

## **The moderating effect of interlocking directors on the relationship between R&D investments and firm value**

### **Abstract**

Although the relationship between firm R&D and performance has been analysed in previous literature from different viewpoints, few studies have analysed how the board of directors, one of the main governing bodies with responsibility at strategic level, may affect this relationship. In particular, previous works have studied some characteristics related to the monitoring role of the board. However, it is also likely that access to external information and resources crucial for firms that want to innovate and improve their performance might be facilitated through the links held by interlocking directors (who also serve as directors in other firms). This paper aims to shed light on this topic by providing the first research focusing on how a board's provision of knowledge and advice proxied by the percentage of interlocking directors may moderate the firm R&D-performance classical relationship. Using a sample of 106 Spanish listed companies in the period 2008-2019, GMM analyses show that R&D investments have a positive effect on firm value, but a larger number of interlocking directors may diminish this positive effect. Our results suggest that firms should be cautious about increasing the proportion of interlocking directors. A larger number of such directors may affect the flow of information within the board and, consequently, positive interactions between the board, firm innovation and performance. In addition, we recommend that policy makers should reinforce incentives to increase firm innovation as it seems to increase firm value and, when drafting corporate governance codes, should reflect in more detail on the role played by interlocking directors.

*Keywords:* Board of directors, interlocking directors, R&D investments, firm innovation, firm value  
JEL Codes: O32, G34

## **1. INTRODUCTION**

Firms seek to improve their performance in the short term, but also to sustain it in the long-term (Taouab & Issor, 2019). For this purpose, they may use innovation as one of the main strategies to generate a competitive advantage (Dustin et al., 2014). Furthermore, enhancing the market position of firms is mainly based on the development of new and innovative products and services, which implies large R&D investments (Boiko, 2022). Consequently, such investments are considered one of the key elements for firms' improved performance in the market (Boiko, 2022; Dustin et al., 2014).

R&D investments involve a previous decision-making process that includes collecting information, evaluating alternatives, and choosing the best option possible (Teirlinck, 2017). In other words, prior to the assignment of resources, managers must decide which projects or strategies are likely to be the most successful for the company. At this point, conflicts of interest may arise between shareholders and managers, known in previous literature as agency problems (Fama, 1980; Fama & Jensen, 1983). On the one hand, shareholders are interested in long-term returns, and, on the other hand, managers may show opportunistic behaviour (propensity to exploit information asymmetry in self-interest) and prefer short-term or less risky investments (Eisenhardt, 1985; Fama, 1980; Fama & Jensen, 1983).

In order to avoid such agency problems, different mechanisms known as corporate governance have been developed (Cuervo, 2002; Fama 1980; Fama & Jensen, 1983). These mechanisms can be internal control mechanisms, those developed inside the company (e.g., ownership structure or board of directors), or external control mechanisms, which arise because of the firm's presence in all the markets in which it operates (e.g., the capital market, goods and services market, or

managerial labour market) (Fama & Jensen, 1983)<sup>1</sup>. In this sense, previous literature on corporate governance highlights the board of directors as one of the most relevant internal control mechanisms, with two main roles: reducing agency problems and opportunistic behaviours, and facilitating management of resources (Ahuja et al., 2008; Boiko, 2022; Fama & Jensen, 1983; Hill & Snell, 1988). Some board characteristics associated with its monitoring and control role have been included in the literature as moderating variables of the relationship between R&D investments and firm performance, such as board size (Mezghanni, 2011; Ren et al., 2012; Yousaf et al., 2019), percentage of independent directors (Jermias, 2007; Le et al., 2006; Mezghanni, 2011; Ren et al., 2012; Wang, 2011; Yousaf et al., 2019), CEO duality (Jermias, 2007; Mezghanni, 2011; Wang, 2011), number of board meetings (Mezghanni, 2011; Ren et al., 2012; Yousaf et al., 2019), and directors' equity ownership (Jermias, 2007; Mezghanni, 2011; Ren et al., 2012). These studies have mainly been carried out in the context of Asia and North America, except in the case of Mezghanni (2011) for France.

However, although the literature on corporate governance also points to the board's role as a source of knowledge and consulting to minimise asymmetry of information related to R&D investments (Chen, 2013; Hillman & Dalziel, 2003), as far as we know, this role has not yet been explored in previous studies on the R&D and firm performance relationship. Thus, delving into how this board function can affect the relationship between firm innovation and performance may be relevant because it will help to intensify or reduce (moderate) this relationship, and ultimately to take optimal strategic decisions about innovation as a potential source of competitive advantage and the benefits associated with it. The complementary role of directors requires great insight to monitor management, but also extensive knowledge of the environment and high-

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<sup>1</sup> For a revision of corporate governance mechanisms, see, for example, Brou et al. (2021), Di Vito & Trottier (2021) or Zattoni et al. (2020).

quality connections in order to identify market opportunities and provide appropriate advice (Teece et al., 2016). Access to external information and knowledge transfer may be facilitated by an ability to network outside the firm, for instance, through interlocking directors (when a director serves as a director in different firms at the same time) (Han et al., 2015; Hernández-Lara & Gonzales-Bustos, 2019; Li, 2019; Sarto et al., 2019).

Thus, although the relationship between R&D investments and firm performance has been widely analysed in previous literature (e.g., Alam et al., 2020; Boiko, 2022; Chen & Ibhagui, 2019; Coad et al., 2016; García-Manjón & Romero-Merino, 2012; Hill & Snell, 1988; Hoskisson et al., 2002, 1994; Jermias, 2007; Le et al., 2006; Lee, 2020; Mezghanni, 2011; Tung & Binh, 2022), there is still potential for further research, in particular, by studying whether there are relevant aspects of boards associated with their role as a provider of knowledge and resources that may enhance or reduce the positive effect of R&D on firms' performance (Boiko, 2022; Mezghanni, 2011). As stated before and as far as we know, few studies have analysed the possible moderation role of board characteristics on the relationship between R&D investment and firm performance. Moreover, the scarce existing studies are focused on traditional characteristics associated with the board's role as a control and monitoring mechanism (Jermias, 2007; Le et al., 2006; Mezghanni, 2011; Ren et al., 2012; Wang, 2011; Yousaf et al., 2019). There is therefore a gap in the literature that needs to be filled to better understand the dual boards' role in firm's R&D and performance relationship.

Hence, our research objective is to analyse whether the the number of interlocking directors affects the relationship between R&D investments and firm value in Spain. A positive impact on the effect of R&D investment on firm value might be expected if connections with other firms help to develop the directors' social capital and knowledge, thus optimising board innovation

decisions and their effect on firm performance in line with previous theories (for instance, *resource dependence* (Pfeffer & Salancik, 1978) and *board social capital theory* (Haynes & Hillman, 2010)). Conversely, negative moderation might be expected if interlocking directors do not provide sufficient support to the focal firm because of the complexity of their participation on several boards (e.g., bounded rationality, time constraints), leading to difficulties in reaching consensus or possible communication and coordination problems among all the members of the board of the focal firm; such problems might ultimately affect the influence of the firm's innovation on its performance. Therefore, the number of interlocking directors could affect the functioning and effectiveness of the board in its decision-making, as well as the impact of R&D decisions on firm performance.

Our study makes two contributions. First, while most previous empirical studies have examined the direct effect of R&D investments on firm performance, some studies have considered the moderating effect of the board of directors on this relationship, omitting directors' characteristics associated with the board's role as a source of information and consulting. We consider that exploring the effect of the board from this perspective (the advisory role) will contribute to the literature, complementing the knowledge obtained so far and providing a better overview of the dual role of the board in terms of firm innovation and performance. Specifically, our study contributes to previous literature by providing an empirical analysis that delves into the effects of interlocking directors as a moderating variable between R&D investments and firm value. Our results support the idea that, although R&D expenditure has relevant associations with firm value, this relationship may be better understood if the moderating effects of the percentage of interlocking directors are analysed. This paper expands prior research on the influence of R&D

on performance by incorporating the corporate governance perspective and, in particular, arguments regarding the number of interlocking directors on the board.

Considering that R&D investment decisions are the cornerstone for firms to be able to exercise their innovative capacity, the role of the board of directors becomes crucial to increase the likelihood that these R&D decisions will be successful and will lead to an increase in firm performance (Bobillo et al., 2018; Hernández-Lara & Gonzales-Bustos, 2019; Lu et al., 2021). Consequently, our findings may provide guidance to firms when structuring their boards of directors in order to support firm innovation and value considering that directors serve not only as a control mechanism, but also as a source of information and consulting. For instance, a larger number of interlocking directors can be expected to enrich the board's social capital and thus optimise the effect of firm innovation on its performance. However, if boardrooms have too many interlocking directors, the whole board's ability to identify market opportunities and to take effective decisions would be limited and the relationship between R&D investments and firm value diminished. It seems that the problem may be not the interlocking directors themselves, but an excessive number of interlocking directors on the board. The larger the number of interlocking directors, the greater the likelihood of increased communication and coordination problems within the board. For example, interlocking directors' outside commitments are likely to disperse their attention or limit their available time to fulfil their advisory functions. In this sense, our results suggest that the percentage of interlocking directors within the board should be enough to improve the innovation-related decision-making process, but not so large that it will diminish the performance of the board as a whole in its advisory and control functions, leading to agency problems.

Second, our study includes companies from the European context, specifically Spain, a country with a continental European tradition characterised by ownership concentration and blockholders with strong board representation (Cuervo, 2002). Until now, previous research that includes board characteristics as a moderating variable in the innovation-performance relationship is still limited and mainly focuses on studies relating to the Anglo-Saxon context. According to Cuervo (2002), the context in which corporate governance mechanisms are applied may differ depending on the legal, financial and corporate governance system prevailing in each region. In Anglo-Saxon systems, shareholding in companies is dispersed, and the presence of the board of directors in these environments is less relevant. In contrast, in systems with a continental European tradition, the firm's ownership concentration and its board characteristics (for example, the presence of interlocking directors) are particularly likely to be key, due to the total or almost total absence of a market for corporate control and weak protection of investor' rights (Fernández-Temprano & Tejerina-Gaite, 2020). Moreover, in environments where not enough resources are allocated to innovation, the connections of interlocking directors outside the firm can be vital to reduce risk costs and minimise information asymmetry for R&D investment efficiency or to provide social capital and financing, which ultimately may optimise R&D and firm performance relationship. This is the case of Spain, which belongs to the group of moderate innovators whose R&D investment is lower than the average for European countries (Artés, 2009; Huergo et al., 2016). Spain is also made up of small and medium-sized firms with low technological intensity (Bayona et al., 2001; Camiña et al., 2020; Huergo et al., 2016).

Therefore, this study allows us to broaden knowledge and understanding of the role of the board in a different context. We consider that testing our hypotheses in a country like Spain with a continental European tradition and moderate innovation intensity may help us to expand the

overview of the interaction between the board of directors, firm innovation and firm performance. Moreover, Spain is also part of the European Union (EU) and is therefore a beneficiary of programmes that promote research and development within its territory. In consequence, our findings also may help private and public organisations to better understand the complexities of R&D decision-making within firms. For instance, our research may provide some insights for EU bodies such as the European Regional Development Fund (ERDF), an organisation that supports the development of R&D projects (including Spanish initiatives), on how to optimise the effect of R&D investments on firm performance in less innovative contexts.

Our findings from GMM analyses carried out on 106 Spanish listed companies in the period 2008-2019 show that R&D investments had a positive effect on firm value. However, this positive effect seems to be reduced when there is a greater percentage of interlocking directors on the board.

The rest of the paper is structured as follows. First, we develop the theoretical framework and pose the hypotheses to be tested (section 2). We then describe the methodology used (section 3), and the results obtained (section 4). These are then discussed (section 5) and, finally, in section 6 we draw some conclusions and consider possible avenues for future research.

## **2. RESEARCH BACKGROUND AND HYPOTHESES**

### **2.1. R&D investments and firm value**

Since innovation stands out among the strategies most commonly used by firms for increasing their performance (Ahuja et al., 2008; Başgoze & Sayin, 2013; Dustin et al., 2014; Hill & Snell, 1988; Lee, 2020), it is important to remember that innovation involves a series of efforts prior to obtaining its outputs (new products, processes, patents, among others). These innovation efforts



or inputs (usually represented by R&D investments) refer to investments in the resources and incentives needed to create an optimal environment for innovation performance (Alam et al., 2020; Guo et al., 2018; Tung & Binh, 2022). Additionally, R&D investments are seen by financial markets as an indication of future profits, which they consider when pricing stocks (Chambers et al., 2002). For example, R&D investments may be used to improve the firm's internal processes by making them more effective and less costly without affecting product quality. Thus, incremental R&D will lead to improved profits, better firm performance, and a better firm valuation in the marketplace (Tebourbi et al., 2020).

In previous literature on R&D investments and firm performance, three points of view stand out. First, from the point of view of *resource-based theory* (Barney, 1991), the ability to innovate is a valuable resource for firms. It must be cultivated within organisations so that it can be transformed into a dynamic capability and become a competitive advantage (Ferreira et al., 2020; Teece et al., 1997). The more resources available to generate innovation (R&D investments), the more likely the firm will be able to improve its performance. In addition, the latest technological advances make it possible to interconnect information and communication technologies with production facilities in an agile and effective way (Sarbu, 2022). As a result, firms that implement these technological changes will be more highly valued than those that do not.

Second, from the point of view of *evolutionary theory* (Nelson & Winter, 1982), one of the determinants of firms' success in a changing environment is innovation. So, while innovative firms earn higher profits, increase their market shares, and survive longer, non-innovative firms earn lower profits, shrink, and eventually exit the industry (Ugur & Vivarelli, 2021). In addition, firms' resources and capabilities become obsolete over time (Cuervo-Cazurra & Un, 2010; Teece et al., 1997). Therefore, taking into account that R&D efforts are not perpetual, firms must

constantly invest in R&D to stay ahead of changes and maintain their market competitiveness and performance (Chen et al., 2021; Cuervo-Cazurra & Un, 2010). Investors are likely to interpret increased R&D investments as a firm sign of continuity in the market. Consequently, this behaviour may provide confidence and stability among future investors who will place a higher value on firms that constantly invest in R&D.

In contrast, a third point of view based on *agency theory* (Jensen & Meckling, 1976) considers that, in the case of high-risk investments such as R&D investments, agency problems may arise between managers and shareholders. As a result, managers are likely to avoid R&D investments and prefer lower-risk investments for their own benefit (Ahuja et al., 2008; Hill & Snell, 1988; Hoskisson et al., 2002). This decrease in R&D investments may also lead to a reduction in firm performance.

In terms of empirical evidence, previous studies agree on the positive effect of R&D investments on firm results measured in different ways (see for a revision Boiko, 2022). For instance, there are papers that find positive effects of R&D investments on firm performance measured as return on assets (ROA) (Guo et al., 2018; Hill & Snell, 1988; Ren et al., 2012; Tung & Binh, 2022), return on equity (ROE) (Guo et al., 2018; Tung & Binh, 2022), return on sales (ROS) (Gui-long et al., 2017) and Tobin's Q (Guo et al., 2018). Along the same line, some studies suggest that the positive effects of R&D investments are sustained even in times of crisis (Dimitropoulos, 2020; Lome et al., 2016). They suggest that, in a recession, firms that are able to maintain or increase their level of R&D investment may be able to maintain or even improve their performance.

Evidence for a positive effect of R&D investments on firm performance is also supported by multi-country studies. For example, Alam et al. (2020) find positive effects of R&D investments

on ROA based on a sample of firms in 12 emerging countries. García-Manjón & Romero-Merino (2012) find that R&D investments are one of the most important mechanisms for growth in firms' sales across 18 European countries. They suggest that this association is stronger for high-growth firms and is especially significant in high-tech sectors.

In the Spanish context, van Auken et al. (2008) also find that several aspects related to innovation (such as R&D investments) positively influence the increase in market share, profitability, and productivity of firms. Similarly, Segarra & Teruel (2014) find a positive influence of R&D investments on firm sales and employment growth. Sánchez-Sellero et al. (2015) also find that innovation (especially R&D) helps to increase productivity growth, especially when firms collaborate with universities or research centres. These positive effects of R&D investments are also found by Coad et al. (2016) on business growth (increase in sales, production, and employees) and by González-Fernández & González-Velasco (2018) on ROE and sales revenue. More recently, Coad et al. (2021) find similar positive effects of R&D investments on firm performance measured as the percentage of growth in sales and productivity over the previous year.

In terms of firm value, there is also empirical evidence that mostly converges on a positive effect of R&D investments. For instance, Johnson & Pazderka (1993) find that R&D investment is beneficial for increasing firm value in their study with a sample of Compustat firms. Ehie & Olibe (2010) in the US context also find that R&D investment positively affects firm value in both manufacturing and services sectors. Similar results are obtained by Hwang et al. (2013) in their study of Korean firms. They suggest that higher R&D investment combined with high foreign ownership leads to higher firm valuation, especially in the case of firms in the IT sector. Likewise, Lee (2020) finds that R&D investment has a strong positive impact on firms' market

value in Chinese stock markets and on firms' market value over time. This seems to indicate that R&D investment returns for such firms produce lagged but higher market values. In the same Chinese context, Opoku-Mensah et al. (2021) find evidence that R&D investments have a positive impact on firm value, especially in older companies. There is also empirical evidence of the positive effects of R&D investments on firm value in the Spanish context. Jiménez-Jiménez & Sanz-Valle (2011) find positive effects of innovation (including R&D investments) on firm value, profits, and productivity. Similarly, Oltra et al. (2018) find a positive effect of R&D investments on firm stock value growth and earnings in Spain.

These results are also observed in multi-country studies. For example, the results of Bae & Kim (2003) with samples from Germany, US, and Japan suggest that the market generally places a higher value on R&D investments, but that US firms are more favourably rewarded than German and Japanese firms. Duqi & Torluccio (2013) also conducted a study for a multi-country sample in Europe: UK, Germany, France, Sweden and Italy. Their results show that the effect of R&D expenditure on firm value is positive and significant in all countries, except for Italy. Moreover, R&D investments are more highly valued for firms operating in high-tech sectors. Gupta et al. (2017) also suggest that the positive effect of R&D intensity on market valuation affects firms in a sample of 72 developing and developed countries.

In view of the theoretical arguments and empirical evidence in different contexts showing that R&D investments play an important role in firm performance, the following hypothesis is posed:

**Hypothesis 1:** R&D investments positively affect firm value.

## **2.2. Interlocking directors as a moderator of the relationship between R&D investments and firm value**

Since R&D investments are risky and may give rise to agency problems (Ahuja et al., 2008; Hill & Snell, 1988; Hoskisson et al., 2002), in previous literature the role of the board of directors as a control organism becomes particularly relevant (Boiko, 2022). The literature also points to the role of the board as a provider of consulting and advice to facilitate decision-making, especially in relation to R&D investments (Chen, 2013; Hillman & Dalziel, 2003). For this reason, there has been a significant increase over the last two decades in the number of studies analysing direct relationships between the board of directors, R&D investments and firm performance (Bae & Kim, 2003; Boiko, 2022; Chan et al., 2001; Dimitropoulos, 2020; Lee, 2020; Sierra-Morán et al., 2021).

However, a small number of studies have analysed the moderating effect of the board of directors on the relationship between R&D investments and firm performance. These studies include conventional characteristics related to the board's role as a control and monitoring mechanism, such as board size (Mezghanni, 2011; Ren et al., 2012; Yousaf et al., 2019), percentage of independent directors (Jermias, 2007; Le et al., 2006; Mezghanni, 2011; Ren et al., 2012; Wang, 2011; Yousaf et al., 2019), CEO duality (Jermias, 2007; Mezghanni, 2011; Wang, 2011), number of board meetings (Mezghanni, 2011; Ren et al., 2012; Yousaf et al., 2019), and directors' equity ownership (Jermias, 2007; Mezghanni, 2011; Ren et al., 2012). Apart from these 'traditional' governance variables, the success of firms' innovation projects depends significantly on their ability to identify opportunities in the market, to make effective decisions and to adapt to changes in the environment as fast as possible (Grant, 1991; Mahoney & Pandian, 1992; Peteraf, 1993; Teece et al., 1997). The corporate governance literature highlights the role of firms' external

networks, such as the connections of interlocking directors, as a way of gaining access to external information, resources, or alliances (Hernández-Lara & Gonzales-Bustos, 2019). In addition, such connections and collaborations in R&D activities may be essential in a context of small and medium-sized enterprises operating in a less dynamic innovation environment (Bayona et al., 2001).

Some arguments based on *resource dependence* (Pfeffer & Salancik, 1978) and *board social capital theory* (Haynes & Hillman, 2010) consider that the role of interlocking directors may serve as a bridge to external resources. This means that such connections can be helpful in forming alliances or in accessing financial resources outside the firm that can be invested in innovation projects and obtain benefits for the firm in the future. Moreover, firms are likely to select interlocking directors based on their links to other more reputable firms in order to benefit from their prestige and send signals to the market of their legitimacy in order to access a higher market valuation (Lamb & Roundy, 2016). Thus, having a higher percentage of interlocking directors in the boardroom can be expected to facilitate access to resources outside the company. In the same vein, according to the *resource-based theory* (Barney, 1991), it is considered that engaging interlocking directors can be beneficial for increasing information sharing within the board and improving the diversity of criteria. Furthermore, this theory suggests that synergies between team members with different backgrounds promote the development of dynamic capabilities that can lead to the identification of market opportunities and the creation of new projects that bring financial profits to the firm (Grant, 1991; Teece et al., 1997).

Besides the above theories, the role of interlocking directors has also been studied in the literature from other similar perspectives such as the *friendly board theory* (Adams & Ferreira, 2007). This theory suggests that the presence of interlocking directors may increase cooperation within the

boardroom and improve the flow of communication between the board and managers for proper decision-making, especially in decisions related to R&D investments to ensure long-term firm performance. More generally, the aforementioned theories (*resource dependence, board social capital theory, resource-based theory, and friendly board theory*) suggest that interlocking directors may play a role as a source of advice and consulting, and as a bridge for accessing environmental information, learning about industry trends, obtaining funding, and negotiating cooperative agreements with other firms to invest in R&D projects (Chen, 2014; Wincent et al., 2010). Also, when a firm selects new directors who also serve as directors in other strategically related firms, such as its suppliers, the linkages produced by board interlocks may help reduce transaction costs and promote the establishment of secure value chain systems to improve competitive advantage (Song et al., 2021). Consequently, a higher percentage of interlocking directors in boardrooms may improve the board's ability to make strategic decisions related to innovation, which may benefit the firm and its performance.

Regarding empirical evidence, positive effects of interlocking directors and firm performance have also been found. For example, Pombo & Gutierrez (2011) find positive effects of board interlocks on ROA in their study of Colombian firms. Similarly, Dass et al. (2014) in their study of US firms, find that interlocking directors from related industries have a significant positive impact on ROA, firm value, and the cash conversion cycle. Lu et al. (2021) report that firms with interlocks in the board achieve better environmental performance in a sample of US firms. They argue that board interlocks act as avenues for knowledge and information from outside the organisation to be converted into resources to improve environmental performance. Song et al. (2021) find that the benefits associated with the presence of interlocking directors are reflected in an increase in Tobin's Q in the same US context. These results are also consistent with those

obtained by Pertiwi & Yulianto (2020) in their study of firms in Indonesia. Their results suggest that the average ROA of firms that have interlocking directors is higher than that of firms without them. In the Spanish context, Barroso-Castro et al. (2016) find that the greater the board's connection with other firms, the greater its external social capital and the more beneficial for ROS. Similarly, Pérez-Calero et al. (2016) also find positive effects of interlocking directors on ROA.

Apart from having a direct effect on firm performance, a higher percentage of interlocking directors might also be expected to increase the impact of R&D on firm performance by fostering knowledge interchange within the board. It is probable that a large number of interlocking directors will contribute to a favourable environment for R&D investments (Chang & Wu, 2021; Nimr Al-Maliki et al., 2023; Nthama, 2017), and consequently, to increase firm value. The expertise of interlocking directors together with their broad market knowledge may help to decrease market uncertainty, thus helping to optimise the effect of R&D investments on firm value. At the same time, the presence of interlocking directors on the board may improve the market's perception of the quality and legitimacy of the firm's R&D decisions and may increase the likelihood that financial institutions or investors would be willing to provide financing and a better stock valuation (Lamb & Roundy, 2016; Pérez-Calero et al., 2016). It is likely that the market perceives the innovative activities of more connected firms (those with more interlocking directors inside the board) as less risky, and thus values the stocks of these firms more highly (Chuluun et al., 2017). Thus, the expertise plus the access to new financial opportunities that each of the interlocking directors brings to the whole board can amplify the positive effects of R&D investments on firm performance. That is, the higher the percentage of interlocking directors on



the board, the stronger the relationship between R&D investments and firm performance will become.

Additionally, interlocking directors tend to replicate in the focal firm the decisions of the other firms in which they are also directors (Li, 2021; Oh & Barker, 2018). That is, if the other firms increase their R&D investment as a strategy to increase their firm performance, the interlocking director will seek to do the same in the focal firm. This would imply that the higher the percentage of interlocking directors, the greater the likelihood for the firms that share them to replicate profitable R&D strategies. Interlocking directors may also provide the same financing alternatives that are applied in the other firms where they sit on the board. These arguments highlight the role of interlocking directors as a source of information and access to resources external to the firm. A larger number of interlocking directors may thus amplify the effectiveness of board consulting activities related to strategic decisions such as R&D investments and, consequently, their effect on firm performance. For instance, interlocking directors are likely to have high-quality links with other organisations that could provide access to resources, new investors, partnerships, or alliances outside the firm to jointly invest in new R&D projects (Hernández-Lara & Gonzales-Bustos, 2019; Makkonen et al., 2018). It is likely that the presence of several interlocking directors on the board could facilitate the flow of information, the exchange of ideas and access to new knowledge inside the boardroom, which in turn may lead the board to make better decisions related to new products, processes, projects, etc. (Chen & Ibhagui, 2019). This effect may be more evident, for example, when interlocking directors come from a high-tech firm; their previous experience in the field can help modernise processes in the focal firm (Dass et al., 2014). Therefore, the relationship between R&D investments and firm value may be favoured because the conditions for innovation will be better. In addition, the presence

(or number) of interlocking directors may affect the initial relationship between R&D investments and firm value by decreasing information asymmetry, given the greater quantity and quality of their viewpoints, as well as their connections outside the firm (Chen, 2013; Hillman & Dalziel, 2003).

Furthermore, interlocking directors may counteract the negative effect of inside directors by enriching the diversity of views when important decisions are considered. In the same way, interlocking directors may owe their multiple seats to their prestigious reputation as leading advisors in the workplace and such prestige may lead the market to value the firm's R&D investment decisions better. In this sense, the market may consider that a large number of interlocking directors is a signal the effectiveness of the whole board as a source of advice and control allowing it to make the best R&D investment choices for future returns.

Based on these arguments, the following hypothesis is suggested:

**Hypothesis 2a:** The percentage of interlocking directors in the boardroom positively moderates the relationship between R&D investments and firm value.

However, other authors suggest that interlocking directors play a limited role in boardrooms when important decisions are made related to strategies that guarantee an increase in firm performance over time (Fich & Shivdasani, 2006; Gu & Zhang, 2016). In this sense, we have found three possible arguments in previous literature on interlocking directors, innovation and performance. First, because of their positions in other firms, interlocking directors may not be as closely linked to the company as the inside directors and may not feel identified with the corporate objectives (Hill & Snell, 1988) and thus may therefore be likely to show less interest in long-term projects such as innovation. Second, their connections outside the firm are likely to

make them busy (Ferris et al., 2003; Fich & Shivdasani, 2006) so they may not have enough time to devote to each firm. Their agendas may become overloaded with activities unrelated to the focal firm, decreasing their effectiveness in advice, control, and monitoring tasks (García-Ramos & Díaz, 2021; Gu & Zhang, 2016). Thus, if interlocking directors are not able to organise themselves to serve the needs of several firms at the same time, the board decisions and, consequently, the effect of R&D investments on firm performance may be also affected negatively (Bravo & Reguera-Alvarado, 2017; Iyer et al., 2020).

Third, due to the presence of bounded rationality in interlocking directors when collecting and processing the information, each one can only collect information from a limited number of sources or firms (March, 1978; Oliveira et al., 2022). From a psychological point of view, this is because information-processing capacity is limited (Ruiz & Botella, 1981). As the amount of information increases, more capacity will be required, and there may be interference with other cognitive tasks and limitations. The information processes associated with a board's advisory function require a great deal of analytical capacity on the part of board members. Consequently, when directors hold different seats, interferences and constraints may become more evident at the individual level and even more critical at the group level. Under these circumstances, the entire board is likely to lose the ability to differentiate between profitable and unprofitable R&D investment projects, and any such projects may prove to not be fruitful for the firm's performance. Additionally, since interlocking directors must dedicate considerable time to monitoring, consulting, and keeping up-to-date on the latest events in the focal firm, it may be physically impossible to replicate these tasks on several boards at the same time (Li & Ang, 2000). This can even lead to coordination and teamwork problems with the rest of the board.

Empirical evidence also shows negative results on the effect of interconnected boards on firm performance. For example, the study by Zona et al. (2018) for Italian firms suggests that interconnected boards may exert a positive or negative effect on subsequent firm performance (ROA), depending on relative firm resources, power imbalance, ownership concentration and CEO ownership. Hamdan (2018) also finds evidence of a negative effect of the presence of interlocking directors on ROA and ROE in a study of Saudi Arabian firms. These results are in line with those obtained by Fich & Shivdasani (2006) in their study of a sample of firms listed in Forbes 500. They find that firms with boards, where the majority of outside directors hold three or more seats, are associated with weak corporate governance and, as a consequence, display significantly lower market-to-book ratios. Moreover, when directors are busy as a result of acquiring an additional seat, other firms in which they hold board seats experience negative abnormal returns.

Furthermore, apart from the direct negative effects of interlocking directors on firm performance, negative consequences on the relationship between firm innovation and firm performance are also to be expected. The three above arguments (lack of close links to the firm, shortage of time and bounded rationality) may affect the performance of the entire board in different ways depending on the percentage of board members. For example, if the percentage of interlocking directors is low, it is likely that the remaining directors are probably to help dissipate and minimise these negative effects. Consequently, neither the performance of the board as a whole nor the relationship between R&D investment and firm performance will be seriously affected. Conversely, if the percentage of interlocking directors is high, this is likely to affect the performance of the board as a whole, hindering the decision-making process. Under these circumstances, the role of the board as a determinant of the relationship between R&D

investments and firm value may mean that this relationship is weakened. For instance, objectivity when evaluating the feasibility of new projects may be reduced, thus diminishing the positive effect of R&D investments on the firm's performance (Li & Ang, 2000; López-Iturriaga & Morrós-Rodríguez, 2012; March, 1978). In addition, with a high percentage of interlocking directors, coordination and communication problems among board members may increase. For example, scheduling board meetings could become a challenge due to their incompatible agendas. This in turn might disrupt the communication flow and exchange of ideas needed for successful R&D investment decisions. In consequence, the greater the number of interlocking directors, the more difficult it will be for the board to reach consensus or make decisions on time, especially those related to profitable R&D investments. A delayed decision might be devastating for firms in regard to innovation. Therefore, even if the right decision to invest in R&D was taken, it might not be profitable for the firm.

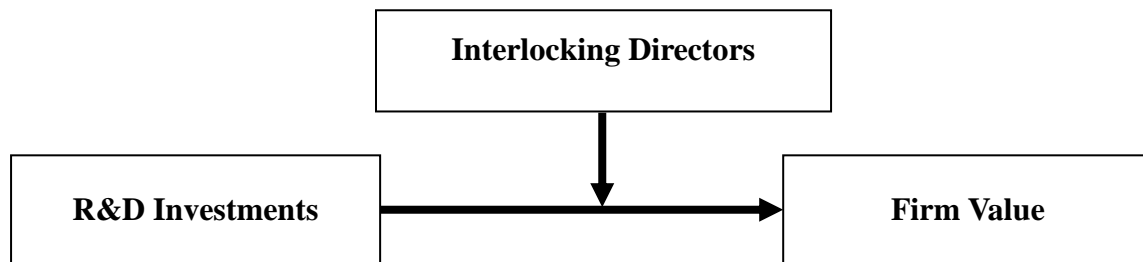
Similarly, this situation becomes more critical if there is a high percentage of interlocking directors with scattered ideas on the board. The ability of the entire board to properly advise on profitable R&D projects could be compromised and result in failed investments, which might decrease firm value. Therefore, the relationship between R&D investments and firm value could be seriously weakened. Another aspect to consider is that a high percentage of interlocking directors may weaken the control function of the board as a whole. As a consequence, managers could take advantage of this situation and derive in abuse and opportunistic behaviour as the board would be more vulnerable to manipulation (De Andrés et al., 2014). Thus, managers may prefer to redirect investments to other less risky, non-R&D areas.

Thus, a higher percentage of interlocking directors in the boardroom could affect the performance of the board and may also negatively influence the relationship between R&D investments and firm value.

Based on the above arguments, the following hypothesis is posed:

**Hypothesis 2b:** The percentage of interlocking directors in the boardroom negatively moderates the relationship between R&D investments and firm value.

Figure 1 shows the research model proposed in this study.



**Figure 1.** Research model

### 3. STATISTICAL ANALYSIS

#### 3.1. Sample

The database used to test the above hypotheses is made up of all Spanish firms listed on the General Index of the Madrid Stock Exchange (IGBM) for the period 2008-2019 (175 companies, 1,396 observations). Information is available because listed firms must comply with certain legal requirements that oblige them to publish information on corporate governance and financial reports (Barroso-Castro et al., 2016). Financial and insurance firms were excluded from this initial database because of their special characteristics, such as their specificity from an

accounting point of view, or because of the regulation or structure of this type of market (41 companies, 234 observations). This results in an initial sample of 134 firms (1,162 observations). In addition to the previous filter, due to missing values in some of the variables considered, our final sample consists of an unbalanced panel of 967 observations from 106 Spanish listed companies for the period 2008-2019. This time-period includes the international financial crisis when firms had to make important decisions about their future strategies and preceded the COVID-19 restrictions on social interactions. These conditions therefore provide a suitable framework for testing the hypotheses proposed.

Information on interlocking directors was obtained manually from the annual corporate governance reports filed with the CNMV (*Comisión Nacional del Mercado de Valores*). Firms' information, including capitalization, R&D investments, age, assets, leverage, sector of activity and number of employees, was obtained from the Madrid Stock Exchange, the CNMV, and from SABI (*Sociedad de Análisis de Balances Ibéricos*).

### **3.2. Measurement of variables**

*Dependent variable.* Firm value is defined as the sum of short and long-term debt and market capitalisation over total assets (VALUE) (Duqi & Torluccio, 2013). According to Simionescu et al. (2021), stock market-based measures reveal investors' forward-looking projections, as they are idiosyncratic. Moreover, they are values that are not easy to manipulate, unlike other accounting proxies (such as ROA) that can be altered by accounting rules and manipulated by the board.

*Explanatory variable.* R&D investments is measured as the sum of development, patents, licenses, and software applications included in annual reports over the total number of employees (R&D) (Baysinger et al., 1991; Hill & Snell, 1988).

*Moderating variable.* Interlocking directors is defined as the number of directors in each firm with multiple directorships over the total number of directors (INTERLOCKING\_DIR) (Cumming & Leung, 2021; Sarto et al., 2019).

*Control variables.* Control variables include the sector to which the company belongs as a dichotomous variable that takes the value of 1 if it belongs to the manufacturing sector and 0 otherwise (SECTOR) (García-Piqueres et al., 2016). Firm age is measured as the logarithm of the years since the firm's creation (AGE) (Oehmichen et al., 2017). Firm size is measured as the logarithm of the total number of employees (SIZE). Finally, we include a proxy of the level of debt, defined as the sum of short and long-term debt over total assets (LEVERAGE) (Cabeza-García et al., 2021).

### **3.3. Methodology**

To test our hypotheses, we used the two-step difference GMM model for dynamic panel data models created by Arellano and Bond (1991). Unlike cross-sectional analysis, the dynamic panel data analysis is a more robust methodology that allows us to control for individual heterogeneity or unobservable individual effects (company effects) by considering first-differences; it also controls for endogeneity. The GMM estimator uses internal instruments that are based on lagged values of the explanatory variables that may present problems of endogeneity. All the



endogenous right-hand-side variables of the model are lagged from t-1 to t-3 for equations in differences<sup>2</sup>.

Following Arellano & Bond (1991), we consider the three specification tests to verify the consistency of the GMM estimator and the validity of the instruments used. First, we check the joint validity of the instruments used by means of Hansen's over-identification test. Second, we check for the absence of second-order serial correlation in the first-difference residuals ( $m_2$ ). Third, we use Wald tests for the joint significance of the explanatory variables ( $z_1$ ) and the time variables ( $z_2$ ). In addition, given a possible heteroscedasticity problem, we use the robust option for the `xtabond2` command of the STATA program.

Therefore, the general dynamic panel data regression model used for the analysis is as follows:

$$\begin{aligned}
 &FIRM\ VALUE_{it} \\
 &= \alpha_0 + \beta_1 R\&D_{it} + \beta_2 INTERLOCKING\_DIR_{it} \\
 &+ \beta_3 R\&D_{it} \times INTERLOCKING\_DIR_{it} + \beta_4 SECTOR_{it} + \beta_5 AGE_{it} + \beta_6 SIZE_{it} \\
 &+ \beta_7 LEVERAGE_{it} + \sum_{t=2008}^{2019} Y_t + \gamma_i + \mu_{it}
 \end{aligned}$$

Where  $i$  refers to the firm,  $t$  to the time,  $\sum_{t=2008}^{2019} Y_t$  is a set of time variables,  $\gamma_i$  is the firm's effect, which we assume is constant for firm  $i$  during period  $t$ , and  $\mu_{it}$  is the error term.

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<sup>2</sup> Our model demonstrates a situation of simultaneity or causality between firm value and firm innovation and other firm characteristics. Instrumental variables (IV) may be another option to solve reverse causality, although identifying suitable instruments is difficult. As Pindado & Requejo (2015) document, the main limitation of IV is to choose those outside instruments that are uncorrelated with the error term and contain sufficient information on the explanatory variables in the model that are not strictly exogenous. Furthermore, the conventional IV estimator (though consistent) is inefficient in the presence of heteroscedasticity (Baum et al., 2003).

In addition, to test our hypotheses, we perform a hierarchical regression analysis according to the moderation analysis procedure. Firstly, in Model 1 we include the control variables. In Model 2, together with the control variables, we consider the main explanatory variable (R&D). In Model 3, we add the moderating variable (INTERLOCKING\_DIR). Finally, in Model 4, we include a new interaction variable resulting from the multiplication of the main explanatory variable by the moderating variable (R&D x INTERLOCKING\_DIR).

#### 4. RESULTS

Table 1 shows the descriptive statistics and Table 2 shows the correlation matrix of the variables used in this study. Although some of the variables were significantly correlated, the analysis of the variance inflation factors (VIF) revealed no evidence of multicollinearity, as all of them remained under 10 (Kleinbaum et al., 1988) and even under 5 (Hair et al., 2010).

**Table 1.** Descriptive statistics

<b>Variable</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>	<b>St. Dev.</b>
<b>Panel A: Continuous variables</b>				
VALUE	1.394	0.382	8.147	0.944
R&D	86.431	0.000	1,856.053	227.963
INTERLOCKING_DIR	23.934	0.000	88.889	18.504
AGE	46.215	1	119	27.777
SIZE	15,290.972	3.000	291,027	35,344.652
LEVERAGE	0.656	0.097	3.426	0.251
<b>Panel B: Dummy variables</b>				
	% (number of observations = 1)			
SECTOR	352 (32.77)			

n=1,074

**Table 2.** Correlation matrix

Variable	1	2	3	4	5	6	7
1. VALUE	1						
2. R&D	0.048	1					
3. INTERLOCKING_DIR	0.017	0.058*	1				
4. SECTOR	-0.070**	-0.066**	-0.114***	1			
5. AGE	-0.025	-0.101***	0.055*	0.287***	1		
6. SIZE	0.118***	0.032	0.373***	-0.288***	0.203***	1	
7. LEVERAGE	0.058*	-0.003	0.042	-0.051*	0.158***	0.334***	1

n=1074

\* p &lt; 0.10; \*\* p &lt; 0.05; \*\*\* p &lt; 0.01

Table 3 shows the results of the GMM analysis following the moderation procedure. Model 1 presents the effects of the control variables on firm value. Model 2 includes the main explanatory variable, R&D investments, and the control variables. A significant positive effect of R&D investments on firm value was found ( $\beta = 3.01e-04$ , p-value 0.084), confirming the existence of a relationship between R&D investments and firm value, as stated in Hypothesis 1. These results are in line with several previous studies on R&D investments and firm value. For instance, they are aligned to the findings of Mezghanni (2011) for a sample of French firms. This study states that investors may look beyond the short-term earnings impact and value the stock price more highly when large firms' R&D efforts are presented. This evidence is also similar to the findings of Ren et al. (2012) for Chinese firms, of Wang (2011) for Taiwanese firms and of Yousaf et al. (2019) for Pakistani firms. There are also some studies in the Spanish context that are consistent with our findings, such as those by van Auken et al. (2008), Coad et al. (2016), Coad et al. (2021), González-Fernández & González-Velasco (2018), Sánchez-Sellero et al. (2015), and Segarra & Teruel (2014).

In Model 3, the moderating variable related to interlocking directors was added. It showed that the percentage of interlocking directors had a positive and statistically significant effect on firm value in line with the findings of Barroso-Castro et al. (2016) for a sample of Spanish firms. The latter argue that the greater the board's connection with other firms, the greater its external social capital will be and the better its ROS. Pérez-Calero et al. (2016) also find positive effects of interlocking directors on ROA in Spain. This evidence is similar to that found by Qiao et al. (2013) in their study for Chinese firms.

Finally, in Model 4, along with the explanatory, moderating and control variables, the interactive variable was included, that is, R&D investments multiplied by the percentage of interlocking directors. The term of interaction (R&D x INTERLOCKING\_DIR) in Model 4 is negative and significant ( $\beta = -9.26e-06$ , p-value = 0.012), supporting Hypothesis 2b. So there seems to be evidence of a negative moderating effect of the percentage of interlocking directors on the relationship between R&D investments and firm value. Additionally, the percentage of interlocking directors can be considered a quasi-moderator, given that it has both direct (positive) and moderating (negative) effects on firm value.

Regarding the control variables, LEVERAGE has a positive and significant effect in all the models estimated. Highly leveraged companies are likely to be able to improve their results because banks and trade creditors monitor their activity and prevent inefficient management, especially in small companies (Tsuruta, 2014). So, in line with agency theory, leverage would be a control mechanism (Fama, 1980; Fama & Jensen, 1983). Additionally, firms that increase leverage are likely to use it to obtain more resources to invest in R&D and this in turn may raise the firm's value in the market. Finally, no significant effects were found for the SECTOR, AGE and SIZE variables on firm value.

Figure 2 was plotted following Dawson's (2014) instructions. It shows the interactions of interlocking directors and gives a better explanation of their effects in the GMM analysis. Our findings suggest that a high percentage of interlocking directors on a board may diminish the positive effects of R&D investments on firm value.

**Table 3.** GMM results

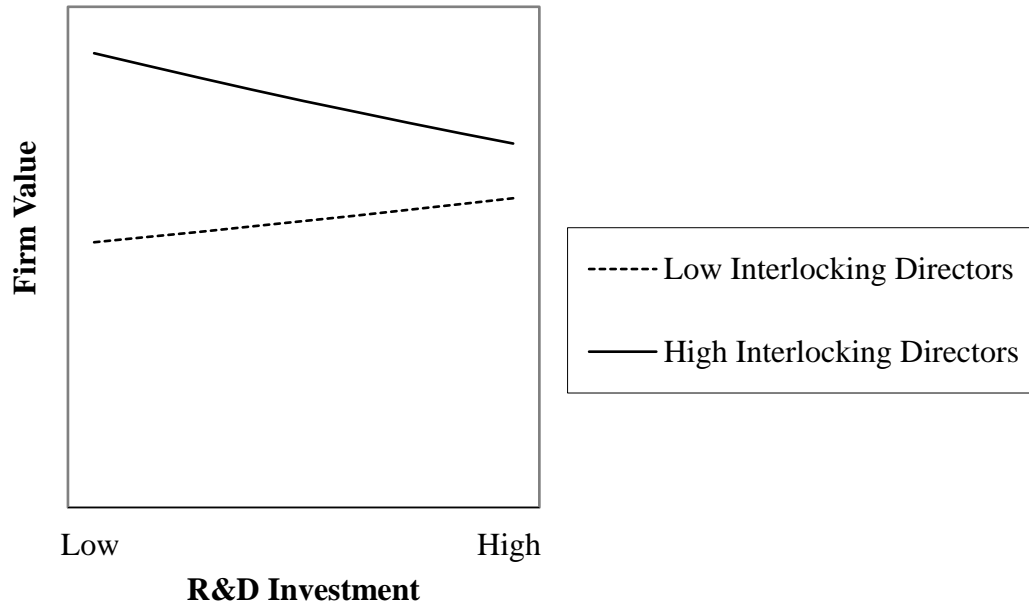
<b>Independent variables</b>	<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>
R&D		3.01e-04*	1.80e-04	3.37e-04**
		(1.73)	(1.06)	(2.04)
INTERLOCKING_DIR			0.003*	0.005**
			(1.87)	(2.48)
R&DxINTERLOCKING_DIR				-9.26e-06**
				(-2.50)
SECTOR	0.016	0.015	0.015	0.021
	(1.06)	(0.91)	(1.01)	(1.43)
AGE	-0.003	-0.073	-0.031	0.058
	(-0.05)	(-0.62)	(-0.22)	(0.50)
SIZE	0.120	0.122	0.061	0.071
	(1.38)	(0.91)	(0.50)	(0.72)
LEVERAGE	0.772***	0.665**	0.741**	0.817***
	(2.81)	(2.05)	(2.57)	(3.33)
Annual effect considered	Yes	Yes	Yes	Yes
z <sub>1</sub>	11.48**	11.47**	15.49**	43.35***
z <sub>2</sub>	80.18***	89.57***	84.15***	91.21***
m <sub>2</sub>	0.43	0.50	0.50	0.50
Hansen	61.93	98.23	97.13	90.32
No. observations	967	967	967	967
No. groups	106	106	106	106

Dependant variable is VALUE

t-value are shown between parentheses

z<sub>1</sub> is a Wald test for the reported coefficients of the explanatory and control variables, asymptotically distributed as  $\chi^2$  under the null of no relationship for all the explanatory variables. z<sub>2</sub> is a Wald test for the reported coefficients of the dummy annual variables, asymptotically distributed as  $\chi^2$  under the null of no relationship for all the explanatory variables. m<sub>2</sub> is the second order serial correlation relation in the regression residuals, asymptotically distributed as N(0, 1) under the null of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as  $\chi^2$  under the null of no correlation between the instruments and the error term (p-value)

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



**Figure 2.** R&D investments and firm value: The role of interlocking directors

*Additional and robustness results*

Although using a larger number of lags may lead to a larger number of instruments in comparison with the number of firms or groups, which might make the results less robust, we repeated our estimations increasing the number of lags and the results did not vary significantly. Furthermore, using a smaller number of lags does not affect the results.

We also estimated the models using two additional proxies for our moderating variable: 'Interlocking\_1' and 'Interlocking\_2'. 'Interlocking\_1' was measured as the number of board members who hold administrative or managerial positions in other firms that are part of the focal firm's group over the total number of board members; 'Interlocking\_2' was defined as the number of board members with at least one connection to another firm (within or outside their group) over the total number of board members. The results remain the same for 'Interlocking\_2',

but not for 'Interlocking\_1'. This may be because, when directors accumulate positions in the same group (Interlocks\_1), the spread effect of ideas and knowledge is smaller, and it does not negatively moderate the relationship between R&D and firm value. However, when board members sit on the board of different firms that do not belong to the same group, it may be more difficult for them to advise the focal firm due to the type of industry to which the external firm belongs.

We also repeated the estimations with a different proxy for the moderating variable to analyse if there are differences between a low and high percentage of interlocking directors. To do so, we created the dummy variable 'interlocking\_low' which takes the value of 1 when the number of interlocking directors in each firm is below the median number of interlocking directors, and 0 otherwise. We find that at a low percentage of interlocking directors, moderation is positive, that is, the initial relationship between R&D investments and firm value is amplified. Conversely, when the percentage of interlocking directors is high, moderation is negative, in line with our findings in Table 3. These moderation effects may be seen in Figure 2, which shows that for a low percentage of interlocking directors, the relationship between R&D and value is positive, while for a high percentage of the moderator variable, the relationship between the explanatory and dependent variable decreases.

## **5. DISCUSSION**

Literature on R&D investments and their impacts on firms' performance is extensive, and there seems to be a consensus on the positive effect of R&D investments (e.g., Alam et al., 2020; Boiko, 2022; Chen & Ibhagui, 2019; Hill & Snell, 1988; Hoskisson et al., 2002, 1994; Jermias, 2007; Le et al., 2006; Lee, 2020; Mezghanni, 2011; Tung & Binh, 2022). However, this is a

complex relationship involving upstream decision-making processes that need to be meticulously analysed (Teirlinck, 2017). Moreover, the uncertainty surrounding the success or failure of R&D decisions involves a high degree of risk to which managers are likely to be averse (Fama, 1980; Fama & Jensen, 1983). On the one hand, there are agency problems where managers are likely to prefer other types of lower-risk investments in order to avoid giving up their economic incentives (Eisenhardt, 1985; Fama, 1980; Fama & Jensen, 1983). In addition, information asymmetry problems are present (Chen, 2013; Hillman & Dalziel, 2003). As a solution to these problems, previous corporate governance literature suggests the board of directors serves as a control and consulting organism (Ahuja et al., 2008; Boiko, 2022; Fama & Jensen, 1983; Hill & Snell, 1988).

However, although previous work has included some board characteristics as moderating variables in the relationship between R&D investments and firm performance (Jermias, 2007; Le et al., 2006; Mezghanni, 2011; Ren et al., 2012; Wang, 2011; Yousaf et al., 2019), these variables (size, independence, CEO duality, meetings, and equity ownership) are more associated with the board's role as a control organism. The board's role as a consulting and advisory body remains understudied. Therefore, the present paper takes a step forward to fill this gap in the literature and contributes by delving deeper into this role of the board when there are interlocking directors (Han et al., 2015; Hernández-Lara & Gonzales-Bustos, 2019; Li, 2019; Sarto et al., 2019). Specifically, we study how the percentage of interlocking directors on the boardroom moderates the relationship between R&D investments and firm value.

Using a panel data methodology on a sample of Spanish listed companies over the period 2008-2019, our findings suggest a positive effect of R&D investments on firm value. These findings add to most of the previous literature on R&D investments and firm performance (e.g., Alam et al., 2020; Boiko, 2022; Chen & Ibhagui, 2019; Hill & Snell, 1988; Hoskisson et al., 2002, 1994;



Jermias, 2007; Lee, 2020; Mezghanni, 2011; Tung & Binh, 2022) which suggests that increased R&D investments are one of the most effective strategies used by firms to increase their level of innovation, gain a competitive advantage in the market and secure long-term growth (Teece et al., 1997). In addition, R&D investment decisions may be an indicator for the stock market of future economic benefits for the firm and may, therefore, lead to an increase in the stock's market value (Chambers et al., 2002). Regarding the effect of the percentage of interlocking directors, we find a quasi-moderation effect, which means that there is a direct positive effect of the percentage of interlocking directors on firm value, as well as a negative moderation effect on the initial positive relationship between R&D investments and firm value. These seemingly contradictory findings may be explained from two points of view.

On the one hand, the presence of interlocking directors may contribute to a decrease in the information asymmetry associated with R&D investments (Chen, 2013; Hillman & Dalziel, 2003). Information sharing plays an important role in the behaviour and performance of insider-based operations (Goergen et al., 2019), especially in the case of key strategic decisions, for which the board of directors is responsible (Helmens et al., 2017). Firms seek to increase the effectiveness of the board by hiring directors with outstanding prestige and experience, who contribute with their knowledge of the environment and serve as a bridge to access resources outside the firm (Hernández-Lara & Gonzales-Bustos, 2019). These arguments are aligned with *resource-based theory* (Barney, 1991) as well as *board social capital theory* (Haynes & Hillman, 2010), *resource dependence* (Pfeffer & Salancik, 1978) and *friendly boards* (Adams & Ferreira, 2007). They all consider interlocking directors in some way to be a source of consulting and advice, as well as a bridge to access environmental information (Chen, 2014; Wincent et al., 2010). Additionally, from the point of view of *agency theory* (Jensen & Meckling, 1976), it is

suggested that directors' links with other firms may be an indicator of the quality and reputation of directors as expert decision-makers. Consequently, the higher the percentage of interlocking directors in a boardroom, the greater the likelihood of that the board will make better strategic decisions on, for example, innovation. Together, these arguments would help explain the positive direct effect of the percentage of interlocking directors on firm performance, in line with previous research findings (Barroso-Castro et al., 2016; Chen, 2014; Dalziel et al., 2011; Dass et al., 2014; Gu & Zhang, 2016; Hernández-Lara & Gonzales-Bustos, 2019; Oh & Barker, 2018; Wu & Dong, 2021).

On the other hand, each interlocking director may have difficulties associated with their position on different boards at the same time (e.g., time constraints and limited rationality) (March, 1978). From this point of view, if a board has a large number of interlocking directors, it might be difficult to fix meeting dates that suit them all, leading to the postponement of important R&D investment decisions. In addition, this would cause a decrease in the quality of consulting tasks within the board and limit its ability to identify market opportunities for investment in new projects. Furthermore, the presence of a large number of interlocking directors in the boardroom may weaken the control function of the board. This in turn would leave the board vulnerable to manipulation and opportunistic behaviour by management. As a consequence, the relationship between R&D and firm value may weaken. These arguments are in line with agency theory and previous studies, which warn about the disadvantages of the presence of too many interlocking directors, and about the possibility that the excessive connections of interlocking directors may cause a decrease in the board's monitoring and control capacity (Gu & Zhang, 2016).

## 6. CONCLUSIONS

Although previous literature finds mostly positive empirical evidence of R&D investments on firm performance, it cannot be denied that this is a complex relationship due to the presence of several factors that may affect (Boiko, 2022; Mezghanni, 2011). Our paper aims to go a step further by analysing the role of the board of directors, one of the main governance mechanisms, as a conditioning factor of the relationship between R&D investments and firm value. The GMM results confirm a positive effect of R&D investments on firm performance moderated by the number of interlocking directors. It appears that a low percentage of interlocking directors could strengthen the relationship between R&D investments and firm performance, while a higher percentage of interlocking directors could weaken this relationship.

Consequently, some important *practical implications* at company level can be extracted from this study. First, we find evidence that R&D investments lead to increased firm performance. We therefore encourage firms to use innovation strategies to turn them into a competitive advantage in line with the *resource-based* (Barney, 1991) and *evolutionary* (Nelson & Winter, 1982) theories. In addition, our findings might help to improve the recruitment profile of interlocking directors that firms should use to enhance firm value. Recommendations include that the number of interlocking directors hired should allow for an adequate flow of information within the board. In addition, the number of additional director interlocks should not interfere with the director's tasks in the focal firm. It may be better to consider the quality of the connections and their affinity with the sector to which the potential board member belongs in order to ensure that they are well-qualified to process information and organise their ideas.

Second, our findings also provide information for *policy makers* on the necessity of continuing to offer R&D programs supporting the development of innovation projects as such strategic decisions may increase firm value. The creation of new public policies to foster R&D may be essential in moderate or low technology-intensive environments (Camiña et al., 2020) considering the positive effect of R&D on performance. Besides, considering that our results also show that the board of directors, and in particular, interlocking directors, condition the firm innovation-value relationship, new guidelines from corporate governance are needed. Thus, when drawing up good corporate governance codes, governments should reflect in more detail on the advantages and disadvantages of having a higher number of interlocking directors in the boardroom. This could help companies to consider the benefits of including interlocking directors, but also to be aware of the difficulties that a higher percentage of interlocking directors may bring to the board, such as coordination and communication problems, and how these may affect their decisions.

The study makes a *theoretical contribution* to the debate on R&D investment and firm performance. First, the findings of the study add to the growing literature on firm innovation by indicating how this type of strategic decision may lead to a higher firm value. Second, it adds to the relatively scarce literature on how the role of the board of directors as a source of knowledge and consulting affects the relationship between innovation and performance. We developed the theoretical reasoning and provided further evidence to the literature on the role of interlocking directors as a specific factor that moderates the above relationship. Firm innovation and board composition are important strategic decisions, so it is important to contribute to their understanding and possible relationships. Furthermore, our findings are in line with the *agency* (Fama, 1980; Fama & Jensen, 1983) and *resource-based* (Barney, 1991) theories that have

traditionally been employed as a theoretical framework in the previous literature on board, innovation and performance, but we adopt a holistic perspective that takes into account their interactions in the decision-making process.

Among the limitations of this study and possible future lines of research, firstly, the context of the study should be mentioned. Although Spain provides an example on the European situation, the database corresponds to a single country, so the generalisability of the results to other countries is limited. A multi-country study should be conducted in order to extend the results to other settings. In terms of the time-period of the study (2008-2019), future research could include later years to study the effects caused by the COVID-19 pandemic crisis and analyse if firm behaviour in terms of innovation and performance has changed. Besides, it is likely the percentage of interlocking directors does not allow us to know the level of commitment and time availability of each interlocking director and how they are working. For this reason, it would be interesting for future research to consider qualitative aspects of this type of directors using interviews or surveys to get a closer look at their day-to-day work. In addition, our study does not consider differences between the sectors to which the interlocking directors belong. It might be interesting to include this variable in future studies to analyse any such differences. Moreover, other aspects of the board associated with their role as a source of information and consulting could be included as possible moderators, such as directors' academic level, profession, previous experience as CEO, tenure at the firm, among others.

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## **DECLARATIONS**

**Conflict of interest:** The authors declare that they have no conflict of interest that would affect the research or the peer review procedure.