara and X. Li: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

The authors acknowledge the support of T19282N project from the Fundació Universitat Rovira i Virgili.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

Aragón, J.A., García, V.J., Cordón, E., 2007. Leadership and organizational learning's role on innovation and performance: lessons from Spain. Ind. Market. Manag. 36 (3), 349–359.

Ashwin, A.S., Krishnan, R.T., George, R., 2015. Family firms in India: family involvement, innovation and agency and stewardship behaviors. Asia Pac. J. Manag. 32 (4), 869–900.

Ashwin, A.S., Krishnan, R.T., George, R., 2016. Board characteristics, financial slack and R&D investments: an empirical analysis of the Indian pharmaceutical industry. Int. Stud. Manag. Organ. 46 (1), 8–23.

Baliga, B.R., Moyer, R.C., Rao, R.S., 1996. CEO duality and firm performance: what's the fuss? Strat. Manag. J. 17 (1), 41–53.

Balsmeier, B., Buchwald, A., Stiebale, J., 2014. Outside directors on the board and innovative firm performance. Res. Pol. 43 (10), 1800–1815.

Barker, V.L., Mueller, G.C., 2002. CEO characteristics and firm R&D spending. Manag. Sci. 48 (6), 782–801.

Barsky, R.B., Juster, F.T., Kimball, M.S., Shapiro, M.D., 1997. Preference parameters and behavioral heterogeneity: an experimental approach in the health and retirement study. Q. J. Econ. 112 (2), 537–579.

Baysinger, B., Hoskisson, R.E., 1990. The composition of boards of directors and strategic control: effects on corporate strategy. Acad. Manag. Rev. 15 (1), 72–87.

Baysinger, B.D., Kosnik, R.D., Turk, T.A., 1991. Effects of board and ownership structure on corporate R&D strategy. Acad. Manag. J. 34 (1), 205–214.

Becheikh, N., Landry, R., Amara, N., 2006. Lessons from innovation empirical studies in the manufacturing sector: a systematic review of the literature from 1993–2003. Technovation 26 (5-6), 644–664.

Belloc, F., 2012. Corporate governance and innovation: a survey. J. Econ. Surv. 26 (5), 835–864.

Berraies, S., Achour, M., Chaher, M., 2015. Focusing the mediating role of knowledge management practices: how does institutional and interpersonal trust support exploitative and exploratory innovation? J. Appl. Bus. Res. 31 (4), 1479–1492.

Berraies, S., Rejeb, W.B., 2019. Boards of directors' roles and size: what effects on exploitative and exploratory innovations? Case of listed Tunisian firms. Int. J. Enterpren. Innovat. Manag. 23 (2), 161–179.

Blanco-Mazagatos, V., de Quevedo-Puente, E., Delgado-García, J.B., 2016. How agency conflict between family managers and family owners affects performance in wholly family-owned firms: a generational perspective. J. Fam. Bus. Strat. 7 (3), 167–177.

Blau, P.M., 1977. Inequality and Heterogeneity. Free Press, New York.

Brunninge, O., Nordqvist, M., Wiklund, J., 2007. Corporate governance and strategic change in SMEs: the effects of ownership, board composition and top management teams. Small Bus. Econ. 29 (3), 295–308.

Camelo-Ordaz, C., Hernández-Lara, A.B., Valle-Cabrera, R., 2005. The relationship between top management teams and innovative capacity in companies. J. Manag. Dev. 24 (8), 683–705.

Casey, C., Skibnes, R., Pringle, J.K., 2011. Gender equality and corporate governance: policy strategies in Norway and New Zealand. Gend. Work. Organ. 18 (6), 613–630.

Cassiman, B., Veugelers, R., 2006. In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. Manag. Sci. 52 (1), 68–82.

Chang, S.C., Wu, W.Y., Wong, Y.J., 2010. Family control and stock market reactions to innovation announcements. Br. J. Manag. 21 (1), 152–170.

Chen, H.L., 2014. Board capital, CEO power and R&D investment in electronics firms. Corp. Govern. Int. Rev. 22 (5), 422–436.

Chen, H.L., Hsu, W.T., 2009. Family ownership, board independence, and R&D investment. Fam. Bus. Rev. 22 (4), 347–362.

Chen, K.Y., Zhou, J., 2007. Audit committee, board characteristics, and auditor switch decisions by Andersen's clients. Contemp. Account. Res. 24 (4), 1085–1117.

Cheng, S., 2008. Board size and the variability of corporate performance. J. Financ. Econ. 87 (1), 157–176.

Chin, C.L., Chen, Y.J., Kleinman, G., Lee, P., 2009. Corporate ownership structure and innovation: evidence from Taiwan's electronics industry. J. Account. Audit Finance 24 (1), 145–175.

Chouaibi, J., Affes, H., Boujelbene, Y., 2010. Characteristics of the board of directors and involvement in innovation activities: a cognitive perspective. Int. J. Manag. Financ. Account. 2 (3), 240–255.

CNAE, 2009. National Classification of Economic Activities. https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736177032&menu=ultiDatos&idp=1254735976614#:~:text=CNAE%2D2009%20is%20the%20National,replaces%20the%20CNAE%2D93%20Rev. (Accessed 15 October 2019).

Conthe Code, 2006. Código unificado de buen gobierno de las sociedades cotizadas. Comisión Nacional de Mercado de Valores, Madrid. Available in: https://www.cnmv.es/portal/home.aspx.

Corbetta, G., Salvato, C.A., 2004a. The board of directors in family firms: one size fits all? Fam. Bus. Rev. 17 (2), 119–134.
Corbetta, G., Salvato, C., 2004b. Self–Serving or self–Actualizing? Models of man and agency costs in different types of family firms: a commentary on "Comparing the agency costs of family and non–Family firms: conceptual issues and exploratory evidence". Enterpren. Theor. Pract. 28 (4), 355–362.
Croissant, Y., 2020. Pglm: Panel Generalized Linear Models. R Package Version 0.2-2. https://CRAN.R-project.org/package=pglm.
Croissant, Y., Millo, G., 2008. Panel data econometrics in R: the plm package. J. Stat. Software 27 (2), 1–43.
Cropley, D., Cropley, A., 2017. Innovation capacity, organisational culture and gender. Eur. J. Innovat. Manag. 20 (3), 493–510.
Daily, C.M., Dalton, D.R., 1997. CEO and board chair roles held jointly or separately: much ado about nothing? Acad. Manag. Perspect. 11 (3), 11–20.
Daily, C.M., Dalton, D.R., 2003. Women in the boardroom: a business imperative. J. Bus. Strat. 24 (5), 8–10.
David, P., O'Brien, J.P., Yoshikawa, T., 2008. The implications of debt heterogeneity for R&D investment and firm performance. Acad. Manag. J. 51 (1), 165–181.
Davis, J.H., Schoorman, F.D., Donaldson, L., 1997. Toward a stewardship theory of management. Acad. Manag. Rev. 22 (1), 20–47.
De Massis, A., Frattini, F., Lichtenthaler, U., 2013. Research on technological innovation in family firms: present debates and future directions. Fam. Bus. Rev. 26 (1), 10–31.
De Massis, A., Minola, T., Viviani, D., 2012. Entrepreneurial learning in Italian high-tech start-ups: an exploratory study. Int. J. Innovat. Learn. 11 (1), 94–114.
Drucker, P.F., 1985. Innovation and Entrepreneurship: Practice and Principle. Harper & Row, New York.
Eisenberg, T., Sundgren, S., Wells, M.T., 1998. Larger board size and decreasing firm value in small firms. J. Financ. Econ. 48 (1), 35–54.
Eisenhardt, K.M., 1989. Agency theory: an assessment and review. Acad. Manag. Rev. 14 (1), 57–74.
Fama, E.F., 1980. Agency problems and the theory of the firm. J. Polit. Econ. 88 (2), 288–307.
Feng, C., Wang, H., Lu, N., Chen, T., He, H., Lu, Y., Tu, X.M., 2014. Log-transformation and its implications for data analysis. Shanghai Arch Psychiatry 26 (2), 105–109.
Forbes, D.P., Milliken, F.J., 1999. Cognition and corporate governance: understanding boards of directors as strategic decision-making groups. Acad. Manag. Rev. 24 (3), 489–505.
Galia, F., Zenou, E., 2012. Board composition and forms of innovation: does diversity make a difference? Eur. J. Int. Manag. 6 (6), 630–650.
García-Ramos, R., García-Olalla, M., 2011. Board characteristics and firm performance in public founder-and nonfounder-led family businesses. J. Fam. Bus. Strat. 2 (4), 220–231.
Golden, B.R., Zajac, E.J., 2001. When will boards influence strategy? Inclination× power= strategic change. Strat. Manag. J. 22 (12), 1087–1111.
Gómez-Mejía, L.R., Haynes, K.T., Núñez-Nickel, M., Jacobson, K.J., Moyano-Fuentes, J., 2007. Socioemotional wealth and business risks in family-controlled firms: evidence from Spanish olive oil mills. Adm. Sci. Q. 52 (1), 106–137.
Gonzales-Bustos, J.P., Hernández-Lara, A.B., Li, X., 2017. Board composition in family and non-family innovative businesses. Corp. Ownersh. Control 15 (1), 459–466.
Goodstein, J., Boeker, W., 1991. Turbulence at the top: a new perspective on governance structure changes and strategic change. Acad. Manag. J. 34 (2), 306–330.
Goodstein, J., Gautam, K., Boeker, W., 1994. The effects of board size and diversity on strategic change. Strat. Manag. J. 15 (3), 241–250.
Gubitta, P., Gianecchini, M., 2002. Governance and flexibility in family-owned SMEs. Fam. Bus. Rev. 15 (4), 277–297.
Hair, J., Black, W.C., Babin, B.J., Anderson, R.E., 2010. Multivariate Data Analysis, seventh ed. Pearson Education International, New Jersey.
Hambrick, D.C., Misangyi, V.F., Park, C.A., 2015. The quad model for identifying a corporate director's potential for effective monitoring: toward a new theory of board sufficiency. Acad. Manag. Rev. 40 (3), 323–344.
Haynes, K.T., Hillman, A., 2010. The effect of board capital and CEO power on strategic change. Strat. Manag. J. 31 (11), 1145–1163.
Hernández, A.B., Camelo, C., Valle, R., 2010. The effects of boards of director son R&D investments: the case of Spain. Int. J. Hum. Resour. Dev. Manag. 10 (2), 152–165.
Hernández-Lara, A.B., Camelo-Ordaz, C., Valle-Cabrera, R., 2014. Does board member stock ownership influence the effect of board composition on innovation? Eur. J. Int. Manag. 8 (4), 355–372.
Hernández-Lara, A.B., Gonzales-Bustos, J.P., 2019. The impact of interlocking directorates on innovation: the effects of business and social ties. Manag. Decis. 57 (10), 2799–2815.
Hernández-Lara, A.B., Gonzales-Bustos, J.P., 2020. The influence of family business and women directors on innovation. Appl. Econ. 52 (1), 36–51.
Hillman, A.J., Dalziel, T., 2003. Boards of directors and firm performance: integrating agency and resource dependence perspectives. Acad. Manag. Rev. 28 (3), 383–396.
Hitt, M.A., Hoskisson, R.E., Kim, H., 1997. International diversification: effects on innovation and firm performance in product-diversified firms. Acad. Manag. J. 40 (4), 767–798.
Iyengar, R.J., Sundararajan, M., 2019. IS firm innovation associated with corporate governance? Int. J. Innovat. Manag. 24 (3).
Jansen, J.J.P., Van Den Bosch, F.A.J., Volberda, H.W., 2006. Exploratory innovation, exploitative innovation, and performance effects of organizational antecedents and environmental moderators. Manag. Sci. 52 (11), 1661–1674.
Jaskyte, K., 2012. Boards of directors and innovation in non-profit organizations. Nonprof. Manag. Leader. 22 (4), 439–459.
Jensen, M.C., 1993. The modern industrial revolution, exit, and the failure of internal control-systems. J. Finance 48 (3), 831–880.
Kim, H., Lin, C., 2010. Diversity, outside directors and firm valuation: Korean evidence. J. Bus. Res. 63 (3), 284–291.
Kor, Y.Y., 2006. Direct and interaction effects of top management team and board compositions on R&D investment strategy. Strat. Manag. J. 27 (11), 1081–1099.
Kroll, M., Walters, B.A., Le, S., 2007. The impact of board composition and top management team ownership structure on post-IPO performance in young entrepreneurial firms. Acad. Manag. J. 50, 1198–1216.
Kwon, U., Shin, J.K., 2007. The exploratory study of predictors affecting on systematic succession planning of family firms in Korea. J. Hum. Resour. Manag. Res. 14 (4), 217–233.
Lane, S., Astrachan, J., Keyt, A., McMillan, K., 2006. Guidelines for family business boards of directors. Fam. Bus. Rev. 19 (2), 147–167.
Lazonick, W., 2010. The Chandlerian corporation and the theory of innovative enterprise. Ind. Corp. Change 19 (1), 13–35.
Le, S.A., Walters, B., Kroll, M., 2006. The moderating effects of external monitors on the relationship between R&D spending and firm performance. J. Bus. Res. 59 (2), 278–287.
Lenard, M.J., Bing, Y., York, E.A., Shengxiong, W., 2014. Impact of board gender diversity on firm risk. Manag. Finance 40 (8), 787–803.
Liang, Q., Li, X., Yang, X., Lin, D., Zheng, D., 2013. How does family involvement affect innovation in China? Asia Pac. J. Manag. 30 (3), 677–695.
Lin, X., Germain, R., 2003. Organizational structure, context, customer orientation and performance: lessons from Chinese state-owned enterprises. Strat. Manag. J. 24 (11), 1131–1151.
Loukil, N., Yousfi, O., 2016. Does gender diversity on corporate boards increase Risk-Taking? Can. J. Adm. Sci. 33 (1), 66–81.
Matzler, K., Veider, V., Hautz, J., Stadler, C., 2015. The impact of family ownership, management, and governance on innovation. J. Prod. Innovat. Manag. 32 (3), 319–333.
Mezghanni, B.S., 2008. Ownership structure, board of directors and R&D investments: evidence from France. Corp. Ownersh. Control 5 (3-2), 250–262.
Michie, S.G., Dooley, R.S., Fryxell, G.E., 2006. Unified diversity top-level teams: enhancing Collaboration and quality in strategic decision-making. Int. J. Organ. Anal. 14 (2), 130–149.
Miller, D., Le Breton-Miller, I., Lester, R.H., 2005. Family involvement, agency and performance in the fortune 1000. In: Academy of Management, Annual Meetings, Honolulu, HI, August.
Milliken, F., Martins, L., 1996. Searching for common threads: understanding the multiple effects of diversity in organizational groups. Acad. Manag. Rev. 21 (2), 402–433.
Nahapiet, J., Ghoshal, S., 1998. Social capital, intellectual capital and the organizational advantage. Acad. Manag. Rev. 23 (2), 242–266.
Nekhili, M., Gatfaoui, H., 2013. Are demographic attributes and firm characteristics drivers of gender diversity? Investigating women's positions on French boards of directors. J. Bus. Ethics 118 (2), 227–249.
OBrien, J.P., 2003. The capital structure implications of pursuing a strategy of innovation. Strat. Manag. J. 24 (5), 415–431.
Østergaard, C.R., Timmermans, B., Kristinsson, K., 2011. Does a different view create something new? The effect of employee diversity on innovation. Res. Pol. 40 (3), 500–509.
O'Sullivan, M., 2000. The innovative enterprise and corporate governance. Camb. J. Econ. 24 (4), 393–416.
Pearce, J.A., Zahra, S.A., 1992. Board composition from a strategic contingency perspective. J. Manag. Stud. 29 (4), 411–438.
Perel, P., 2002. Corporate courage breaking the barrier to innovation. Res. Technol. Manag. 45 (3), 9–17.
Pfeffer, J., Salancik, G.R., 1978. The External Control of Organizations: A Resource Dependence Perspective. Harper & Row, New York.
Perez-Calero, S., Guerrero-Villegas, J., Hurtado, J.M., 2017. The influence of organizational factors on board roles. Manag. Decis. 55 (5), 842–871.
Post, K., Byron, C., 2015. Women on boards and firm financial performance: a meta-analysis. Acad. Manag. J. 58 (5), 1546–1571.
Principe, A., 2016. Board composition and innovation in university spin-offs, evidence from the Italian context. J. Technol. Manag. Innovat. 11 (6), 33–39.
R Core Team, 2017. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL. http://www.R-project.org/.
Reeb, D.M., Zhao, W., 2009. Director capital and corporate disclosure quality. J. Account. Publ. Pol. 32 (4), 191–212.
Schulze, W.S., Lubatkin, M.H., Dino, R., 2002. Altruism, agency, and the competitiveness of family firms. Manag. Decis. Econ. 23 (4-5), 247–259.
Shapiro, D., Tang, Y., Wang, M., Zhang, W., 2015. The effects of corporate governance and ownership on the innovation performance of Chinese SMEs. J. Chin. Econ. Bus. Stud. 13 (4), 311–335.
Simpson, W.G., Gleason, A.E., 1999. Board structure, ownership, and financial distress in banking firms. Int. Rev. Econ. Finance 8 (3), 281–292.
Terjesen, S., Sealy, R., Singh, V., 2009. Women directors on corporate boards: a review and research agenda. Corp. Govern. Int. Rev. 17 (3), 320–337.
Torchia, M., Calabró, A., Huse, M., 2011. Women directors on corporate boards: from tokenism to critical mass. J. Bus. Ethics 102 (2), 299–317.
Treichler, C.M., 1995. Diversity of board members and organizational performance: an integrative perspectives. Corp. Govern. Int. Rev. 3 (4), 189–200.
Valenti, A., Horner, S.V., 2020. Leveraging board talent for innovation strategy. J. Bus. Strat. 41 (1), 11–18.
Van Essen, M., Van Oosterhout, J.H., Carney, M., 2012. Corporate boards and the performance of Asian firms: a meta-analysis. Asia Pac. J. Manag. 29 (4), 873–905.

Villalonga, B., Amit, R., 2006. How do family ownership, control and management affect firm value? J. Financ. Econ. 80 (2), 385–417.
Withers, M.C., Hillman, A.J., Cannella, A.A., 2012. A multidisciplinary review of the director selection literature. J. Manag. 38 (1), 243–277.
Wincent, J., Anokhin, S., Ortqvist, D., 2010. Does network board capital matter? A study of innovative performance in strategic SME networks. J. Bus. Res. 63 (3), 265–275.
Yoo, T., Sung, T., 2015. How outside directors facilitate corporate R&D investment? Evidence from large Korean firms. J. Bus. Res. 68 (6), 1251–1260.
Zahra, S.A., Hayton, J.C., Salvato, C., 2004. Entrepreneurship in family vs. non-family firms: a resource-based analysis of the effect of organizational culture. Enterpren. Theor. Pract. 28 (4), 363–379.
Zahra, S.A., Neubaum, D.O., Huse, M., 2000. Entrepreneurship in medium-size companies: exploring the effects of ownership and governance systems. J. Manag. 26 (5), 947–976.
Zehir, C., Altindag, E., Acar, A.Z., 2011. The effects of relationship orientation through innovation orientation on firm performance: an empirical study on Turkish family-owned firms. Procedia - Soc. Behav. Sci. 24, 896–908.
Zona, F., 2016. Agency models in different stages of CEO tenure: the effects of stock options and board independence on R&D investment. Res. Pol. 45 (2), 560–575.
Zona, F., Minichilli, A., Zattoni, A., 2008. Boards of directors and firm innovation: an empirical analysis on large Italian companies. In: Huse, M. (Ed.), The Value Creating Board: Corporate Governance and Organizational Behavior, Matter and Selection. Canada, pp. 495–504.