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Article

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ACCOUNTING, CORPORATE GOVERNANCE & BUSINESS ETHICS | RESEARCH ARTICLE

Board gender diversity and innovation activities: Evidence from R&D investments in the UK

Ala'a Azzam^{1*}

Abstract: This study examines the relationship between board gender diversity and R&D investments in the UK. Also, the study goes deeper and examines whether the relationship between board gender diversity and R&D investments is affected by the female tenure in the board. Using a sample from the UK FTSE350 index between 2009 and 2018, the findings show that board gender diversity has a positive impact on R&D intensity. Importantly, we find that this relationship is not affected by the tenure of female directors. Therefore, this result alleviates the concern that long female tenure might lead to weak monitoring, thereby adversely impacting the relationship between gender diversity and R&D investments. The findings hold after using different proxies for gender diversity and after controlling for endogeneity. The study injects the literature with up-to-date evidence on the role of female directors in R&D investment in the UK where female representation in the board is still optional. Moreover, the findings of this study contribute to the merits of the tense debate on female representation in the board of directors. In this regard, given that the current regulations in the UK recommend, but do not oblige, board gender diversity, regulatory bodies (e.g., FRC) could take this issue into consideration for future governance reform. Furthermore, companies that are eager to maintain sustained innovation should pay close attention to gender diversity during the process of the directors' appointment.

Subjects: Accounting; Strategic Management; Corporate Governance

Keywords: board of directors; gender diversity; female tenure; R&D

1. Introduction

Investment in research and development (R&D) has been an important component of corporate strategy as it enables introducing new products and processes, therefore enhancing firm's growth (Guellec & de La Potterie, 2004). Board of directors plays an important role in shaping corporate strategy especially concerning R&D investments, e.g., monitoring the CEO's decisions to ensure a proper investment in R&D (Dalziel et al., 2011). The diversity of the board of directors is of vital importance within corporate governance, where the aim is to identify structures that align the interests of management and stakeholders. As an important type of board diversity, gender diversity received particular attention and has been promoted as a way to improve different corporate outcomes (Gul et al., 2011; Srinidhi et al., 2011; Terjesen et al., 2009). Hence, this study has a motivation to examine whether board gender diversity affects R&D investment in the UK market.

The UK context is of particular interest for different reasons: First, the UK code for corporate governance, which relies on the principle of comply or explain, does not contain any obligatory recommendations concerning board gender diversity. This is compared with most European countries where a quota is set to ensure a minimum representation of women in board of directors. Second, although the gender diversity is still optional, the FTSE350 firms are characterized by a high proportion of women among board directors. The proportion of female directors has significantly risen to 27.5% in 2018, compared with 10.5% in 2008 and 18% in 2013 (Spencer Report, 2018). Third, The UK has a strong common-law tradition, which is featured by dispersed ownership and a high degree of investor protection. These characteristics of the UK market highlight two views: First, where liquidity is key for investors and management (Driver et al., 2012), managers might spend less on risky and uncertain projects (e.g., R&D investments). The second view suggests that a strong corporate governance system in the UK induces managers to spend more on R&D to reassure investors that they are not shrinking (Hassanein et al., 2021). Hence, in both cases, an effective corporate governance mechanism (e.g., a board with diverse gender [S. Chen et al., 2016]) is essential to control the CEO's behavior and maintain long-term shareholders' interests. This discussion leads to the key research question: do female directors contribute to R&D investments in the UK context?

This study argues that board gender diversity might affect R&D expenditure through better monitoring ability of women and an increase in managerial accountability (Adams & Ferreira, 2009). Female directors can contribute to new insights, diversified experiences, knowledge and skills which are essentially beneficial for innovation (Galia & Zenou, 2012; Gonzales-Bustos et al., 2020). However, having a diverse board does not necessarily lead to a more effective board (Rose, 2007). The appointment of female directors might involve tokenism or merely to satisfy regulatory requirements, thereby the real value of diversity might not be appreciated (AlHares, 2020; Rose, 2007). Also, given that R&D initiatives are high-risk investments, and given that women are considered more risk-averse than men, board gender diversity might result in lower investment in R&D projects.

Furthermore, both prior studies and governance regulations have warned over the adverse impact of directors' tenure on independence and, therefore, on monitoring effectiveness. Also, long tenure might increase directors' commitments to the status quo, thereby limiting their perspectives, ideas, and ability to pursue strategic change (Finkelstein & Hambrick, 1990). This creates a motive to also examine whether and how the tenure of female directors moderates the relationship between gender diversity and R&D intensity. In other words, whether the relationship between gender diversity and R&D intensity [if any] holds if the female directors stay in their role for a long period of time.

Using a sample from the UK FTSE350 index between 2009 and 2018, we find that board gender diversity has a positive impact on R&D intensity. This outcome is consistent with the argument that female directors provide new insights, divergent experiences and skills which contribute positively to R&D investments. It also supported the agency theory proposition that the presence of women on boards improves the oversight process, leading to more effective boards. In particular, they can maintain shareholders' interests by effectively monitoring R&D investments made by CEOs. This result has not been affected by the tenure of female directors, ruling out the concern over the potential negative impact of tenure on the relationship between gender diversity and R&D intensity.

These findings enrich the extant literature by providing new empirical evidence on the relationship between board gender diversity and R&D investments from a developed, and common-law context where female representation in the board is yet to be mandatory. Therefore, the findings contribute to the inconsistent literature concerning the impact of female directors, especially in the area of strategic decision-making. Beyond its contribution to the literature, this study has implications for policy-makers and practice. Given that most of the management literature reports that

women are risk-averse, our findings also alleviate the concern over the impact of women's behavior on risky expenditures such as R&D. Furthermore, our findings provide an important contribution for the UK regulatory bodies to consider this issue for future governance reform. In addition, the results have significant implications for nomination committees of public firms. Specifically, companies that are eager to maintain sustained innovation should pay further attention to gender diversity during the process of the directors' appointment (or reappointment).

The paper is structured as follows: The next section covers a discussion of the literature review and hypothesis development, followed by the methodology section. The last two sections present the discussion of the findings and the conclusion, respectively.

2. Literature review and hypotheses development

2.1. Board gender diversity: a background

Gender diversity is arguably the most debated issue in board compositions by both literature and policy-makers (Alhababsah & Alhaj-Ismail, 2021; The UK Corporate Governance Code, 2010). Prior studies document that board gender diversity has a positive impact on different corporate outcomes. In particular, these studies show that the presence of females on boards improves the monitoring process, leading to more effective boards (Damak, 2018; Terjesen et al., 2009), improves the quality of disclosures (Gul et al., 2011), enhances earnings quality (Ghaleb et al., 2021; Srinidhi et al., 2011), reduces the probability of loan default and the cost of debt (Usman et al., 2019), and improves audit quality (Alhababsah & Alhaj-Ismail, 2021). Also, several governments have chosen to include gender quotas in their legislation (Terjesen et al., 2009). For example, France, Germany, Finland, Norway, Spain, Iceland, Italy, and Belgium have introduced a legislative quota requiring companies to have 30% and 40% female representation in corporate boards. In contrast, the UK adopted a voluntary approach to allow a fundamental change in the culture of the board internally instead of imposing the change which might lead to just increasing the number of female directors (Brahma et al., 2021).¹

Women are generally considered more risk-averse and are more sensitive to losses than men, thereby being more conservative in their decisions (Watson & McNaughton, 2007; Zalata et al., 2018). In the same vein, prior studies show that women are less tolerant than men towards opportunistic behavior, more sensitive to ethical issues, and place less emphasis on expediency, self-interest, and common practice (Zalata et al., 2018). Accordingly, women's conservative mindset and ethical leadership contribute to more conservative and higher standards of financial reporting (Ho et al., 2015). Adams and Ferreira (2009) found that female directors have better attendance records and that in gender-diverse boards male directors have less attendance issues.

The aforementioned discussion is essentially supported by agency theory which deals with conflicts of interest between principals (e.g., shareholders) and agents (e.g., managers) and how the directors play an important role in monitoring and resolving these conflicts (Jensen & Meckling, 1976; Brahma et al., 2021). The view of this theory is that diversity enhances the monitoring role. For example, Adams and Ferreira (2009) drew on agency theory to explore the link between gender diversity on a board and firm value and found a positive relationship between gender diversity and firm performance. Adams and Ferreira (2009) found that female directors have better monitoring ability as they think independently and board gender diversity also increases managerial accountability, such as improving board meeting attendance and CEO accountability.

However, although the evidence presented in most prior studies on the positive role of female directors, there is also evidence showing that gender diversity is not always beneficial. For instance, Earley and Mosakowski (2000) mention that gender diversity has a negative impact on teamwork. In particular, they argue that female directors tend to communicate less frequently as they are less likely to share the same opinions as their male counterparts. Campbell and Mínguez-Vera (2008) and Lau and Murnighan (1998) point out that the presence of women in the board

might lead to some coordination and communication difficulties, conflicting views, and a delay in decision-making. In the same vein, Tajfel and Turner (2004) indicate that gender-diverse groups are less cooperative and experience higher emotional conflicts. In support of these arguments, Adams and Ferreira (2009) report that the presence of women in the board of directors is negatively associated with financial performance.

2.2. Board gender diversity and R&D

Prior literature highlights the important role of the board of directors' monitoring role in the area of R&D spending (e.g., Kor, 2006; Yoo & Sung, 2015). Although decisions about the allocation of R&D spending are in particular within a CEO's realm of responsibility (Balkin et al., 2000), CEOs tend to prune R&D spending due to the high level of uncertainty and the chance of failure (Kor, 2006). Even for successful investments, they are recouped in the long term, leaving an adverse impact on financial performance in the short term (Sanders & Carpenter, 2003). Accordingly, while investments in R&D benefit shareholders, CEOs often resist investing in R&D because of the potential adverse consequences on short-term financial performance (Faleye et al., 2014).

Given the divergence of interests between shareholders and CEOs (as proposed by agency theory), directors can align these interests by effectively monitoring R&D investments made by CEOs (Kor, 2006). Furthermore, directors who are vigilant in their monitoring role can remind CEOs that R&D investment is useful for the long-term health of the firm, even if doing so might adversely affect short-term performance (Guldiken & Darendeli, 2016). Thus, given that the dominant evidence in the literature on the monitoring effectiveness of female directors, it is plausible that these directors help mitigate agency problems and could encourage CEOs to invest more in R&D to maintain shareholders' value. Relatedly, Johnson et al. (2015) and Griffin et al. (2021) argue that more gender diverse boards could positively affect corporate innovation practices through their impact on corporate culture. Women in this case are more likely to challenge tradition and the status quo and inspire other directors to consider new ways of thinking.

Furthermore, female directors provide divergent experiences, broader perspectives, knowledge and skills which could fuel innovation activities and positively contribute to the firm's R&D investment (Galia & Zenou, 2012). Prior studies argue that women are better at understanding customer needs, thereby they could offer means and opportunities for firms to satisfy these needs (Galia & Zenou, 2012; Gonzales-Bustos et al., 2020). In support of this notion, empirical evidence on group decision-making shows that gender-diverse groups provide a more thorough evaluation of choices and high-quality decisions than homogeneous groups on complicated tasks (Amason, 1996) and also offer more innovative solutions through cognitive conflict (Amason, 1996). These arguments are supported by the resource dependency theory which suggests that companies seek to attract directors that best complement their existing resource profile and who can bring new forms of human and social capital (Pfeffer & Salancik, 1978). In addition, this theory suggests that board diversity can create a strong connection between companies and their external environments (1994; Pfeffer, 1973). In this regard, board gender diversity helps the human capital of board members; advice and counsel; and channels of communication (Hillman & Dalziel, 2003; Pfeffer & Salancik, 2003). Hence, a company should look to constitute a board which has individuals with a broad scope of knowledge across relevant demographics and can add legitimacy and valuable resources (Brahma et al., 2021).

On the other hand, the majority of prior studies report that female directors exert more effective monitoring over managers (e.g., Gul et al., 2011; Srinidhi et al., 2011; Terjesen et al., 2009). Thus, intense board monitoring might increase CEOs' risk aversion and decrease their willingness to invest in risky and long-term investments such as R&D initiatives (Cheng, 2004; Garg, 2013). In other words, CEOs who experience excessive monitoring might invest less in R&D, and instead might allocate funds to other conventional less risky projects (Guldiken & Darendeli, 2016). In support of this argument, Faleye et al. (2011) find that R&D spending is lower in firms whose board intensely monitors top managers. Moreover, given that R&D investments are high-risk investments,

and based on the literature on gender from the previous section (which highlights that women are more risk-averse), board gender diversity might also lead to lower R&D investments. Consistent with this notion, Almor et al. (2019) find a negative association between board gender diversity and R&D investments. J. Chen et al. (2018) argue that intra-group conflict that stems from more diverse board might affect the allocation of resources of the firm to risky investments, such as investment in R&D and innovation. Moreover, Rose (2007) and AlHares (2020) point out that the appointment of female directors might involve tokenism or merely to satisfy regulatory requirements, thereby not necessarily leading to effective monitoring.

Accordingly, given the above competing arguments concerning the potential impact of gender diversity on R&D investments, the hypotheses are formulated as follows:

H1: Board gender diversity positively affects R&D investments.

H2: Board gender diversity negatively affects R&D investments.

The essential arguments behind the impact of female directors on corporate outcomes are based on their ability to monitor effectively. Prior studies argue that long tenure of directors might establish the so-called familiarity bias which could be detrimental to monitoring, and therefore to R&D spending (Dalton et al., 1998). This bias could threaten directors' independence, thereby compromising the quality of monitoring (Fan et al., 2019). In particular, this could be in the form of less scrutinizing and critical judgment of the CEO's decisions. Less scrutinizing decreases the need of the CEO to provide more information to convince the board, which therefore negatively affects monitoring effectiveness (Adams & Ferreira, 2007). Further concern over directors' tenure is evident in the governance regulations across the globe. These regulations urge companies to adopt term limits for their boards to reduce the risk of excessive familiarity between directors and management (The UK Corporate Governance Code, 2018). Moreover, the long tenure of directors could affect their commitment to the status quo and might decrease the opportunity for new perspectives, skills and ideas (Finkelstein and Hambrick, 1990), thereby adversely affecting strategic decisions. These arguments on the possible adverse impact of directors' tenure create a concern that tenure of female directors could attenuate the relationship between gender diversity and R&D investments (if any). Hence, we draw the following hypothesis:

H3: Tenure of female directors negatively moderates the relationship between board gender diversity and R&D investments.

3. Methodology

3.1. Study sample

The study sample comprises the non-financial companies listed in the UK FTSE350 Index between 2010 and 2018. The FTSE350 index is of particular interest to policy-makers (e.g., FRC) as it represents the top-listed UK companies on the stock exchange based on their market capitalization (Alhababsah & Alhaj-Ismail, 2021).² Financial and utility firms (71 firms) are excluded because they work under different and more stringent regulations. The BoardEx database is utilized to obtain demographic data of directors and CEOs as well as other board characteristic data. Firm-specific variable data are sourced from DataStream. Our final sample includes 1,732 observations.

3.2. Empirical model and study variables

To test our hypotheses, we employ the following models:

$$R\&Dintensity_{it} = a_0 + a_1Gender_Diversity_{it} + a_2Control_Variables_{it} + \epsilon_{it} \quad (1)$$

$$R\&Dintensity_{it} = a_0 + a_1Gender_Diversity_{it} + a_2Gender_Diversity * Female_Tenure + a_3Control_Variables_{it} + \epsilon_{it} \quad (2)$$

Following prior studies (e.g., Jiang et al., 2020; Konno et al., 2018), the R&D intensity is calculated as the ratio of R&D expenses to sales. R&D expenditures form the initial stage for innovation activity and illustrate a firm's current innovation willingness and capability (Ebersberger & Herstad, 2011). Two proxies are used to measure the independent variable (gender diversity): first, board gender diversity is measured as the percentage of female directors to the total members of the board of firm *i* in time period *t*. The second proxy is defined as an indicator variable equal to 1 if the board of firm *i* in time period *t* has a female director at least, and 0 otherwise.

The study controls for several variables that appear in prior studies which could affect R&D intensity. These variables are CEO age, CEO tenure, CEO female, CEO change, CEO ownership, board tenure, board age, leverage, ROA, firm size, loss, busy board, board independence, and board size (e.g., Barker & Mueller, 2002; Guldiken & Darendeli, 2016; Rodrigues et al., 2020; Azzam & Alhababsah, 2022b). All continuous variables were winsorized at the top and bottom 1 percentile. The definition of the variables is presented in [Appendix 1](#).

4. Findings and discussion

4.1. Descriptive statistics and collinearity test

The descriptive statistics presented in [Table 1](#) state that the average R&D ratio to sales is 1.6%. Compared with other countries, previous studies show that the average R&D ratio to sales is 2% in the US (Bravo & Reguera-Alvarado, 2017) and 1.26% in Europe countries (Honoré, Munari, & Potterie, 2015). Concerning the variable of interest, the statistics show that, on average, one-fifth of directors in a firm are female. Also, 85% of boards of directors have female representation (i.e. have at least one female director). The tenure of female directors is 3.2 years. The Pearson correlation matrix in [Table 2](#) indicates that none of the correlations is sufficiently large to pose multicollinearity threats. Gujarati (2003) sets ± 0.80 as a threshold for harmful multicollinearity. The unreported results of the variance inflation factor (VIF) also show that all values are below the threshold of 10, providing further assurance over multicollinearity concerns.

4.2. Regression results and discussion

The key research question of this study is whether female representation in the board of directors has an impact on R&D intensity. We test this relationship between our variable of interest (board gender diversity) and R&D intensity using panel data regression.³ The statistical outcomes in [Panel 1](#) ([Table 3](#)) show that the proportion of female directors has a significant and positive coefficient. [Panel 2](#) ([Table 3](#)) is used as a supplementary test where gender diversity is measured as an indicator variable equal to 1 if the board of firm *i* in time period *t* has a female director at least, and 0 otherwise. This is because prior studies provide evidence that the presence of one female director, at least, has a significant impact on board's monitoring effectiveness (S. Chen et al., 2016; Hernández-Lara & Gonzales-Bustos, 2020; Rose, 2007). The outcome of both regressions support *H1*, suggesting that female representation in the board of directors has a positive impact on R&D investments.⁴

The findings of this study are consistent with the argument that female directors provide new insights, broader perspectives, higher creativity and innovation, and better risk management (J. Chen et al., 2018) which contributes positively to R&D investments. The positive impact on R&D could also come from the women's understanding of consumer behavior and needs, thereby they are better at representing means and opportunities of companies to satisfy those necessities (Galia & Zenou, 2012). Our findings are consistent with Hernández-Lara and Gonzales-Bustos (2020) and Gonzales-Bustos et al. (2020) who provide evidence from the Spanish context. They report that firms with female directors tend to invest more in innovation (as measured by R&D). However, our

Table 1. Descriptive statistics

Variables	Mean	SD	Min	P50	Max
R&D intensity	0.016	0.041	0.000	0.000	0.241
Gender diversity	0.192	0.119	0.000	0.200	0.590
Gender diversity (dummy)	0.850	0.355	0.000	1.000	1.000
Female tenure	3.220	2.113	0.000	2.900	17.000
CEO age	54.041	5.702	40.000	54.000	70.000
CEO tenure	5.653	5.433	1.000	4.000	29.000
CEO female	0.053	0.223	0.000	0.000	1.000
CEO change	0.158	0.365	0.000	0.000	1.000
CEO ownership	0.021	0.067	0.000	0.004	0.537
Board tenure	4.529	2.194	1.000	4.000	12.00
Board size	9.081	2.070	5.000	9.000	15.00
Board independence	0.705	0.101	0.429	0.714	0.900
Board age	57.23	3.106	48.90	57.30	65.00
Busy board	0.039	0.194	0.000	0.000	1.000
Size (log)	14.729	1.475	11.553	14.518	19.173
Leverage	0.712	1.862	-10.521	0.528	10.532
ROA	0.066	0.096	-0.629	0.060	2.043
Loss	0.107	0.310	0.000	0.000	1.000
Intangibles	0.289	0.223	0.000	0.265	0.833

Note: All variables are defined in [Appendix 1](#). All variables are winsorised at 1% and 99%.

results are inconsistent with Galia and Zenou (2012) who reported a negative association between female representation on board and innovation activities.

These results support the agency theory proposition that board gender diversity improves the monitoring process, leading to more effective boards. In particular, female directors can maintain shareholders' interests by effectively monitoring R&D investments made by CEOs. Relatedly, the findings of this study obtain support from resource dependence theory. Resource dependence theorist argues that female directors bring divergent experiences, broader perspectives, knowledge and skills which could fuel innovation activities. Moreover, prior studies show that intense monitoring could result in lower R&D intensity because CEOs might avoid risky investments (e.g., R&D investments) and instead choose other conventional less risky projects (Faleye et al., 2011; Guldiken & Darendeli, 2016). Our findings show that this is not the case (at least in the context of this study) and therefore alleviate the concern over R&D reduction when women are represented in the board.

The second key objective of this study is examining the moderating role of female tenure on the relationship between board gender diversity and R&D intensity. Table 4 shows the results of the regressions after including female tenure as a moderating variable (empirical model 2). The result shows that the interaction variable is insignificant, while gender diversity remains significant. This result rules out the concern over the impact of the so-called familiarity bias which could threaten the quality of monitoring and therefore adversely affect R&D investments. This result does not support the argument that tenure of directors affects their commitment to the status quo and restricts their abilities to establish strategic changes.

It is worth mentioning that a number of control variables appear to have a significant relationship with R&D investments. The regression shows that intangible intensity and board tenure have

Table 2. Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. R&D intensity	1																
2. CEO age	-0.0017	1															
3. CEO tenure	-0.0065	0.30***	1														
4. Female CEO	0.021	-0.047	-0.033	1													
5. CEO change	0.024	-0.11***	-0.41***	-0.024	1												
6. CEO ownership	0.0052	0.12***	0.23***	-0.059*	-0.080***	1											
7. Board tenure	0.013	0.15***	0.46***	-0.0043	-0.22***	0.046	1										
8. Board size	0.0051	0.12***	0.011	0.037	-0.039	-0.11***	0.011	1									
9. Board independence	-0.0032	0.053*	-0.26***	-0.011	0.072**	-0.11***	-0.27***	0.27***	1								
10. Gender diversity	0.0021	-0.09***	0.034	-0.15***	-0.0053	0.10***	0.16***	-0.15***	-0.25***	1							
11. Board age	0.13***	0.49***	0.075**	-0.014	-0.056*	-0.056*	0.28***	0.18***	0.26***	-0.0074	1						
12. Size	-0.071***	0.19***	-0.086***	0.023	-0.04	-0.094***	-0.040	0.57***	0.38***	-0.25***	0.35***	1					
13. Leverage	-0.043	-0.037	-0.017	0.032	-0.017	0.0074	0.010	0.066**	0.074**	-0.058*	0.0094	0.12***	1				
14. ROA	-0.11***	0.038	0.096***	0.013	-0.058*	0.087***	0.10***	-0.071**	-0.14***	-0.059*	-0.0065	-0.18***	-0.025	1			
15. Intangibles	0.21***	0.0099	-0.064**	0.11***	0.034	-0.14***	-0.076**	0.059*	0.023	-0.084***	-0.039	-0.0055	0.03	-0.18***	1		
16. Busy board	-0.062***	0.055*	-0.046	-0.048*	-0.031	0.015	0.061*	0.041	0.082***	0.051*	0.15***	0.21***	0.0012	0.044	-0.061*	1	
17. Loss	-0.023	-0.0058	-0.057*	-0.04	0.080***	0.026	-0.11***	0.075**	0.083***	0.047*	0.0037	0.086***	0.027	-0.48***	-0.031	-0.022	1

Note: *, **, *** indicate statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 3. Gender diversity and R&D intensity

	Panel 1		Panel 2	
	Coefficient	t-value	Coefficient	t-value
Gender diversity	0.750**	2.22	0.158*	1.73
CEO age	-0.009	-0.09	0.0010	0.10
CEO tenure	-0.0285***	-2.59	-0.0287***	-2.60
Female CEO	-0.104	-0.48	-0.0401	-0.19
CEO change	-0.044	-0.53	-0.0414	-0.50
CEO ownership	-0.834	-1.01	-0.860	-1.05
Board tenure	0.047**	2.33	0.0429**	2.13
Board size	-0.0044	-0.17	-0.0077	-0.30
Board independence	-0.718	-1.34	-0.542	-1.03
Board age	0.0026	0.13	0.0036	0.18
Busy board	-0.075	-0.35	-0.0892	-0.41
Size	-0.328***	-2.85	-0.260**	-2.42
Leverage	-0.0035	-0.23	-0.0017	-0.11
ROA	-0.831	-1.32	-0.758	-1.20
Intangibles	1.106**	2.36	0.957**	2.07
Loss	-0.317***	-2.75	-0.317***	-2.75
Constant	7.188***	3.78	5.219***	3.35
N	1,732		1,732	
Adj. R ²	0.185		0.187	

Note: *, **, and *** indicate statistical significance at the 0.10, 0.05, and 0.01 levels (two-tailed), respectively. All tabulated t-statistics are based on robust standard errors that are clustered at the firm level.

a positive impact on R&D intensity, while CEO tenure, loss, and size have an adverse impact. These findings support arguments presented in prior studies. Prior studies show that longer-tenured board members have greater knowledge about the firm's business environment, leading to better expertise in discharging their monitoring responsibilities (Ben-Amar et al., 2013). Also, directors with longer tenure are better at advising as this allows them to learn more about the company's operations and thereby understand its unique economic environment and opportunities (Livnat et al., 2021). Intangible intensity indicates the size of the past investments in innovative activities (Honoré et al., 2015). Chrisman and Patel (2012) argue that intangible intensity reflects a firm's preference for long-term investment. Hence, the positive impact of intangibles on R&D is expected.

Moreover, longer-tenured CEOs may be less interested in pursuing strategies of innovation through higher R&D spending, preferring instead to emphasize stability (Barker & Mueller, 2002). The result concerning firm size is consistent with the argument that large firm and the market power it produces may demotivate managers to invest in innovations that may upset the status quo (Barker & Mueller, 2002; Azzam & Alhababsah, 2022a). In support of this argument, Revilla and Fernández (2012) point out that large firms are more bureaucratic, less flexible, and information flows are slower and more complex. Finally, a poorly performing firm (e.g., a firm that has a loss) tends to reduce their R&D spending (Bravo & Reguera-Alvarado, 2017). Firms might not afford to invest in R&D activities given the high level of uncertainty and the chance of failure.

4.3. Additional test: gender diversity and R&D in R&D-intensive industries

In an additional test (Table 5), we use a sample of three sectors known as R&D-intensive industries. This sub-sample covers healthcare, pharmaceutical, technology, and manufacturing sectors. It also forms 43% of the overall sample (751 out of 1,732 observations). These sectors

Table 4. Gender diversity and R&D intensity (using interaction term with female tenure)

	Panel 1		Panel 2	
	Coefficient	t-value	Coefficient	t-value
Gender diversity	0.834	1.52**	0.149	1.830*
Gender diversity×Female tenure	0.164	1.02	0.254	0.570
Female tenure	0.1410	1.080	0.249	0.255
CEO age	-0.0026	-0.26	-0.017	-0.160
CEO tenure	-0.0181	-1.69*	-0.028	-1.74*
Female CEO	-0.0121	-0.060	-0.003	-0.020
CEO change	-0.047	-0.57	-0.044	-0.540
CEO ownership	-1.352	-1.55	-1.455	-1.69*
Board tenure	0.022	1.830*	0.0186	1.880*
Board size	-0.003	-0.14	-0.001	-0.020
Board independence	-0.068	-1.29	-0.155	-0.023
Board age	0.008	0.37	0.006	0.290
Busy board	-0.074	-0.31	-0.071	-0.310
Size	-0.421	-3.42***	-0.385	-3.35***
Leverage	-0.006	-0.056	-0.003	-0.030
ROA	-0.831	-2.29**	-0.890	-2.230**
Intangibles	1.566	3.31***	1.490	3.20***
Loss	-0.347	-2.93***	-0.355	-3.00***
Constant	7.828	3.90***	6.371	3.790***
N	1,732		1,732	
Adj. R ²	0.193		0.195	

Note: *, **, *** indicate statistical significance at the 0.10, 0.05, and 0.01 levels (two-tailed), respectively. All tabulated t-statistics are based on robust standard errors that are clustered at the firm level.

have been considered separately by several prior studies (e.g., Dalziel et al., 2011; Oh & Barker, 2018). Consistent with the main outcome using the full sample (Table 3), we also find a significant positive relationship between gender diversity and R&D investments. Moreover, when we tried an interaction term between gender diversity and female tenure (Table 6), we also find insignificant impact of female tenure on the relationship between gender diversity and R&D intensity.

4.4. Endogeneity test

The issue of endogeneity is a dominant concern in accounting and finance. A common approach to address such an issue is to use instrumental variables in a two-stage least-squares model (2SLS; Larcker & Rusticus, 2010). Adams and Ferreira (2009) argue that a valid instrument should be correlated with the proportion of female directors on the board but uncorrelated with the dependent variable, except through variables we control for (i.e., in the case of this study, the instrument variable should be correlated with board gender diversity but should not be correlated with the R&D intensity). In the context of corporate governance, it is difficult to find a valid instrument because the variables that are correlated with the endogenous variable are already (or should be) included in R&D regressions (Adams & Ferreira, 2009).

Following Marinova et al. (2016), we implement a 2SLS approach using the industry average gender diversity as the instrument variable. This is a reasonable instrument because it is correlated

Table 5. Gender diversity and R&D intensity (for R&D-intense sample)

	Panel 1		Panel 2	
	Coefficient	t-value	Coefficient	t-value
Gender diversity	1.33**	2.25	0.356**	1.88
CEO age	0.0038	0.02	0.0049	0.24
CEO tenure	-0.0595**	-2.44	-0.0618**	-2.53
Female CEO	-1.018	-1.47	-0.878	-1.28
CEO change	-0.100	-0.55	-0.113	-0.61
CEO ownership	-1.759	-0.96	-1.690	-0.92
Board tenure	0.0866*	1.90	0.0750*	1.66
Board size	0.0465	0.80	0.0347	0.59
Board independence	-1.923	-1.62	-1.618	-1.38
Board age	0.0401	0.91	0.0430	0.97
Busy board	-0.132	-0.23	-0.218	-0.38
Size	-0.778***	-2.97	-0.601***	-2.51
Leverage	-0.0151	-0.52	-0.0119	-0.41
ROA	-2.152	-1.58	-1.843	-1.36
Intangibles	2.607**	2.55	2.243**	2.24
Loss	-0.828***	-3.12	-0.794***	-2.99
Constant	13.61***	3.11	9.015**	2.55
N	751		751	
Adj. R ²	0.157		0.161	

Note: *, **, and *** indicate statistical significance at the 0.10, 0.05, and 0.01 levels (two-tailed), respectively. All tabulated t-statistics are based on robust standard errors that are clustered at the firm level.

with board gender diversity at the firm-level but is not likely to determine a firm's R&D intensity. In the first stage, we run a regression of gender diversity on market gender diversity and all the control variables. In the second stage, we use the predicted gender diversity (Gender Diversity_Predict) derived from the first-stage regression to examine its effect on R&D intensity. The findings (Table 7) are quantitatively consistent with the main regression presented earlier.

5. Conclusion

The objective of this study is to examine the impact of board gender diversity on R&D intensity using a sample comprising the UK FTSE 350 index between 2009 and 2018. This study finds that female directors positively affect R&D intensity. Consistent with agency theory, this result suggests that female directors are more effective in protecting shareholders' interests, e.g., monitoring R&D investments made by CEOs. This result is not affected by the length of female tenure, alleviating the concern over the potential impact of tenure on women's monitoring effectiveness and, therefore, on the relationship between gender diversity and R&D intensity. The findings appear robust after employing different proxies for gender diversity as well as R&D intensity.

This study offers a valuable contribution to the literature and has implications for policy-makers and practice. This study implies a step forward in the R&D and strategy literature, and also in the literature on corporate governance. In particular, this study contributes to the inconsistent literature concerning the impact of female directors, especially in the area of strategic decision-making. Moreover, the potential impact of gender diversity is one of the topics that has obtained much debate by policy-makers and practitioners, and a consensus is yet to be reached. The findings of this study contribute to the merits of this debate. In this regard, regulators could take this issue

Table 6. Gender diversity and R&D intensity for R&D-intense sample (using interaction term)

	Panel 1		Panel 2	
	Coefficient	t-value	Coefficient	t-value
Gender diversity	2.340	2.650**	1.387	1.93**
Gender diversity*Female tenure	0.507	1.360	0.303	0.610
Female tenure	0.411	1.350	0.307	0.600
CEO age	-0.008	-0.380	-0.006	-0.028
CEO tenure	-0.035	-1.680*	-0.033	-1.650
Female CEO	-0.721	-0.990	-0.734	-1.010
CEO change	-0.105	-0.570	-0.086	-0.460
CEO ownership	-2.604	-1.410	-2.823	-1.540
Board tenure	0.024	0.530	0.025	0.550
Board size	0.030	0.501	0.053	0.900
Board independence	-0.694	-0.550	-0.484	-0.380
Board age	0.041	0.901	0.032	0.710
Busy board	-0.109	-0.018	-0.005	-0.001
Size	-0.890	-3.570***	-1.101	-3.80***
Leverage	-0.008	-0.030	-0.007	-0.271
ROA	-1.98	-2.62***	-2.380	-2.75***
Intangibles	2.690	3.22**	3.687	3.580***
Loss	-0.849	-3.14***	-0.898	-3.32***
Constant	17.38	3.68***	17.55	3.66***
N	751		751	
Adj. R ²	0.158		0.160	

Note: *, **, and *** indicate statistical significance at the 0.10, 0.05, and 0.01 levels (two-tailed), respectively. All tabulated t-statistics are based on robust standard errors that are clustered at the firm level.

seriously into consideration for future governance reform, especially where female representation in the board of directors is still optional (like in the UK context). Furthermore, the results have significant implications for companies and, in particular, for nomination committees. Specifically,

Table 7. Regression of the relationship between board gender diversity and R&D intensity using 2SLS

Variables	1 st Stage		2 nd Stage	
	Coeff.	t-value	Coeff.	t-value
Gender diversity_predict	0.023	1.81*		
Gender diversity			0.013	2.05**
Gender diversity (dummy)			0.035	1.71*
Control variables	Included		Included	
Partial R ²			0.0132	

Note: *, **, and *** indicate statistical significance at the 0.10, 0.05, and 0.01 levels (two-tailed), respectively. Control variables are included in both stages but not presented for brevity. All tabulated t-statistics are based on robust standard errors that are clustered at the firm level.

companies that are eager to maintain sustained innovation should pay further attention to gender diversity during the process of the directors' appointment (or re-appointment).

This study is not without limitations. This research is conducted in the UK where the corporate governance system is robust. This limits the generalizability of our findings to other developing countries where the corporate governance system is underdeveloped and where women are often related to controlling families. Considering these countries for future research will be useful for advising on diversity policy decisions within different corporate governance environments. Moreover, the study employs R&D intensity as an input of innovation. Future research might consider patents or new products as real outputs of innovation.

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Correction

This article has been republished with minor changes. These changes do not impact the academic content of the article.

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Notes

1. The UK Corporate Governance Code (2010) recommends companies giving due regard to diversity, including gender diversity, when making appointments of directors.
2. The majority of UK-based empirical studies in corporate governance area consider the FTSE350 index (e.g., Li, Gong, Zhang, & Koh, 2018; Hawas & Tse, 2016; Goh & Gupta, 2010).
3. Given that the dataset includes different firms across many years, the panel data approach is considered more appropriate and provide more robust results (Wooldridge, 2010).
4. Following prior studies (e.g., Kor, 2006), we use the R&D spending to total assets as another common proxy for R&D intensity. The findings (untabulated for brevity) are significant and positive, therefore provide a confirmation to the main findings.

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Appendix 1: Variables definition

Variables	Definition
R&D Intensity	Research and development expenditures scaled by the total sales for firm <i>i</i> in year <i>t</i> .
Gender Diversity	The percentage of female directors to the total members of the board of firm <i>i</i> in year <i>t</i> .
CEO Age	Chronological age of CEO for firm <i>i</i> in year <i>t</i> .
CEO Tenure	The number of continuous years CEO has been in his/her role for firm <i>i</i> in time period <i>t</i> .
CEO Female	An indicator variable equal to 1 if the CEO of firm <i>i</i> in year <i>t</i> is female, and 0 otherwise.
CEO Change	An indicator variable equal to 1 if the CEO of firm <i>i</i> was appointed in year <i>t</i> , and 0 otherwise.
CEO Ownership	The percentage of shares held by CEO of firm <i>i</i> in year <i>t</i> scaled by the number of outstanding shares.
Board Tenure	The average tenure of all board members for firm <i>i</i> in year <i>t</i> .
Board Size	The total number of members on the board for firm <i>i</i> in time period <i>t</i> .
Board Independence	The percentage of independent directors on the board of firm <i>i</i> in year <i>t</i> .
Board Age	The average age of all board members of firm <i>i</i> in year <i>t</i> .
Busy Board	Dummy variable that takes the value of one if at least 50% of the shareholder representatives hold three or more directorships, and zero otherwise.
Size	The natural logarithm of total assets for firm <i>i</i> in year <i>t</i> .
Leverage	The total debt for firm <i>i</i> in year <i>t</i> scaled by the total equity.
ROA	Net operating income divided by total assets for firm <i>i</i> in time period <i>t</i> .
Intangible Intensity	Intangible assets scaled by the total assets for firm <i>i</i> in time period <i>t</i> .
Loss	An indicator variable equal to 1 if firm <i>i</i> in year <i>t</i> has reported a loss in the previous year, and 0 otherwise.



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