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Global minds, local impact: exploring the effect of foreign directors on corporate R&D expenditure

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Abstract

Background: In the contemporary business environment, corporate research and development (R&D) expenditure is pivotal for fostering technological innovation and advancing technological progress. While much research has focused on the influence of boards of directors on corporate innovation, the role of foreign directors in shaping corporate R&D expenditure, particularly in developing countries, remains underexplored.

Purpose: The aim of this paper is to investigate the pivotal role of foreign directors in corporate R&D expenditure within Chinese listed manufacturing firms. It also provides micro-level evidence of the economic consequences of foreign directors, considering heterogeneity across property rights, industry, regional dimensions, and board positions.

Study design/methodology/approach: This study utilizes the largest and most detailed dataset of Chinese listed manufacturing firms in the CSMAR database, offering comprehensive proxy variables. The sample encompasses 18,273 observations from 2008 to 2021. Multivariate regression models, employing static two-way fixed effects models with clustered robust standard errors and dynamic generalized method of moment (GMM) models, were established to investigate the relationship between foreign directors and corporate R&D expenditure. Sensitivity tests involve the substitution of dependent and core explanatory variables. Moreover, heterogeneity test and situational analysis are conducted.

Findings/conclusions: The results confirmed a significant augmentation in corporate R&D expenditure attributable to foreign directors. Heterogeneity analysis reveals that the positive impact of foreign directors on R&D expenditure is more pronounced in private-owned enterprises, high-tech industries, and economically developed regions of China. Situational analysis further confirms that foreign independent directors are the main driving force behind this effect.

Limitations/future research: This research is confined to a single-country and single-industry sample, without a comprehensive consideration of the individual traits of foreign directors. Future research avenues could involve cross-national comparisons and a more nuanced categorization of foreign directors.

Keywords

Foreign directors, corporate R&D expenditure, corporate governance, agency theory, developing countries

Introduction

Corporate research and development (R&D) expenditures play a critical role in the process of transforming new technologies into innovative outcomes, consequently attracting increasing attention in the academic literature (e.g., Domazet et al., 2023; Pu & Zulkafli, 2024; Schot & Steinmueller, 2018; Sharma et al., 2022). Strategies concerning R&D expenditure are often intertwined with the board of directors, who are entrusted with the responsibility of protecting shareholder interests and returns (Ali et al., 2021; Xia et al., 2023). The presence of foreign directors among these board members has rarely ignited discussions within the field of firms' innovation

strategies. While some financial economists have confirmed that the inclusion of foreign directors in board governance structures can be an effective governance tool with the potential to promote patent output and reshape the competitive landscape of firms (e.g., Prencipe et al., 2022; Tao et al., 2022; Xiang & Yi, 2022), the extent to which foreign directors, with their unique backgrounds, perspectives, and experiences, stimulate R&D expenditure remains a relatively understudied issue in the field of R&D strategy.

Indeed, the decisions and monitoring exercised by the board of directors play a key role in determining the success or failure of innovation strategies (Balsmeier et al., 2014; Chen et al., 2016; Shui et al., 2022). This is mainly because innovation activities in most cases require long-term commitments and have a high failure rate (Xiang & Yi, 2022; Xie et al., 2022). Such complexity can lead to managerial conservatism (Jun & Wang, 2018) and potentially hinder investment in R&D projects, as managers may prefer to allocate resources to short-term projects that promise more immediate returns (Chen et al., 2016; Sharma et al., 2022; Xiang & Yi, 2022). Therefore, the monitoring role of the board of directors should be emphasised to mitigate managerial self-interested behaviour.

In contrast to local directors, foreign directors are more independent from the firm's managers. Due to this greater independence, foreign directors have a better vantage point for monitoring managers, which is beneficial for ensuring that R&D resources are well allocated (Masulis et al., 2012; Xiang & Yi, 2022). Therefore, this paper argues that foreign directors can significantly monitor a firm's R&D decisions. Previous research has suggested that foreign directors may not significantly contribute to R&D investment (e.g., Attia et al., 2020). However, our findings are inconsistent with the prior literature. As far as we are concerned, this may arise from the following factors:

(1) Data quality. Previous research has been constrained by regional limitations, and the majority of studies were conducted before 2010. The information on R&D investment was fragmented and not uniformly reported at the national level, making it difficult for these researchers to obtain both accurate and complete data.

(2) Method heterogeneity. Prior studies failed to address potential problems arising from firm-specific characteristics over time. Additionally, the presence of heteroscedasticity and serial correlation issues in panel data often affect the validity of their results.

(3) Differences in the institutional environment. Divergences in institutional environments between developing and developed countries have significant implications for a firm's talent acquisition strategies, resource availability, and intellectual property landscape in the context of innovation (Balsmeier et al., 2014; Donbesuur et al., 2020; Masulis et al., 2012). In short, the conclusions drawn from previous studies conducted with developed countries as samples may not be applicable to developing nations. These factors collectively shape a firm's strategic tendency and ability to invest in innovation in different institutional environments.

To address the limitations above, our research sample primarily focuses on publicly listed manufacturing firms in China. As of 2022, China has maintained its position as the world's leading manufacturer for 13 consecutive years (Pu & Zulkafli, 2024). The rich dataset available in this industry can provide valuable insights into how R&D strategies drive innovation trends. Additionally, since the Chinese government-initiated policies such as the "Thousand Talents Plan" in 2008 to attract foreign talent, the manufacturing sector has emerged as a key area for attracting foreign managerial talent to drive innovation and technological advancement (Lin & Guan, 2023; Yuan & Wen, 2018).

Using R&D data from publicly listed manufacturing firms in China spanning from 2008 to 2021 and employing multiple estimation techniques (static panel data estimation and dynamic GMM estimation), our study reveals a significant positive relationship between the presence and proportion of foreign directors and corporate R&D expenditure. Heterogeneity analysis indicates that the facilitating role of foreign directors is particularly pronounced in private-owned enterprises, high-tech industries, and developed regions of China. Situational analysis further confirms that foreign independent directors are the main driving force behind this effect. These findings underscore the critical role of foreign directors in driving corporate R&D strategies.

Our paper provides several contributions. First, given the limited academic attention to the involvement of foreign directors in corporate decision-making (Florackis & Sainani, 2018), this study provides theoretical support within the

context of the corporate governance literature from an agency theory perspective. Second, by adopting static and dynamic model estimation techniques that focus on the personal characteristics of foreign directors, this study further substantiates the determinants of a firm's R&D investment effort. This empirical evidence sheds light on the question of which board composition is more conducive to innovation activities Third, the heterogeneity effects of foreign directors in boosting corporate R&D strategies underscores a valuable implication for policymakers, as it supports the shift towards an innovation-centred economy through improved corporate governance mechanisms and an innovative institutional environment.

The structure of the paper is as follows: Section 1 reviews the theory and develops the hypotheses. Section 2 explains the data sources and methods used. Section 3 presents the empirical findings. The concluding section provides a summary following a discussion of the results.

1. Literature review and hypotheses

1.1. Agency theory

Agency theory is one of the most important theories in corporate governance (Eisenhardt, 1989; Fama & Jensen, 1983; Farooq et al., 2022). The theory emphasises that agents may not always serve the best interests of the principal, especially in situations of information asymmetry and potential conflicts of interest with the principal (Balsmeier et al., 2014; Fama & Jensen, 1983; Xiang & Yi, 2022). This could lead to managers pursuing their interests at the expense of shareholders (Du et al., 2017; Eisenhardt, 1989; Farooq et al., 2022).

Indeed, corporate governance often requires the involvement of the board of directors. According to Palia and Lichtenberg (1999), information asymmetry can lead self-interested managers to shirk their responsibilities or use firm resources for their benefit, such as seeking excessive compensation and personal consumption. The monitoring role of the board serves as a mechanism to mitigate agency problems between shareholders and managers (Chen et al., 2016; Eisenhardt, 1989; Jun & Wang, 2018). The directors' independence and expertise enable it to assess the long-term potential value of innovation projects, rather than focusing solely on short-term returns (Farooq et al., 2022; Xiang & Yi, 2022; Xie et al., 2022). More important is the board monitoring the managerial execution of decisions and resource allocation; this monitoring function helps to reduce managerial conservatism and promote investment in innovation activities (Fama & Jensen, 1983; Jun & Wang, 2018; Sharma et al., 2022).

1.2. Determinants of corporate R&D expenditure

Existing research indicates that R&D expenditure serves as a driver for corporate innovation, technological collaboration, and economic growth (Ahmad & Zheng, 2022; Boeing et al., 2022). In response to the changing landscape of business competition, firms strive to develop new inventions and enhance competitiveness, thereby generating substantial profits from innovative activities (Farida & Setiawan, 2022). However, in the realm of daily operational management, various factors including firm assets, firm age, financial leverage, board size, industry concentration, return on equity, and Tobin's Q, exert influences on R&D expenditure.

Previous studies have shown that firms with larger asset bases often possess stronger financial capabilities to allocate resources towards R&D activities (Choi et al., 2021). Drawing from the resource dependency perspective, firms endowed with abundant resources are deemed better positioned to invest in innovation and technological advancement (Ahmad et al., 2024). Simultaneously, younger firms, characterized by higher levels of entrepreneurial spirit and risk propensity, tend to allocate a greater proportion of resources to R&D activities compared to their more mature counterparts (Zhou et al., 2023). Concerns regarding debt servicing and financial risk may impose constraints on firms with higher levels of financial leverage when seeking external financing for R&D projects. Consequently, such firms may exhibit lower R&D expenditure compared to those with lower leverage ratios (O'Connell et al., 2022).

Moreover, larger board sizes are associated with greater diversity of expertise and perspectives, facilitating strategic decision-making regarding R&D investments (Muhammad et al., 2024). Firms operating in industries with higher concentrations may face lesser competitive pressures for innovation, resulting in lower R&D expenditure. Conversely, firms in highly competitive industries may prioritize R&D investments as a means to differentiate themselves and gain competitive advantages (Du et al., 2022). Meanwhile, higher return on equity levels suggests greater financial capacity to allocate resources

towards R&D activities (Tömöri et al., 2022). Firms with higher Tobin's Q ratios are inclined towards investing in R&D activities to enhance intangible assets, increase market value, and maintain competitiveness (Vithessonthi & Racela, 2016).

1.3. Foreign directors and corporate R&D expenditure

Empirical research on the relationship between foreign directors and corporate R&D expenditure is relatively scarce and has focused on developed countries within the European Union. Attia et al. (2020) used a sample of 120 firms listed on the French stock exchange from 2002 to 2013 and reached a negative conclusion, which suggests a significant negative impact of foreign directors on R&D expenditure. However, the results highlight the limitations of using small sample data to examine the relationship between foreign directors and corporate R&D expenditure.

In explaining the relationship between foreign directors and corporate R&D expenditure, this study uses agency theory since one of the main roles of the board of directors is to monitor managers (Fama & Jensen, 1983; Farooq et al., 2022). Agency theory emphasises that the board of directors is an effective mechanism for constraining managerial opportunism and addressing agency problems between managers and shareholders (Eisenhardt, 1989; Masulis et al., 2012). On the one hand, independence of foreign directors can reduce managerial discretion and thus prevent managerial manipulation of R&D investments. Asymmetric information causes increased costs associated with transactions, which leads to issues of moral hazards and asymmetric information. These issues can significantly decrease the effectiveness of R&D capital allocation (Chen et al., 2016; Jun & Wang, 2018). Compared to local directors, foreign directors have much weaker social networks that enhance their independence and, in turn, their ability to improve the efficiency of board monitoring, thereby reducing managerial discretion and avoiding underinvestment in R&D expenditure (Balsmeier et al., 2014; Jun & Wang, 2018).

On the other hand, heterogeneity of foreign directors can more effectively mitigate agency problems in R&D activities. Some research has indicated that foreign directors are more likely to exhibit heterogeneity in terms of background and experience (Castro et al., 2009; Farooq et al., 2022). The monitoring role of the board is enhanced by director heterogeneity, and agency conflicts are reduced because diverse backgrounds and experiences are more likely to question management's decisions, which homogeneous boards may not possess (Balsmeier et al., 2014; Jun & Wang, 2018; Masulis et al., 2012).

In summary, the above argument has led to the following hypothesis:

H1: There is a positive relationship between foreign directors and corporate R&D expenditure.

2. Data and methodology

2.1. Data sources

Considering data quality, all the data used in this study are sourced from the China Stock Market and Accounting Research (CSMAR) database, which includes items such as R&D expenditure, directors' nationalities, and other pertinent financial information. The CSMAR database is a well-known repository in the field of economic and financial data, renowned for its extensive coverage and credibility within the context of Chinese financial markets.

Furthermore, our dataset encompasses manufacturing firms listed on the Shenzhen and Shanghai stock exchanges from 2008 to 2021. This selection is based on the dominance of manufacturing firms within this database, offering comprehensive and abundant information. To ensure the reliability of our analysis, drawing on previous research (e.g., Xiang & Yi, 2022; Zhang et al. 2020), the study conducted several preprocessing procedures. First, "special treatment" firms, defined as those that suffered continuous losses for two consecutive years and thus faced delisting risks, were excluded from the dataset to avoid the influence of extraordinary financial conditions. Second, observations with missing data were systematically removed to mitigate the potential impact of missing values. Third, to further reduce the influence of extreme values, a winsorisation process was applied to all continuous variables at the 1st and 99th percentiles. Finally, this process of rigorous data preparation resulted in a total sample of 18273 firm-year observations.

Table 1 Variable definitions and measurements

	Measurements	References
Panel A: Dependent variables		
Corporate R&D expenditure (CRDE and CRDE_alter)	CRDE is the R&D input divided by business revenue. CRDE_alter is the R&D input divided by assets.	(Sunder et al., 2017; Zhang et al., 2020)
Panel B: Independent Variables		
Foreign directors (FD1, FD2, and FD3)	FD1 is the percentage of foreign directors divided by the total number of board members. FD2 is a dummy variable that takes the value of 1 for the presence of a foreign director on the board and 0 otherwise. FD3 is the number of foreign directors on the board.	(Du et al., 2017; Yuan & Wen, 2018)
Panel C: Control variables		
Firm age (FA)	The natural logarithm of the number of years since the firm's establishment plus one.	(Liu & Lv, 2022)
Firm size (FS)	The logarithm of total assets.	(Ding et al., 2022)
Financial leverage (LEV)	The total debts of a firm divided by total assets.	(Yuan & Wen, 2018)
Board size (BS)	The natural logarithm of total number of board members.	(McGuinness et al., 2017)
Market concentration (HHI)	Measured by the Herfindahl-Hirschman Index (HHI), reflects the degree of market competitiveness within an industry.	(Wu et al., 2018)
Return on equity (ROE)	The ratio of net Income divided by average shareholders' equity.	(Shan et al., 2023)
Tobin's Q (TQ)	The ratio of the market value of a firm's assets to their replacement cost.	(Hou & Li, 2022)

Source: the authors

2.2. Variable measurement

The dependent variable of this study was corporate R&D expenditure (CRDE and CRDE_alter). Its measurement uses research and development investment information from the CSMAR database as the measurement source for R&D expenditure. Following past studies (e.g., Morbey 1989; Sunder et al. 2017; Zhang et al. 2020), the measure of corporate R&D expenditure (CRDE), is R&D input divided by business revenue. The second measure is CRDE_alter, which is R&D input divided by assets. It should be emphasized that the second indicator serves as a measure of corporate R&D expenditure for robustness checks.

The independent variable of our focus is foreign directors (FD1, FD2, and FD3). Following the approach of Du et al. (2017) and Yuan and Wen (2018), this study uses a ratio variable (FD1), a dummy variable (FD2), and a number variable (FD3) to explore the role of foreign directors. Specifically, FD1 is the percentage of foreign directors divided by the total number of board members, FD2 is a dummy variable that takes the value of 1 for the presence of a foreign director on the board and 0 otherwise, and FD3 is the number of foreign directors on the board.

Regarding control variables, following previous studies (e.g., Ding et al., 2022; Liu & Lv, 2022; McGuinness et al., 2017; Yuan & Wen, 2018), this study controls for a set of variables that may be biased towards R&D expenditure, such as firm size (FS), firm age (FA), financial leverage (LEV), board size (BS), market concentration (HHI), return on equity (ROE), and Tobin's Q (TQ). Additionally, this research also controls for the impact of firm and year factors to capture firm and year fixed effects. Table 1 presents the definitions and measurements of all variables used in this study.

2.3. Estimation techniques

To mitigate potential endogeneity concerns, this research employs both static panel data estimation and dynamic panel data estimation. Specifically, a two-way fixed effects model is adopted for the static panel data analysis. This selection is motivated by two crucial factors. First, the two-way fixed-effects model effectively captures both firm-specific and time-specific effects, thus providing a robust framework for identifying causal relationships between influencing factors and corporate innovation investment. Second, the F test and Hausman test both reject the null hypothesis of the validity of the pooled ordinary least squares (POLS) and random effects (RE) model estimates, indicating that the fixed effects (FE) model is appropriate for the primary analysis and further heterogeneity testing.

Furthermore, as there may be reverse causality and the potential presence of unobservable variables affecting the relationship between foreign directors and corporate R&D expenditure,

some endogeneity issues are expected. The dynamic generalized method of moments (GMM) model, which depends on instrumental variables, is an effective method for addressing endogeneity concerns of reverse causality and omitted variables (Arellano & Bond, 1991; Blundell & Bond, 1998). Consequently, this study also uses a two-step system GMM panel data estimation, known for its improved estimation efficiency, to estimate the relationship between foreign directors and corporate R&D expenditure. The basic empirical model used in the two-way fixed effects Model (1) and dynamic innovation investment Model (2) are as follows:

$$CRDE_{i,t} = \alpha_0 + \alpha_1 FD_{i,t} + \alpha_2 FS_{i,t} + \alpha_3 FA_{i,t} + \alpha_4 LEV_{i,t} + \alpha_5 ROA_{i,t} + \alpha_6 BS_{i,t} + \alpha_7 HHI_{i,t} + \alpha_8 ROE_{i,t} + \alpha_9 TQ_{i,t} + Year + Firm + \varepsilon$$

Model (1)

$$CRDE_{i,t} = \alpha_0 + \alpha_1 CRDE_{i,t-1} + \alpha_2 FD_{i,t} + \alpha_3 FS_{i,t} + \alpha_4 FA_{i,t} + \alpha_5 LEV_{i,t} + \alpha_6 ROA_{i,t} + \alpha_7 BS_{i,t} + \alpha_8 HHI_{i,t} + \alpha_9 ROE_{i,t} + \alpha_{10} TQ_{i,t} + Year + Firm + \varepsilon$$

Model (2)

where α_0 denotes the intercept, and $\alpha_1 - \alpha_{10}$ are the coefficients to be estimated. This study added dummy variables that control for year and firm fixed effects (Year and Firm), ε is the error term, i denotes the cross-sectional dimension for firms, and t denotes the time series dimension. The definitions of all key variables are given in Table 1.

3. Empirical results

3.1. Descriptive statistics

Table 2 presents the descriptive statistics of the number of observations; and the mean, minimum and maximum values of the main variables of our sampled firms from 2008 to 2021. According to Table 2, the mean (standard deviation) value of corporate R&D expenditure (CRDE and CRDE_alter) are 0.0433 (0.0387) and 0.0231 (0.0178) respectively. The mean value of the first indicator, foreign directors (FD1) is 0.0174 with a standard deviation of 0.0571, suggesting that the presence of foreign directors varies from firm to firm. The second measure of foreign directors (FD2) is a dummy variable, and its mean (standard deviation) value is 0.1043 (0.3056). The average and standard deviation of the third foreign directors (FD3) measurement are 0.1600 and 0.5781, respectively. In terms of the control variable, the firms in our sample have an average firm size of 22.0298, firm age of 2.8370, financial leverage of 3.7024, board size of 2.1198, market concentration of 0.1570, return on equity of 0.0796, and Tobin's Q of 2.1041.

Table 2 Descriptive statistics

	Observations	Mean	Std.Dev	Min	Max
CRDE	18273	0.0433	0.0387	0.0000	0.2950
CRDE_alter	18273	0.0231	0.0178	0.0000	0.1207
FD1	18273	0.0174	0.0571	0.0000	0.3333
FD2	18273	0.1043	0.3056	0.0000	1.0000
FD3	18273	0.1600	0.5781	0.0000	10.0000
FS	18273	22.0298	1.1520	19.5394	25.8518
FA	18273	2.8370	0.3495	0.6931	4.1589
LEV	18273	3.7024	3.1617	1.2221	35.3616
BS	18273	2.1198	0.1884	1.6094	2.7081
HHI	18273	0.1570	0.1069	0.0144	0.5950
ROE	18273	0.0796	0.1013	-0.5532	0.4500
TQ	18034	2.1040	1.2650	0.8481	9.8236

Source: the authors' calculation based on the CSMAR database.

3.2. Correlation and variance inflation factor analysis

Table 3 shows Pearson's correlation coefficients for the main variables. The preliminary correlation among variables in which the value of the correlation coefficient of foreign directors (FD1), financial leverage (LEV), and Tobin's Q (TQ) has a positive relationship with corporate R&D expenditure (CRDE), while firm size (FS), board size (BS), market concentration (HHI), and return on equity (ROE) has an adverse effect on CII. In addition, firm age (FA) was not found to have a significant association with CRDE.

To further investigate the presence of multicollinearity, this study calculates the variance inflation factor (VIF) for the main variables. The largest VIF is 1.38, which is well below the rule of thumb cut-off of 10.00 for multiple regression models (Akinwande et al. 2015). Therefore, it is improbable that there is a major issue of multicollinearity in our models.

Table 3 Pearson correlation and variance inflation factor

	CRDE	FD1	FS	FA	LEV	BS	HHI	ROE	TQ	VIF
CRDE	1.000									-
FD1	0.091***	1.000								1.01
FS	-0.158***	0.047***	1.000							1.38
FA	-0.003	-0.017**	0.209***	1.000						1.09
LEV	0.226***	0.030***	-0.359***	-0.123***	1.000					1.18
BS	-0.131***	0.000	0.225***	-0.016**	-0.098***	1.000				1.07
HHI	-0.101***	0.050***	0.107***	-0.129***	0.020***	-0.029***	1.000			1.06
ROE	-0.079***	0.027***	0.121***	-0.047***	0.064***	0.051***	0.139***	1.000		1.12
TQ	0.212***	0.057***	-0.254***	0.006	0.199***	-0.095***	-0.039***	0.214***	1.000	1.17

Notes: This table presents Pearson correlation coefficients for the key variables and as defined in Table 1. VIF denotes the variance inflation factor.

Source: the authors' calculation based on the CSMAR database

3.3. Static panel data estimations

As our empirical estimation relies on panel data, it may introduce potential biases of heteroskedasticity and autocorrelation, thereby decreasing the validity and reliability of our findings. Following the approaches of Abadie et al. (2022) and Thompson (2011), this research uses firm-level clustered robust standard error estimators to address these concerns.

Table 4 reports the regression analysis outputs of model (1), column (1) includes corporate R&D expenditure (CRDE), the first ratio measure of foreign directors (FD1), control variables, year-fixed effects, and firm-fixed effects. The coefficient of foreign directors (FD1) is 0.0246 (t=2.64), which is significantly positive at the 1% level. Additionally, column (2) of Table 4 shows the regression results of the second measure of foreign directors' variable (FD2) on CRDE; the coefficient on FD2 is 0.0043 (t=2.99) and significant at the 1% level. This indicates that foreign directors promote R&D expenditure, both statistically and economically.

Table 4 The Impact of foreign directors on corporate R&D expenditure in static panel data estimations

	CRDE	
	(1)	(2)
FD1	0.0246***	
	(2.64)	
FD2		0.0043***
		(2.99)
FS	0.0012	0.0012
	(1.04)	(1.02)
FA	-0.0074*	-0.0072*
	(-1.73)	(-1.69)
LEV	0.0005***	0.0005***
	(3.11)	(3.12)
BS	0.0043**	0.0040*
	(2.08)	(1.94)
HHI	0.0120**	0.0125**
	(1.97)	(2.06)
ROE	-0.0326***	-0.0326***
	(-11.27)	(-11.25)
TQ	0.0002	0.0002
	(0.67)	(0.64)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	18034	18034
P-value of F test	0.0000	0.0000
P-value of Hausman test	0.0000	0.0000
Adj. R^2	0.186	0.186

Notes: Parentheses report the t values of firm--clustered robust standard errors. The signs *, ** and *** indicate a significance level of 10%, 5% and 1% respectively. All variables are defined as shown in Table 1.

Source: the authors' calculation based on the CSMAR database.

In terms of control variables, the results are generally consistent with prior studies. Consistent with Attia et al. (2020), financial leverage (LEV), board size (BS), and market concentration (HHI) are positively and significantly related to CRDE, suggesting that firms with higher financial leverage, board size, and market concentration have better R&D investment levels. However, return on assets (ROE) and firm age (FA) are significantly and negatively related to CRDE. This demonstrates that firms with better financial performance and older firms lack the incentives to promote R&D investment levels.

Overall, H1 is supported by the positive and significant coefficients on two measures of foreign directors in static panel data regressions with corporate R&D expenditure.

3.4. Dynamic panel data estimations

Considering omitted variables and reverse causation may affect the relationship between foreign directors and corporate R&D expenditure. The use of a two-step system generalized method of moments (GMM) approach for estimation can mitigate the bias caused by the endogeneity issue due to omitted variables and reverse causation (Chinoda & Kwenda 2019). This approach provides a consistent parameter estimation by using instruments that can be obtained from the orthogonal condition between the variables and the disturbance lag variables.

Table 5 reports the results of dynamic corporate R&D expenditure (CRDE) models using a two-step system GMM panel data estimations. The diagnostic tests, which are acceptable for models (1) to (2), show that the null hypothesis of no first-order serial correlation (AR1) was rejected, but the null hypothesis of no second-order serial correlation (AR2) was accepted. The Hansen test for instrument overlap was not rejected at standard significance levels. The number of instrumental variables is smaller than the number of individual firms. This means that our instruments are effective and well-specified. In columns (1) to (2), there is a significant positive relationship between lagged CRDE and current CRDE, indicating that previous R&D expenditure affect current corporate R&D expenditure, which confirms that corporate R&D expenditure are a dynamic process.

Table 5 The impact of foreign directors on corporate R&D expenditure in dynamic panel data estimations

	CRDE	
	(1)	(2)
FD1	0.0506***	
	(2.64)	
FD2		0.0036**
		(2.07)
Lagged CRDE	0.6855***	0.7382***
	(18.24)	(16.27)
FS	-0.0115**	-0.0058*
	(-2.24)	(-1.77)
FA	0.0019	-0.0031*
	(0.07)	(-1.93)
LEV	0.0007**	0.0003
	(2.31)	(1.34)
BS	0.0906***	0.0061
	(2.84)	(1.59)
HHI	-0.0909	-0.0515
	(-1.29)	(-0.75)
ROE	-0.0601***	0.0068
	(-8.94)	(0.17)
TQ	0.0043***	-0.0003
	(3.69)	(-0.25)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	15644	15644
Number of firms	2052	2052
Number of instruments	52	47
P-value of AR (1)	0	0
P-value of AR (2)	0.290	0.642
P-value of Hansen test	0.212	0.415

Notes: Corresponding robust z-values are reported in parentheses. The signs *, ** and *** indicated a significance level of 10%, 5% and 1% respectively. All variables are defined as shown in Table 1.

Source: the authors' calculation based on the CSMAR database.

Columns (1) to (2) of Table 5 display the dynamic GMM panel data regression results that tested our hypothesis; column (1) based on the first ratio indicator of foreign directors (FD1), gives the results of regressing FD1 on CRDE. The positive coefficient of 0.0506 is significantly positive at the 1% level, which suggests that FD1 can enhance CRDE. In addition, the use of the second dummy foreign directors (FD2) indicator in column (2) also has a positive and significant effect on CRDE (α=0.0036, $p<0.05$). Hence, these results show that foreign directors have a positive impact on corporate R&D expenditure in dynamic panel data estimations. This finding is consistent with hypothesis (H1) of our study.

3.5. Additional sensitivity test

In this section, we conducted two sensitivity tests on the baseline specifications of Model (1) and Model (2). The purpose was to mitigate potential spurious relationships arising from measurement errors in the core explanatory and dependent variables.

(1) Substitution of explanatory variable: In the baseline regressions, we utilized the proportion of foreign directors (FD1) and a dummy variable (FD2) as proxies for the presence of foreign directors. An inherent concern is that the proportion of foreign directors on the board may not solely depend on the number of foreign directors but also all board members. Additionally, dummy variables may not precisely capture the specific quantity of foreign directors. Drawing from the approach proposed by Yuan and Wen (2018), we directly employed the actual number of foreign directors on the board as a sensitivity check proxy for foreign directors. Regression results in columns (1) and (3) of Table 6 demonstrate that foreign directors are significantly positive at the 5% or 1% level, indicating that the variation in the foreign director measure did not significantly undermine the study's conclusions.

(2) Substitution of dependent variable: The primary regression models of this study utilize the ratio of R&D expenditure to business revenue as a measure of firms' R&D expenditure. This measurement approach helps balance the impact of differing business revenue levels across firms to some extent. Considering that innovation activities are long-term, continuous, and high-risk processes, introducing uncertainty into firms' strategic innovation choices, this method addresses the challenge of evaluating innovation. Inspired by studies by Gu (2016) and Sunder et al. (2017) regarding R&D expenditure indicators, we further employed an alternative variable (CEDE_alter), which represents R&D input divided by assets. Subsequently, we re-estimated Model (1) and Model (2). Regression results in columns (2) and (4) of Table 6 show that the foreign director indicator (FD3) remains significantly positively associated at the 10% and 5% levels, respectively, providing additional support for the conclusions of this study.

Table 6 Additional sensitivity test

	FE			GMM	
	CRDE	CRDE_alter		CRDE	CRDE_alter
	(1)	(2)		(3)	(4)
FD3	0.0025**	0.0010*		0.0021***	0.0014**
	(2.47)	(1.91)		(1.96)	(2.01)
Lagged CRDE				0.7523***	
				(15.76)	
Lagged CRDE_alter					0.8929***
					(16.99)
Controls	Yes	Yes		Yes	Yes
Year FE	Yes	Yes		Yes	Yes
Firm FE	Yes	Yes		Yes	Yes
Adj. R^2	0.187	0.215			
Observations	18034	18034		15644	15644
Number of Firms				2052	2052
Number of Instruments				43	32
P-value of AR (1)				0	0
P-value of AR (2)				0.636	0.717
P-value of Hansen test				0.987	0.403

Notes: Parentheses report the t values of firm--clustered robust standard errors (columns 1 and 2) / robust z-values (columns 3 and 4). The signs *, ** and *** indicated a significance level of 10%, 5% and 1% respectively. All variables are defined as shown in Table 1.

Source: the authors' calculation based on the CSMAR database.

3.6. Heterogeneity test

Foreign directors play a crucial governance role in corporate R&D activities. This study confirms the positive influence of foreign directors on corporate R&D expenditure. However, further exploration is needed to examine some internal and external characteristics of firms to determine whether other factors may affect the outcomes of foreign directors in influencing R&D expenditure. Specifically, this paper conducts heterogeneity tests from three perspectives.

Table 7 SOEs Vs POEs

	CRDE				
	SOEs			POEs	
	(1)	(2)		(3)	(4)
FD1	-0.0137			0.0323***	
	(-1.05)			(3.06)	
FD2		-0.0007			0.0058***
		(-0.33)			(3.25)
Controls	Yes	Yes		Yes	Yes
Year FE	Yes	Yes		Yes	Yes
Firm FE	Yes	Yes		Yes	Yes
Observations	5267	5267		12476	12476
Adj. R^2	0.310	0.310		0.141	0.141

Notes: Parentheses report the t values of firm--clustered robust standard errors. The signs *, ** and *** indicated a significance level of 10%, 5% and 1% respectively. All variables are defined as shown in Table 1.

Source: the authors' calculation based on the CSMAR database.

(1) Heterogeneity of property rights. State-owned enterprises (SOEs) and private-owned enterprises (POEs) may exhibit significant differences in governance structure and strategic decision-making (Lu et al., 2024; Luo et al., 2016). SOEs are typically subject to direct government supervision and intervention, with their decisions potentially influenced by political considerations and short-term economic growth targets (Yang et al., 2024). Conversely, facing greater market competition due to relatively limited resources, POEs are likely to have a stronger motivation for investing in innovation activities (Zhang et al., 2024). Additionally, the role of foreign directors in governance may vary between SOEs and private enterprises. In SOEs of China, directors and senior managers are often bureaucratic appointments by the government, serving political goals and strategic intentions, potentially diminishing the efforts of foreign directors in driving innovation investment (Liao et al., 2024; Zhang et al., 2023). However, in POEs, pursuing long-term performance maximization due to ownership characteristics (Battilana et al., 2022), we anticipate that the impact of foreign directors may be more pronounced.

The results in Table 7 indicate that foreign directors (FD1 and FD2) do not facilitate increased R&D expenditure in SOEs, but both FD1 and FD2 show a significant positive correlation at the 1% level in POEs. Consequently, the influence of foreign directors on R&D activities is heterogeneous due to equity differences, with foreign directors positively affecting corporate R&D expenditure, and this effect is observed exclusively in POEs.

Table 8 High-tech vs non-high tech

	CRDE				
	High-Tech			Non-High Tech	
	(1)	(2)		(3)	(4)
FD1	0.0259**			0.0066	
	(2.37)			(0.76)	
FD2		0.0048***			0.0009
		(2.74)			(0.67)
Controls	Yes	Yes		Yes	Yes
Year FE	Yes	Yes		Yes	Yes
Firm FE	Yes	Yes		Yes	Yes
Observations	13957	13957		4077	4077
Adj. R^2	0.193	0.194		0.176	0.176

Notes: Parentheses report the t values of firm--clustered robust standard errors. The signs *, ** and *** indicated a significance level of 10%, 5% and 1% respectively. All variables are defined as shown in Table 1.

Source: the authors' calculation based on the CSMAR database.

(2) Industry heterogeneity. In the context of different industries, the role of foreign directors in influencing corporate R&D expenditure may vary. We classified the samples into high-tech and non-high-tech industries based on the "Classification Catalogue of High-tech Industries" released by the National Bureau of Statistics of China. Typically, high-tech industries are more knowledge-intensive, relying on highly specialized technical and scientific knowledge (Zhang et al., 2021). Moreover, these industries often face intense global competition, resulting in a more urgent demand for innovation (Liu et al., 2014; Rađenović et al., 2023). In such an environment, foreign directors may find it easier to comprehend and advocate for R&D investment in innovative activities due to their deeper understanding of global technological trends and best practices. Conversely, in non-high-tech industries, these factors might be relatively weaker, and firms may prioritize stable production and market share over long-term innovation investments (Zhang et al., 2021). Consequently, we anticipate that the role of foreign directors in R&D expenditure may not be as prominent in non-high-tech industries as in high-tech industries.

The results presented in Table 8 indicate that foreign directors (FD1 and FD2) do not promote R&D expenditure in non-high-tech industries, as shown in columns (3) and (4). The regression results for foreign directors in high-tech industries, as depicted in columns (1) and (2), reveal significantly positive coefficients at the 5% or 1% significance level, indicating that foreign directors only stimulate R&D expenditure in high-tech industries. This confirmation is grounded in the impact of industry heterogeneity.

(3) Regional heterogeneity. China exhibits spatial heterogeneity in its economic development across provinces. In developed regions, firms may have easier access to advanced technological resources and innovation support due to the generally more developed technological infrastructure, research and development institutions, and higher education facilities (Li & North, 2017). In such circumstances, foreign directors may need to pay more attention to innovation strategies and global market trends to better propel firms into R&D expenditure in developed regions. On the contrary, in less developed regions, firms may face challenges such as insufficient infrastructure, immature markets, and inadequate technological support (Rodríguez-Pose et al., 2021). In this environment, the monitoring role of foreign directors may struggle to overcome the adverse effects of institutional environments.

Previous research has indicated that China's eastern regions are the most economically developed (Wu et al., 2019). We conducted a subsample analysis based on whether the spatial geographic location of the sampled provinces is in the eastern region, defining it as developed, and others as less developed. The results in Table 8 demonstrate that the promoting effect of foreign directors (FD1 and FD2) on corporate R&D expenditure is only significant in developed regions, as indicated in columns (1) and (2). This further substantiates the validity of our inference as mentioned earlier.

Table 9 Developed regions vs less developed regions

	CRDE			
	Developed Regions		Less Developed Regions	
	(1)	(2)	(3)	(4)
FD1	0.0262***		0.0178	
	(2.79)		(0.74)	
FD2		0.0047***		0.0034
		(3.05)		(0.94)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	12807	12807	5227	5227
Adj. R^2	0.175	0.175	0.214	0.214

Notes: Parentheses report the t values of firm--clustered robust standard errors. The signs *, ** and *** indicated a significance level of 10%, 5% and 1% respectively. All variables are defined as shown in Table 1.

Source: The authors' calculation based on the CSMAR database

3.7. Situational analysis

To explore whether the involvement of foreign directors in different roles affects firms' R&D expenditure, we further examine situations where foreign individuals serve as independent directors (FID) and non-independent directors (non-FID). Typically, independent directors are presumed to

prioritize the overall interests of the firm and shareholders, thus favouring investments in future growth, including R&D (Muhammad et al., 2024; Shi et al., 2023). Conversely, non-independent directors may lean more towards their interests or those of the management team, potentially favouring short-term profit investments over the high-risk, long-term nature of R&D expenditure (Li et al., 2023). For instance, although foreign chairpersons are board members, their role may be influenced by the short-term profit expectations of shareholders, investors, and the market, leading them to allocate funds to short-term projects to meet market demands and expectations, potentially avoiding the long-term investment and risks associated with R&D projects (Tan et al., 2022). Additionally, foreign managing directors, serving both as board members and CEOs of the management team, may have incentive structures that prioritize short-term performance metrics, such as stock price performance and financial results, over long-term R&D strategic goals (Belderbos et al., 2020; Eklund, 2022; Li et al., 2023), which could influence their decisions regarding R&D investment.

The results in columns (1) and (2) of Table 10 indicate that when foreign board members serve as independent directors (FID), their impact on CRDE is statistically significant and positive (α=0.0055; p-value<0.05). Conversely, foreign non-independent directors (non-FID) do not yield statistically significant. Furthermore, when non-FID are further divided into foreign chairpersons (FC) and foreign managing directors (FMD), the coefficients remain statistically insignificant, confirming our hypothesis.

Table 10 Situational analysis

	CRDE			
	(1)	(2)	(3)	(4)
FID	0.0055**			
	(2.20)			
Non-FID		0.0023		
		(1.17)		
FC			-0.0004	
			(-0.01)	
FMD				0.0026
				(0.65)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	18034	18034	18034	18034
Adj. R^2	0.186	0.185	0.185	0.185

Notes: Parentheses report the t values of firm--clustered robust standard errors. The signs *, ** and *** indicated a significance level of 10%, 5% and 1% respectively.

Source: the authors' calculation based on the CSMAR database

Discussion and conclusion

From the perspective of board governance, this research fills the gap in an understudied area that bridges two distinct streams of literature: foreign directors and R&D investment. Our research findings align with the predictions of agency theory, indicating a positive correlation between foreign directors and corporate R&D expenditure. The enhanced independence and diverse experiences of foreign directors may provide them with a better ability to monitor managers' continuous resource allocation to R&D activities, thereby increasing corporate R&D expenditure.

Previous research has argued that the capacity for cultural diversity possessed by foreign directors is not crucial for innovation R&D activities and may even have a significant negative impact (Attia et al., 2020). However, this result largely overlooks issues related to data quality, method heterogeneity, and differences in institutional environments. To mitigate these concerns, this paper uses a comprehensive dataset from the CSMAR database with the most extensive records and the largest number of sample firms in Chinese listed firms, covering the period from 2008 to 2021. Moreover, the paper re-examines the impact of foreign directors on R&D expenditure in the world's largest developing economies using static two-way fixed effects models with clustered robust standard errors, dynamic GMM models, and additional sensitivity tests. The conclusion of this study suggests that within the context of developing countries with less robust corporate governance mechanisms and institutional environments, the presence of foreign directors appears to enhance the level of firms in R&D investment. One possible explanation is the strong

connection between domestic directors and firm executives, which may influence the board's supervisory functions (Balsmeier et al., 2014; Liu & Lv, 2022; Masulis et al., 2012). Foreign directors with weaker external connections and diverse backgrounds seem to offer effective monitoring for board governance, which is a pivotal factor in corporate R&D activities (Du et al., 2017; Fabrizio & Richard, 2015; Tao et al., 2022; Xia et al., 2023). It is noteworthy that the relationship between foreign directors and R&D expenditure exhibits heterogeneity at the levels of property rights, industry, and geographical location. Specifically, the enhancing effect of foreign directors on R&D expenditure is more pronounced in private-owned enterprises, high-tech industries, and samples from developed regions. Moreover, our results further confirm that foreign independent directors are the main driving force behind this effect.

The contribution of this study can be summarized in two dimensions. Theoretically, the economic consequences of foreign directors have garnered widespread attention in academia. This paper empirically examines the impact of foreign directors on corporate R&D expenditure, enriching the literature on the financial effects of board governance. Meanwhile, grounded in the perspective of agency theory, it also provides a new viewpoint to enhance our understanding of board roles in mitigating agency conflicts in R&D activities.

This research also holds policy implications. Firstly, as the world's largest emerging economy, China strategically promotes the introduction of foreign talent as a key innovation driver. In 2008, China even launched the "Thousand Talents Program," emphasizing the importance of attracting foreign expertise. The irreversible trend of economic globalization, especially in developing countries, underscores the pivotal role of foreign talent. In this context, state-owned enterprises should recognize the effectiveness of foreign directors in driving R&D investments, prompting adjustments to their innovation investment policies. For non-high-tech industry firms and those located in underdeveloped regions, a focus on the governance role of foreign directors in R&D activities is crucial for gaining a competitive edge in this era of innovation-driven economic development. Lastly, the heterogeneity effects of foreign directors offer insights for the governments of developing countries. Policymakers should formulate differentiated policies for the introduction of foreign talent and create an institutional environment more conducive to innovation. This effort aims to exert a more positive impact on the innovative investments of state-owned enterprises, non-high-tech industry firms, and firms located in less developed regions.

Nevertheless, this study has its limitations, but it also points the way for future research. On the one hand, the paper acknowledges that our research has a certain level of external validity as it does not delve into other industry-specific characteristics. As the sample sizes for other industries listed in China are relatively small, the sample of the paper is based on Chinese listed manufacturing firms. Future research should also examine the universality across other industries and countries. On the other hand, foreign directors, when considered together with their educational backgrounds and experiences, may exert unique and complex influences on corporate R&D investment. It has been observed that diverse educational backgrounds and experiences often influence directors' investment preferences and levels of risk-taking (Masulis et al., 2012; Prencipe et al., 2022; Xiang & Yi, 2022). Future research could further explore this dimension.

To conclude, this paper addresses a largely overlooked question of whether foreign directors affect corporate R&D expenditure. The findings suggest that concerning the presence and proportion of foreign directors, this unique nationality attribute often leads to greater R&D expenditure. Through our research findings, we hope to stimulate and enrich the academic conversation on how foreign directors impact various dimensions of innovation activities.

Declarations

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

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