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The influence of boardroom gender diversity on business innovation strategies intensity, scalability and firms' performance: New evidence from the United States

Wei Wu [a], Fadi Alkaraan [b,c,d,e], Chau Le [f], Yulu Shi [g], V.G. Venkatesh [h], Yangyan Shi [i,j,*]

[a] School of Finance and Accounting, Fuzhou University of International Studies and Trade, Fuzhou, China
[b] University of Gloucestershire, UK
[c] University of Jordan, Amman, Jordan
[d] Aleppo University, Syria
[e] Jinan University, Lebanon
[f] University of East Anglia, UK
[g] China Europe International Business School, China
[h] EM Normandie Business School, Metis Lab, Le Havre, France
[i] College of Business Administration, Capital University of Economics and Business, Beijing, China
[j] Macquarie Business School, Macquarie University, Sydney, Australia

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ABSTRACT

Scaling innovation strategies has become a central challenge for firms operating in rapidly evolving technological and competitive environments. While corporate governance structures play a critical role in shaping strategic decision-making, limited attention has been paid to how board composition influences firms' capacity to intensify and scale innovation strategies and translate them into sustainable performance outcomes. This study examines how boardroom gender diversity influences the intensity and scalability of business innovation strategies through the enabling role of financial flexibility. Drawing on the Resource-Based View (RBV) and dynamic capabilities perspectives, we argue that gender-diverse boards enhance governance quality and improve strategic resource allocation, thereby strengthening firms' financial flexibility. Greater financial flexibility enables firms to intensify innovation investments, scale innovation activities across organizational processes, and more effectively convert these initiatives into improved firm performance. In this way, boardroom gender diversity functions not only as a governance attribute but also as a strategic mechanism that supports scalable innovation and long-term value creation.

The empirical analysis uses panel data on U.S.-listed firms from the BoardEx–WRDS database over a 13-year period, comprising 70,630 firm-year observations. The results indicate that higher female representation on corporate boards is positively associated with financial flexibility, greater innovation strategy intensity and scalability, and enhanced firm performance. These relationships remain robust across alternative model specifications and performance measures. Overall, the study advances the governance and innovation literature by demonstrating how boardroom gender diversity enables firms to scale innovation strategies and build long-term value within contemporary corporate governance systems.

1. Introduction

Innovation strategies are widely recognized as essential drivers of firms' growth, productivity, and long-term success. However, the strategic value of innovation depends not only on how much firms invest in innovation but also on their ability to expand innovation outcomes across markets and over time. Innovation strategy intensity indicates the level and consistency of a firm's commitment to innovation activities

* Corresponding author at: College of Business Administration, Capital University of Economics and Business, Beijing, China; Macquarie Business School, Macquarie University, Sydney, Australia.
E-mail addresses: wuwei@fzfu.edu.cn (W. Wu), Falkaraan@glos.ac.uk (F. Alkaraan), chau.le@uea.ac.uk (C. Le), svenus@ceibs.edu (Y. Shi), Vgvenkatesh@em-normandie.fr (V.G. Venkatesh), ys102@hotmail.com (Y. Shi).

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through sustained investments in research and development (R&D), knowledge creation, and technological progress. Conversely, innovation scalability refers to an organization's ability to replicate, expand, and commercialize innovation outputs across products, markets, and units, turning innovation efforts into broader competitive and economic benefits (Nakatani, 2023; Karamchand, 2024; Chotia et al., 2025).

This distinction highlights a key strategic challenge. Innovation investments create value only when companies have the capabilities and resources needed to turn innovation efforts into scalable results. Business innovation strategies, such as product innovation, process innovation, and technological progress, require the effective mobilization of financial and knowledge resources amid uncertainty. Prior research shows that innovation intensity is affected by governance structures, financing strategies, company size, and managerial expertise (Seclen-Luna et al., 2024), with important effects on customer satisfaction, business model sustainability, and company performance (Dankwah et al., 2024; Bergmann and Utikal, 2021). However, maintaining high levels of innovation investment does not automatically ensure better performance unless companies have the organizational and financial capacity to expand innovation outputs. This study therefore does not collapse intensity and scalability into an undifferentiated construct. Instead, it retains a dual conceptualisation in which intensity represents the input and commitment side of innovation strategy, while scalability represents the deployment and conversion side. The two dimensions are examined jointly because innovation investments generate performance value only when firms possess the governance and financial capacity to extend those investments across products, processes, markets, and time.

Knowledge-generating capabilities, such as internal R&D and external venturing, serve a dual role in this process by enhancing innovation intensity and enabling scalability through the diffusion and commercialization of innovative outputs. At the macro level, the significance of scalable innovation strategies is evident in the rapid growth of global R&D investment. Over the past two decades, global R&D spending has tripled to over $2 trillion in 2019, with U.S. firms accounting for about 90% of experimental development and 58% of applied research (OECD, 2021). These trends highlight the central role of innovation strategies in economic performance while revealing an ongoing tension: firms must sustain innovation investments while maintaining the financial flexibility and governance structures needed to deploy innovation at scale amid uncertainty (Sarpong et al., 2023).

Corporate governance plays a crucial role in shaping how firms manage innovation investments and allocate strategic resources. Following major corporate governance failures such as Enron, WorldCom, and Carillion, and in the aftermath of the global financial crisis, policymakers and regulators have increasingly emphasised the importance of board composition and diversity. Regulatory reforms, including the Sarbanes–Oxley Act (2002) and successive UK Corporate Governance Codes (2016, 2018, 2024), reflect this growing emphasis on board accountability and diversity. A growing body of research suggests that boardroom gender diversity enhances innovation-related decision-making, improves the efficiency of R&D investments, and strengthens strategic resource allocation processes (Makpotche et al., 2024; Saggese et al., 2021). These improvements in innovation governance have been associated with stronger firm performance outcomes (Kong et al., 2023).

Despite these advances, the existing literature remains fragmented. For instance, Khan et al. (2021) examines the relationship between board diversity, financial flexibility, and corporate innovation using Chinese firms and show that female and younger directors positively influence innovation outcomes measured through patenting activity, particularly in financially flexible firms. While this study offers valuable insights into the governance–innovation connection, it mainly focuses on innovation outputs like patents, rather than exploring how governance structures impact the strategic intensity of innovation investments and a firm's ability to turn innovation outcomes into sustained performance. Similarly, Wu et al. (2023) analyze U.S. listed firms and demonstrate that corporate governance mechanisms and investment efficiency enhance the link between financial flexibility and firm performance. Their findings emphasize the significance of financial adaptability and governance oversight in shaping corporate results. However, the study does not explicitly investigate innovation strategies or how financial flexibility and governance structures together influence the intensity and scalability of innovation activities.

The above studies provide valuable insights but also reveal a significant gap in the literature. While previous research has explored governance and financial flexibility separately in relation to innovation outcomes or firm performance, limited attention has been given to how governance structures and financial adaptability jointly affect both the level and expandability of innovation strategies and their translation into performance results. This study addresses this gap by analyzing the interaction between boardroom gender diversity, financial flexibility, and the intensity and scalability of business innovation strategies. Financial flexibility is a vital enabling factor for innovation strategies, helping firms reduce investment inefficiencies (Wu et al., 2024), withstand adverse shocks like the COVID-19 pandemic (Chao and Huang, 2022), and pursue growth opportunities amid uncertainty (Zhang et al., 2020). Simultaneously, gender-diverse boards can improve governance effectiveness by broadening strategic viewpoints, enhancing monitoring mechanisms, and fostering more inclusive and forward-thinking innovation decisions.

Despite growing calls for integrative research connecting governance mechanisms, innovation strategies, and firm performance (Alkaraan et al., 2025), the combined role of gender-diverse governance and financial adaptability in influencing innovation strategy intensity and scalability remains underexplored, especially in large, innovation-driven capital markets. By incorporating these elements into a unified empirical framework, this study offers a deeper understanding of how firms translate innovation investments into scalable performance outcomes.

The unified framework is retained because the theoretical concern is not whether innovation intensity and scalability are identical, but how firms move from innovation commitment to scalable value creation. Separating them into disconnected models would weaken this strategic mechanism by treating resource commitment and organizational deployment as unrelated processes. The present model instead specifies them as complementary dimensions within one innovation-strategy pathway.

To address this issue, we analyze a panel of 12,221 U.S.-listed firms from 2010 to 2022 (70,630 firm-year observations). This empirical setting offers a valuable context for examining how boardroom gender diversity impacts firms' innovation strategy intensity and scalability, and how these mechanisms translate into long-term performance. Accordingly, the study focuses on the following research question:

RQ: *How does boardroom gender diversity influence the intensity and scalability of business innovation strategies and, in turn, firms' long-term performance?*

Grounded in the Resource-Based View (RBV) and dynamic capabilities theory, we view boardroom gender diversity as a strategic governance resource that boosts firms' ability to reconfigure financial and knowledge assets in support of innovation strategy execution. From this standpoint, gender-diverse boards enhance firms' dynamic capabilities by strengthening strategic oversight, risk assessment, and resource management, thus allowing innovation strategies to be pursued with greater focus, scalability, and impact on performance.

This study makes four primary contributions. First, building on RBV-based innovation research, we demonstrate that boardroom gender diversity improves firms' financial flexibility, a crucial yet underexplored organizational resource that supports innovation strategy focus and scalability. Second, using dynamic capabilities theory, we show that gender-diverse boards boost firms' ability to expand innovation strategies, helping organisations sustain innovation efforts and improve long-

term performance. Third, we find that women directors amplify the positive effects of financial flexibility and innovation strategy focus, clarifying how governance structures influence the conversion of innovation investments into value. Finally, methodologically, we utilize a large longitudinal dataset and multidimensional innovation measures to capture both innovation focus and scalability, offering strong empirical evidence on the relationship between governance, innovation, and performance in large capital markets.

The rest of the paper is organized as follows. Section 2 reviews the literature on business innovation strategy intensity, financial flexibility, and corporate governance, and develops the study's hypotheses. Section 3 explains the research methodology, including sample selection, variable measurement, and model design. Section 4 presents the empirical findings. Section 5 discusses the results and their implications for innovation intensity, scalability, and firm performance. Section 6 concludes by summarizing the key findings and highlighting theoretical, managerial, and future research implications.

2. Literature: hypotheses development

2.1. Theoretical framework

This study uses the RBV and the dynamic capabilities perspective to examine how gender diversity on boards affects the intensity, scalability, and performance of business innovation strategies. The RBV, based on the work of Wernerfelt (1984) and expanded by Barney (1991), argues that firms gain sustained competitive advantage by controlling resources that are valuable, rare, inimitable, and non-substitutable. In this framework, governance structures are strategic resources because they influence a firm's access to knowledge, strategic judgment, and resource allocation for innovation. Gender-diverse boards serve as a unique governance resource, offering different types of human and social capital through broader expertise, diverse viewpoints, and better stakeholder engagement. These qualities improve strategic decision-making and help firms balance innovation investments with financial limitations. Among firm-specific resources, R&D intensity is widely recognized as a key driver of innovation strategy and long-term competitiveness (Boone et al., 2019; Wu et al., 2026b). R&D investments create new knowledge and technological capabilities that support product and process innovation, while also enhancing firms' market positions through superior customer value creation (DP Tran et al., 2024). However, while the RBV explains why governance-based and knowledge-based resources are important for competitive advantage, it provides limited insight into how firms continuously adapt, scale, and redeploy these resources in dynamic environments marked by rapid technological change and market uncertainty.

The dynamic capabilities perspective complements the Resource-Based View (RBV) by focusing on firms' abilities to integrate, build, and reconfigure resources in response to changing environments (Teece et al., 1997; Teece, 2012; Helfat and Martin, 2015). From this perspective, boardroom gender diversity may enhance firms' dynamic capabilities by fostering inclusive knowledge-sharing, supporting risk-balanced investment decisions, and encouraging adaptive strategic behaviour. These mechanisms are particularly pertinent for maintaining financial flexibility while intensifying and scaling innovation strategies. Effective innovation strategies rely on absorptive capacity, defined as the ability to acquire, assimilate, and utilize knowledge (Zahra & George, 2002; Blesa & Ripollés, 2021), as well as adaptive capacity, or the ability to reorganise activities in response to shifting technological and market demands (Dixon et al., 2014). Collectively, these dynamic capabilities enable firms to transform innovation inputs into scalable outputs that underpin superior performance.

To improve conceptual precision, this study distinguishes innovation strategy intensity from scalability. Innovation strategy intensity captures the depth, persistence, and resource commitment of firms' innovation activities, including internal R&D and external knowledge acquisition. Innovation scalability captures firms' capacity to deploy, replicate, and commercialize innovation outcomes through operational expansion and knowledge-based asset accumulation. From the RBV perspective, intensity reflects the accumulation of valuable innovation resources, while the dynamic capabilities perspective explains how these resources are reconfigured and deployed across organizational activities and market opportunities. Thus, the two dimensions are conceptually distinct but theoretically linked as sequential and mutually reinforcing elements of innovation strategy execution. Since effective innovation strategies require R&D capabilities, external knowledge access, and adaptability to technological change (Y. Liu et al., 2023; M. Liu et al., 2023), both intensity and scalability depend on governance mechanisms that support resource use at the board level.

Within this theoretical framework, the U.S. context offers a relevant empirical setting for examining the relationships among boardroom gender diversity, innovation strategy intensity, and firm performance. The U.S. economy features some of the highest concentrations of knowledge- and technology-intensive industries, where innovation strategies increasingly rely on open innovation rather than solely on internal R&D. Facilitating open innovation through online marketplaces reduces the costs for firms seeking solutions to connect with external problem-solvers. Evidence shows that about 50% of manufacturing firms reported that new products introduced between 2007 and 2009 came from external sources, highlighting the importance of external knowledge in boosting innovation intensity (Arora et al., 2016). Importantly, external sources complement rather than replace internal innovation efforts, significantly contributing to a firm's overall innovation outcomes.

Collaboration thus serves as a key mechanism for scaling, allowing firms to leverage the intensity of their innovation strategies (Ciulli et al., 2022; Fan et al., 2025b) and enabling sustained, rapid growth trajectories (Reuber et al., 2021). Trade liberalization policies further support this scaling by lowering cross-border barriers and facilitating the international commercialization of innovative products and services. For instance, the expanded Information Technology Agreement in 2015 eliminated customs duties on over 200 IT products, strengthening firms' ability to gain competitive advantages globally through innovation. These contextual features highlight the crucial roles of dynamic capabilities and governance structures in shaping how firms mobilize resources toward scalable innovation strategies. The RBV emphasizes how gender-diverse boardrooms strengthen firms' resource bases, while the dynamic capabilities perspective explains how these enhanced resources are mobilized and reconfigured to improve financial adaptability and innovation strength. This integration positions boardroom gender diversity not just as a governance reform but as a strategic driver of sustainable value creation in changing environments (Kogan et al., 2017). By combining the RBV and dynamic capabilities perspectives, this study views boardroom gender diversity as both a valuable governance resource and a catalyst for developing the dynamic capabilities needed to maintain financial flexibility and expand innovation strategies. By measuring innovation strategy execution through separate intensity and scalability proxies, the study offers a theoretically grounded and measurable construct. This integrated framework provides a clear foundation for the hypotheses designed in the next section and contributes to governance, finance, and innovation literatures. This operational logic directly follows the theoretical argument that innovation value emerges through both the creation of innovation resources and their scalable deployment.

2.2. Hypotheses development

2.2.1. Trends and contextual background of R&D and innovation intensity

Innovation strategies are widely recognized as essential determinants of a company's growth paths, productivity improvements, and long-term success. Specifically, the intensity of innovation strategy indicates how deeply, consistently, and persistently a company engages in innovation activities, often demonstrated through ongoing investments in research

and development (R&D), knowledge creation, and technological progress. These continuous investments enable companies to develop technological capabilities, improve their ability to absorb new knowledge, and strengthen their competitive edge in increasingly knowledge-driven markets.

From a dynamic capabilities perspective, R&D represents a vital organizational capability that allows firms to identify technological opportunities, capitalize on emerging market potential, and continually reconfigure their resource base in response to environmental changes. Companies with high R&D intensity are therefore better equipped to adapt to technological discontinuities and maintain long-term performance advantages.

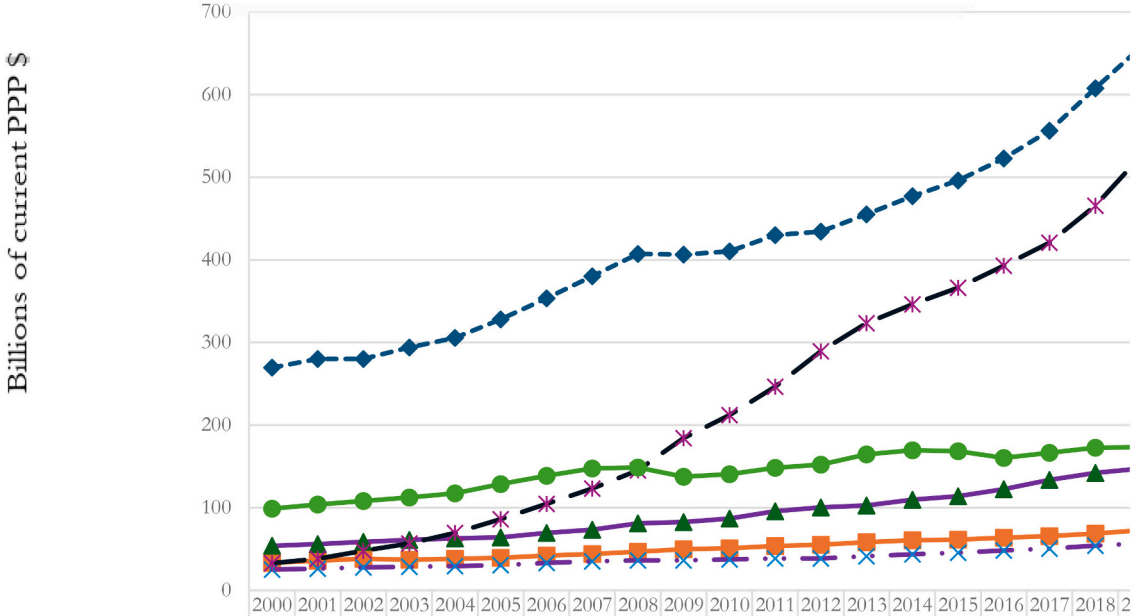
At the macro level, recent evidence highlights a steady increase in R&D investment across advanced economies. According to the OECD (2021), average R&D spending among OECD countries rose from 2.4% of GDP in 2018 to 2.5% in 2019, with the non-government sector primarily driving this growth. Global R&D activity remains highly concentrated geographically, with the United States and China accounting for roughly half of worldwide R&D expenditure. In 2019, the United States invested about $656 billion (27% of global R&D), while China invested $526 billion (22%). Overall, global R&D expenditure has tripled over the past twenty years, rising from $726 billion in 2002 to over $2 trillion in 2019. Notably, the composition of R&D funding shows the increasing dominance of business-sector investment, especially in the United States, where companies perform most experimental development. This structural change strengthens the strategic importance of corporate innovation strategies in driving technological progress and firm performance. Figs. 1 and 2 depict these global trends in R&D spending and highlight the growing strategic role of innovation investments for corporate competitiveness. Based on this context, the following subsections present the theoretical arguments connecting innovation strategy intensity, financial flexibility, governance mechanisms, and firm performance.

2.2.2. Business innovation strategies intensity, scalability, and firm performance

Business innovation strategies are embedded in firms' strategic investment decisions and reflect how organisations allocate resources to develop new technologies, products, and processes. These strategies typically include investments in R&D, mergers and acquisitions (M&A), product and process innovation, advanced manufacturing systems, and digital technologies (Alkaraan and Northcott, 2006). Although such investments involve uncertainty and long payback periods, they are essential for sustaining long-term competitiveness.

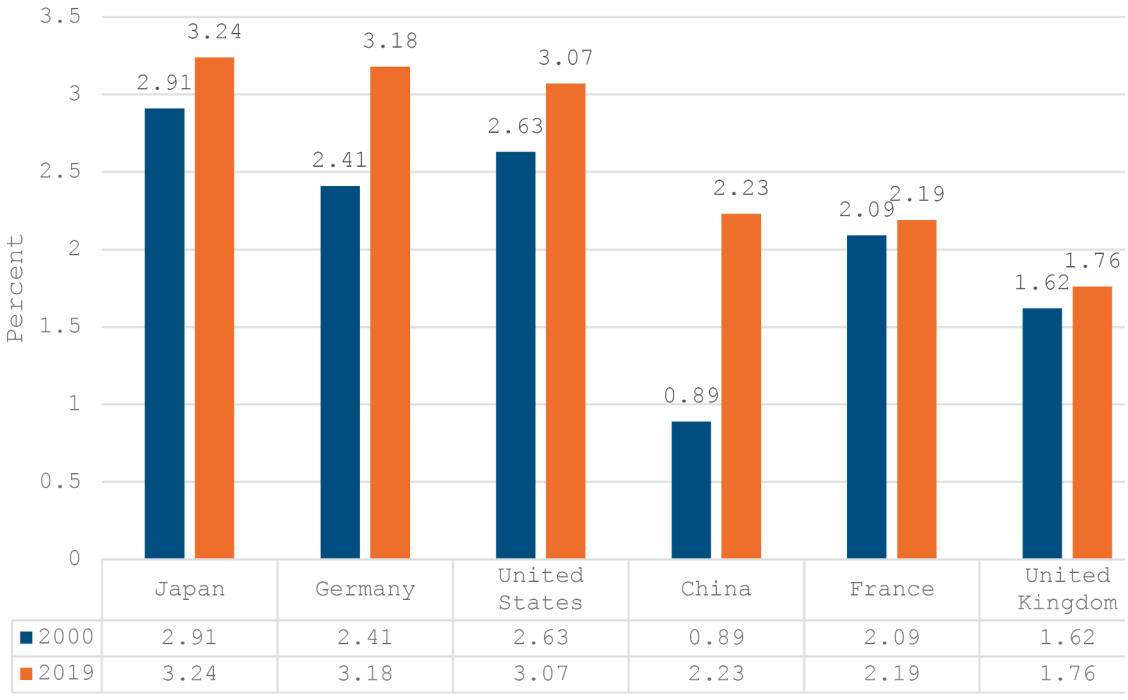
Extensive literature documents a positive relationship between innovation activities and firm performance. Innovation investments enhance firm value, competitiveness, and operational efficiency through knowledge creation, technological advancement, and productivity improvements (Kong et al., 2023). Similarly, Y. Liu et al. (2023), M. Liu et al. (2023), and Wu et al. (2025) show that digital innovation improves organizational performance in manufacturing firms, Other demonstrate that eco-innovation contributes positively to multiple performance indicators (Zheng and Iatridis, 2022; Alkaraan et al., 2025).

Innovation intensity boosts performance through various mechanisms. Ongoing R&D investment can improve product quality, lower production costs, enhance brand reputation, and strengthen competitive positioning. Simultaneously, the ability to expand innovation strategies across organizational activities enables firms to convert innovation investments into both tangible and intangible assets, thereby aiding the dissemination and commercialization of innovation outcomes. Firms are increasingly combining internal R&D with external knowledge acquisition through collaborations, alliances, and acquisitions, thereby enhancing their capacity to intensify and scale innovation efforts. However, most previous studies measure innovation using input or output indicators such as R&D spending or patenting results. For instance, Khan et al. (2021) show that board characteristics influence corporate innovation as measured by patent outcomes, while Wu et al.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2
United States	269.5	280.2	279.9	293.9	305.6	328.1	353.3	380.3	407.2	406.4	410.1	429.8	434.3	455.1	477	495.9	522.7	556.3	607.5	6
France	33.3	36.1	38.3	37.1	38.1	39.5	42.3	44.2	46.6	49.7	50.9	53.6	55.1	58.4	60.6	61.6	63.7	65.7	68.6	7
Germany	53.9	56.2	58.6	61	62.9	64	69.5	73.4	81.2	82.8	87	95.8	100.5	102.9	109.6	114.1	122.5	133.7	142.1	1
United Kingdom	25.2	26.3	27.9	28.6	29.4	30.6	33.3	35.2	36.5	36.5	37.6	38.8	38.5	41.5	43.8	45.7	48.1	50.8	54.2	5
China	32.9	38.4	47.9	56.8	69.7	86.2	104.7	123.3	145.1	184.1	212.1	246.5	289.2	323.4	346.3	366.1	393	420.8	465.5	5
Japan	98.9	103.8	108.2	112.4	117.5	128.7	138.7	147.5	148.7	137.4	140.6	148.4	152.3	164.7	169.6	168.5	160.3	166.6	172.8	1

Fig. 1. Gross domestic R&D expenditures (2000–2019).



Source: NCSES: OECD, R&D dataset https://ncses.nsf.gov/pubs/nsb20221/u-s-and-global-research-and-development

Fig. 2. R&D intensity (2000–2019).
Source: NCSES: OECD, R&D dataset https://ncses.nsf.gov/pubs/nsb20221/u-s-and-global-research-and-development.

(2023) emphasize that governance mechanisms and investment efficiency moderate the link between financial flexibility and firm performance. These studies offer valuable insights but provide limited understanding of how firms develop and expand innovation strategies as integrated strategic capabilities. This study conceptualises business innovation strategy intensity and scalability as complementary dimensions of firms' innovation behaviour. Innovation intensity captures firms' commitment to innovation investments, while innovation scalability reflects the organizational capacity to expand and translate these investments into broader operational and knowledge-based capabilities that support improved firm performance. Hence, we propose the following hypothesis:

H1. There is a positive association between business innovation strategy intensity and scalability and firm performance.

2.2.3. The influence of financial flexibility on business innovation strategies intensity, scalability, and firms' performance

While innovation investments are crucial for long-term growth, they require significant financial resources and involve considerable uncertainty. Financial flexibility thus plays a vital role in helping firms sustain innovation efforts and manage the risks associated with strategic investments. Financial flexibility describes a firm's ability to access and reallocate financial resources when needed, typically reflected in cash holdings, borrowing capacity, and capital structure decisions (Denis and McKeon, 2012). Firms with higher financial flexibility are better equipped to withstand financial shocks and maintain consistent investment in R&D and innovation activities during uncertain times (Han et al., 2021). By leveraging both internal and external financing channels, companies can allocate resources more efficiently and pursue innovation opportunities more effectively. Empirical evidence shows that financial flexibility reduces underinvestment problems and enables firms to fund new projects and expand innovation activities (Marchica and Mura, 2010; Ferrando et al., 2017). It also helps mitigate financing constraints that may otherwise limit innovation investments (Garmaise and Natividad, 2021; Hao et al., 2022). Consequently, financially flexible firms are better positioned to sustain innovation strategies and translate innovation investments into improved performance outcomes. Recent evidence also suggests that financial flexibility enhances investment efficiency and firm performance (Wu et al., 2023). Building on these insights, this study argues that financial flexibility not only supports innovation strategy intensity but also enables firms to scale innovation outcomes, allowing organisations to convert innovation investments into tangible and intangible assets that strengthen competitive advantage. Accordingly, we propose the following hypothesis:

H2. Firms' financial flexibility strengthens the relationship between business innovation strategy intensity and scalability and firms' performance.

2.2.4. The influence of governance mechanisms on business innovation strategies intensity

Corporate governance plays a critical role in shaping firms' strategic decisions and investment policies (Alkaraan and Northcott, 2006). Boards of directors serve as a key monitoring mechanism that mitigates agency problems and improves the quality of managerial decision-making (see Jensen & Meckling, 1976; Ye et al., 2021). Within this governance framework, boardroom gender diversity has received increasing attention in the literature. Prior research suggests that gender-diverse boards enhance governance effectiveness by improving monitoring intensity, encouraging diverse perspectives, and strengthening strategic deliberation (Campbell and Mínguez-Vera, 2008; Farooq et al., 2023). Female directors are often associated with stronger oversight of managerial behaviour and more balanced risk-taking, which may influence firms' investment decisions and innovation strategies.

Empirical evidence also suggests that board diversity can positively influence corporate innovation outcomes. For instance, Khan et al. (2021) show that female and younger board members positively affect corporate innovation in Chinese firms, particularly when firms possess strong financial flexibility. These findings highlight the importance of

governance structures in shaping innovation decisions. However, existing studies primarily focus on innovation outputs such as patenting activity, while limited attention has been given to how governance mechanisms influence innovation strategy intensity and the capacity of firms to scale innovation investments into sustainable performance outcomes. This study extends the literature by examining how boardroom gender diversity strengthens governance effectiveness in guiding innovation investments and supporting firms' ability to scale innovation strategies. We propose the following hypothesis.

H3. Corporate governance structure moderates the relationship between the intensity and scalability of business innovation strategies and firms' performance.

Additionally, governance mechanisms can interact with financial flexibility to further enhance firms' innovation strategies. When firms have both strong financial resources and inclusive governance structures, they may be better equipped to sustain and effectively manage innovation investments and to expand innovation outcomes across organizational activities. Consequently, the following hypothesis is proposed:

H4. The combined influence of financial flexibility and boardroom gender diversity reinforces the relationship between business innovation strategy intensity and scalability and firms' performance.

Fig. 3 illustrates the study's conceptual framework, which connects business innovation strategy intensity and scalability to firm performance, while including the moderating roles of financial flexibility and boardroom gender diversity. Innovation strategy intensity indicates how committed firms are to innovation investments, while innovation scalability refers to the organizational ability to turn those investments into tangible and intangible assets that facilitate the spread and commercialization of innovation results. The framework suggests that innovation strategy intensity and scalability positively affect firm performance (H1). It also proposes that financial flexibility (H2) and boardroom gender diversity (H3) enhance this relationship by helping firms maintain innovation investments and expand innovation outcomes. Additionally, the framework introduces a joint moderating effect (H4), emphasizing the combined influence of financial adaptability and inclusive governance on scalable innovation and firm performance.

3. Research methodology

3.1. Sample selection processes and analysis

The empirical analysis uses panel data from 12,221 U.S.-listed firms covering 2010–2022, sourced from the BoardEx–WRDS database, a common resource for corporate governance and firm-level financial data. BoardEx offers detailed information on board composition, including gender diversity, while financial variables are obtained through the WRDS platform. The United States provides a suitable institutional context for studying the links between corporate governance, innovation strategies, and firm performance due to its advanced capital market, strong investor protection, and high levels of technological innovation.

Financial firms are excluded because their regulatory environment, capital structures, and accounting practices differ substantially from those of non-financial firms. The sample period begins in 2010 to minimise distortions associated with the 2007–2009 global financial crisis and to capture a period characterised by rapid technological development and innovation-driven growth.

After removing observations with missing values and abnormal asset values, the final dataset comprises 70,630 firm-year observations. The analysis is conducted using STATA 17, applying panel-data regression techniques appropriate for longitudinal datasets.

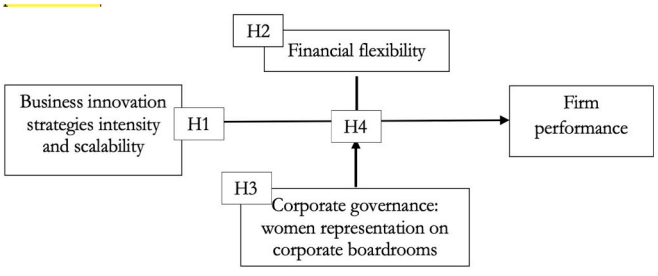


Fig. 3. Conceptual framework: The combined impact of women representation and financial flexibility on business innovation strategy intensity, scalability, and firms' performance.

3.2. Proxies and measurement

This study conceptualises business innovation strategy intensity and scalability as a multidimensional construct reflecting firms' internal and external innovation activities and their capacity to scale innovation outcomes. Consistent with the theoretical framework, the measurement strategy separates the commitment dimension from the scalability dimension while retaining them within one innovation-strategy framework. RD_intensity and RD_inter capture innovation intensity because they represent internal and external resource commitments to innovation. Tang_exp and Intang capture innovation scalability because they represent the operational and knowledge-based capacity through which innovation investments are expanded and converted into performance outcomes. This approach addresses the risk of conceptual breadth by making the two dimensions explicit in both theory and operationalisation.

- Innovation strategy intensity and scalability: Four complementary proxies capture these dimensions. First, R&D intensity (RD_intensity) measures internal innovation investment. Following Cornett et al. (2019) and Adomako et al. (2021), it is calculated as R&D expenditure scaled by total assets and, alternatively, by annual sales. This variable reflects firms' commitment to knowledge creation, technological development, and exploratory innovation. Second, RD_inter captures external innovation investment through mergers and acquisitions (M&A). M&A enables firms to acquire technological capabilities, access complementary knowledge resources, and accelerate innovation scalability. Firms often use acquisitions to expand technological capabilities, strengthen market positions, and access new knowledge bases (Alkaraan, 2019). Third, tangible investment expansion (Tang_exp) measures firms' ability to scale innovation through productive capacity. Following Cornett et al. (2019), it is calculated as the percentage growth in annual property, plant, and equipment (PPE) relative to capital expenditure. This variable reflects the infrastructure required to translate innovation into scalable production capabilities. Fourth, intangible asset growth (Intang) captures the accumulation of knowledge-based resources supporting innovation scalability. It is measured as the percentage growth in intangible assets scaled by total assets. Consistent with Bagna et al. (2021), intangible assets such as patents and intellectual property represent key organizational capabilities supporting innovation development and expansion. Collectively, RD_intensity, RD_inter, Tang_exp, and Intang capture complementary dimensions of innovation strategy intensity and scalability.
- Financial flexibility: Financial flexibility reflects a firm's ability to maintain liquidity and borrowing capacity to support strategic investments under uncertainty. Following Marchica and Mura (2010), it is measured using indicators of liquidity reserves, leverage capacity, and internal financing capability. In addition, a dummy variable identifies firms with high financial flexibility (top 20% cash holdings and bottom 20% leverage) for robustness testing.
- Corporate governance mechanism: The key governance variable is boardroom gender diversity, measured by the proportion of female directors on the board (Gender). Prior research suggests gender-

diverse boards enhance monitoring quality, strategic decision-making, and broader perspectives in governance (Griffin et al., 2021). In this context, diversity may improve the evaluation and scaling of innovation investments.

- Dependent variable: Firm performance is measured using return on assets (ROA), calculated as net income divided by total assets. ROA captures operational performance and is widely used in innovation and governance studies (Raza et al., 2021; Xu et al., 2025). Tobin's Q is used as an alternative market-based measure for robustness.
- Control variables: Several firm-level control variables are included to account for heterogeneity across firms. Age is measured as the number of years since the firm's IPO, capturing organizational maturity and experience. Size is measured as the natural logarithm of total assets, reflecting firm scale and resource availability (Wu et al., 2026a; Fan et al., 2025a). Turnover represents annual sales growth and captures firms' growth dynamics. Employee is measured as the natural logarithm of the total number of employees, reflecting organizational scale and labour capacity. In addition, industry dummy variables are included to control for sector-specific effects that may influence firms' innovation strategies and performance.
- The definitions of the variables and measurements employed in this study are presented in Table 1.

3.3. Research models

To examine the relationship between innovation strategy intensity, governance mechanisms, and firm performance, the following panel regression models are estimated.

The empirical specification therefore preserves the unified model but avoids treating innovation intensity and scalability as a single unobserved black box. Each proxy is estimated separately, allowing the analysis to show how resource commitment and scalable deployment contribute to firm performance while remaining part of the same innovation-strategy execution pathway.

Table 1
Definitions of the variables and measurements.

Category	Variable	Definition and measurement
Dependent variables	ROA	Return on assets: net income divided by total assets.
	TobinQ	Market value of equity plus total debt divided by total assets.
Innovation strategy intensity and scalability	RD_intensity	R&D expenditure scaled by total assets, capturing internal innovation investment
	RD_inter	M&A investment scaled by total assets, capturing external innovation investment and knowledge acquisition.
	Tang_exp	Growth rate of property, plant and equipment (PPE), reflecting firms' capacity to scale production and operational innovation.
	Intang	Growth rate of intangible assets, capturing expansion of knowledge-based and digital innovation assets.
Moderating variable Corporate governance mechanism	FF	Financial flexibility measured by liquidity reserves and borrowing capacity; robustness based on firms in the top 20% of cash holdings and bottom 20% of leverage.
	Gender	Proportion of female directors on the corporate board, an indicator of corporate governance mechanism.
Control variables	Age	Firm age measured as years since IPO.
	Size	Natural logarithm of total assets.
	Turnover	Annual sales growth.
	Employee	Natural logarithm of total number of employees.
Fixed effects	Industry dummies	Industry classification controls.

Model 1, innovation strategy intensity, scalability and firm performance (H1), tests whether innovation strategy intensity and scalability influence firm performance.

$$Performance_{i,t} = \beta_0 + \beta_1 RD\_intensity_{i,t} + \beta_2 RD\_inter_{i,t} + \beta_3 Tang\_exp_{i,t} + \beta_4 Intang_{i,t} + \beta_5 Age_{i,t-1} + \beta_6 Size_{i,t-1} + \beta_7 Turnover_{i,t-1} + \beta_8 Employee_{i,t-1} + Industry\ dummies + \varepsilon_{i,t}$$

Model 2, moderating role of financial flexibility (H2), examines whether financial flexibility strengthens the relationship between innovation strategies and firm performance.

$$Performance_{i,t} = \beta_0 + \beta_1 RD_{intensity_{i,t}} + \beta_2 RD_{inter_{i,t}} + \beta_3 Tang_{exp_{i,t}} + \beta_4 Intang_{i,t} + \beta_5 FF_{i,t} + \beta_6 InnFF_{inten_{i,t}} + \beta_7 InnFF_{ma_{i,t}} + \beta_8 InnFF_{ppe_{i,t}} + \beta_9 InnFF_{intan_{i,t}} + Controls + \varepsilon_{i,t}$$

Model 3, moderating role of boardroom gender diversity (H3) examines whether boardroom gender diversity strengthens the effectiveness of innovation strategies.

$$Performance_{i,t} = \beta_0 + \beta_1 RD\_intensity_{i,t} + \beta_2 RD\_inter_{i,t} + \beta_3 Tang\_exp_{i,t} + \beta_4 Intang_{i,t} + \beta_5 Gender_{i,t} + \beta_6 InnCG\_inten_{i,t} + \beta_7 InnCG\_ma_{i,t} + \beta_8 InnCG\_ppe_{i,t} + \beta_9 InnCG\_intan_{i,t} + Controls + \varepsilon_{i,t}$$

Model 4 examines the combined moderating influence of financial flexibility and boardroom gender diversity on innovation strategy effectiveness (H4)

$$Performance_{i,t} = \beta_0 + \beta_1 RD\_intensity_{i,t} + \beta_2 RD\_inter_{i,t} + \beta_3 Tang\_exp_{i,t} + \beta_4 Intang_{i,t} + \beta_5 FF_{i,t} + \beta_6 Gender_{i,t} + \beta_7 InnFF\_inten_{i,t} + \beta_8 InnCG\_inten_{i,t} + \beta_9 InnFF\_ma_{i,t} + \beta_{10} InnCG\_ma_{i,t} + \beta_{11} InnFF\_ppe_{i,t} + \beta_{12} InnCG\_ppe_{i,t} + \beta_{13} InnFF\_intan_{i,t} + \beta_{14} InnCG\_intan_{i,t} + Controls + \varepsilon_{i,t}$$

4. Analysis of the results

After comparing the fixed-effects and random-effects models, we used the Hausman test to identify the most suitable estimator for the dataset. The Hausman test assesses whether there is a systematic difference between the coefficients estimated by the two models and, consequently, whether the random-effects estimator is inconsistent. The test results reject the null hypothesis and suggest that the fixed-effects model is more appropriate for the current analysis (see Appendix 1). Therefore, the empirical analysis is performed using fixed-effects panel regression models, which account for unobserved firm-specific heterogeneity that remains constant over time and may affect both innovation activities and firm performance. This approach enhances the reliability and consistency of the estimated relationships.

The descriptive statistics for the variables used in this study are shown in Table 2, while Table 3 presents the correlation matrix among these variables. The descriptive statistics indicate significant variation among firms regarding innovation investment, innovation scalability, financial flexibility, governance characteristics, and performance outcomes. This variation supports the appropriateness of panel-data estimation and enables the analysis to examine how these factors interact over time. The correlation matrix displays relationships among the variables that generally align with theoretical expectations and does not suggest serious multicollinearity issues.

Table 2
Descriptive statistics.

Variable	N	Mean	SD	Min	Max
ROA	70,630	−0.238	1.247	−11.000	0.354
TobinQ	70,630	2.852	11.850	0.00174	106.300
RD_intensity	70,630	0.163	1.011	0	9.529
RD_inter	70,630	−1.643	9.396	−69.47	14.30
Tang_exp	70,630	1.752	109.900	−623.0	672.2
Intang	70,630	0.000456	0.0445	−0.179	0.249
FF	70,630	0.0325	0.177	0	1
Gender	70,630	0.0766	0.112	0	0.800
Age	70,630	14.090	5.672	3	75
Size	70,630	6.184	2.714	−2.538	12.370
Turnover	70,630	0.0790	0.481	−0.964	3.654
TA	70,630	8067	30,308	0.0790	235,821
Employee	70,630	−0.227	2.117	−6.215	5.024

Table 3
Correlations between proxies.

Variable	ROA	RD_intensity	RD_inter	Tang_exp	Intang	FF	Gender
ROA	1						
RD_intensity	−0.068***	1					
RD_inter	−0.033***	0.029***	1				
Tang_exp	0.018***	0.024***	0.010***	1			
Intang	0.020***	−0.012***	−0.130***	0.004*	1		
FF	0.039***	−0.012***	−0.040***	0.002**	−0.010***	1	
Gender	0.100***	0.030***	−0.147***	−0.003	0.006	0.065***	1
Age	0.024***	−0.027***	−0.031***	0.001	0.003	0.035***	0.070***
Size	0.446***	−0.133***	−0.237***	−0.010***	−0.005	0.222***	0.299***
Turnover	0.009**	0.067***	−0.030***	−0.005	−0.010***	0.002	0.010***
TA	0.056***	−0.038***	−0.175***	−0.002	−0.005	0.305***	0.124***
Employee	0.240***	−0.178***	−0.245***	−0.006	−0.004	0.157***	0.269***

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

4.1. Business innovation strategies intensity and firms' performance

The baseline regression results examine the relationship between the intensity of business innovation strategies and firm performance. The results show that several dimensions of innovation investment significantly influence firm performance, providing empirical support for H1, which proposes that the intensity of business innovation strategies positively affects firm performance, as illustrated in Table 4.

Table 4
The influence of business innovation strategies intensity and scalability on firms' performance.

Variables	ROA			
RD_intensity	0.0341***			
	(0.0104)			
RD_inter		0.00244***		
		(0.000250)		
Tang_exp			0.000161***	
			(4.35e−05)	
Intang				0.615***
				(0.112)
Age	−0.00499**	−0.00487**	−0.00506**	−0.00474**
	(0.00239)	(0.00238)	(0.00238)	(0.00238)
Size	0.140***	0.141***	0.140***	0.142***
	(0.0273)	(0.0273)	(0.0273)	(0.0272)
Turnover	0.0310***	0.0300***	0.0296***	0.0308***
	(0.0110)	(0.0110)	(0.0110)	(0.0110)
TA	−3.27e−06***	−3.28e−06***	−3.28e−06***	−3.13e−06***
	(5.45e−07)	(5.43e−07)	(5.44e−07)	(5.39e−07)
Employee	−0.0103*	−0.0107	−0.0114	−0.00806
	(0.0177)	(0.0177)	(0.0177)	(0.0177)
Constant	−1.016***	−1.014***	−1.013***	−1.030***
	(0.149)	(0.149)	(0.148)	(0.148)
Observations	70,630	70,630	70,630	70,630
R-squared	0.009	0.009	0.009	0.010
Number of firms	12,221	12,221	12,221	12,221

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

First, R&D intensity (RD_intensity) shows a positive and statistically significant coefficient ($\beta = 0.0341$, $p < 0.01$), indicating that firms investing more in internal innovation activities achieve better operational performance. This finding aligns with previous research suggesting that continuous R&D investment enhances firms' technological abilities, boosts absorptive capacity, and strengthens long-term competitive advantage (Zheng and Iatridis, 2022; Kong et al., 2023). From a dynamic capabilities standpoint, R&D investment allows firms to constantly sense technological opportunities and reconfigure organizational resources in response to environmental changes.

Second, external innovation investment through mergers and acquisitions (RD_inter) also shows a positive and statistically significant relationship with firm performance ($\beta = 0.00244$, $p < 0.01$). This finding suggests that firms complement internal innovation with external knowledge acquisition strategies. Mergers and acquisitions enable firms to access complementary technologies, strengthen their knowledge base, and speed up innovation dissemination across markets. This supports the open innovation perspective, which emphasizes the integration of internal and external knowledge flows to improve innovation performance (Kong et al., 2023).

Third, tangible expansion capacity (Tang_exp) shows a positive relationship with firm performance ($\beta = 0.000161$, $p < 0.01$). This result indicates that firms need to develop sufficient operational and production infrastructure to translate innovation outcomes into marketable products and services. Innovation scalability therefore relies not only on technological development but also on the ability to increase productive capacity.

Finally, intangible asset growth (Intang) shows the strongest positive link with firm performance ($\beta = 0.615$, $p < 0.01$). Intangible assets like patents, intellectual property, and technological capabilities are key knowledge-based resources that support competitive advantage. This finding confirms prior studies showing that innovation efficiency and knowledge accumulation significantly boost firm value and market performance (Kong et al., 2023; Y. Liu et al., 2023; M. Liu et al., 2023).

Overall, the results confirm that innovation strategy intensity influences firm performance through multiple complementary mechanisms, including internal knowledge development, external technology acquisition, and the buildup of both tangible and intangible assets. These findings strongly support H1, reinforcing the idea that sustained and scalable innovation investment is a key driver of firm performance.

4.2. The moderating influence of financial flexibility on innovation intensity, scalability, and firms' performance

Table 5 presents the regression results examining how financial flexibility moderates the relationship between the intensity of business innovation strategies and firms' performance. The findings support H2, showing that financial flexibility amplifies the effect of innovation intensity and scalability on firm performance. As shown in Model 1, R&D intensity (RD_intensity) is positively and significantly linked to firm performance ($\beta = 0.0324$, $p < 0.01$), implying that firms investing more in internal innovation tend to perform better operationally. The coefficient for financial flexibility (FF) is positive and significant across all models, indicating that firms with greater liquidity and borrowing capacity generally achieve superior performance. The moderating role of financial flexibility becomes more apparent when looking at the interaction terms between financial flexibility and innovation variables. Notably, the interaction between financial flexibility and intangible asset growth (FF × Intang) is positive and statistically significant ($\beta = 2.370$, $p < 0.05$), with the coefficient for Intang remaining positive and significant ($\beta = 0.578$, $p < 0.01$). These results suggest that financially flexible firms are more capable of converting intangible innovation investments into enhanced firm performance. Likewise, the interaction

Table 5
The moderating effect of financial flexibility on innovation intensity, scalability and firms' performance.

Variable	ROA			
RD_intensity	0.0324***			
	(0.0104)			
FF	0.0205*	0.0615***	0.0326***	0.0545***
	(0.0111)	(0.0132)	(0.0113)	(0.0112)
FF × RD_intensity	0.0622*			
	(0.0320)			
Age	−0.00482**	−0.00461*	−0.00495**	−0.00454*
	(0.00239)	(0.00239)	(0.00239)	(0.00239)
Size	0.140***	0.140***	0.140***	0.142***
	(0.0273)	(0.0272)	(0.0272)	(0.0272)
Turnover	0.0308***	0.0297***	0.0293***	0.0308***
	(0.0110)	(0.0110)	(0.0110)	(0.0110)
TA	−3.29e−06***	−3.20e−06***	−3.35e−06***	−3.13e−06***
	(5.45e−07)	(5.55e−07)	(5.49e−07)	(5.39e−07)
Employee	−0.0101	−0.0106	−0.0115	−0.00797
	(0.0177)	(0.0177)	(0.0177)	(0.0177)
RD_inter		0.00154***		
		(0.000375)		
FF × RD_inter		0.0114***		
		(0.00404)		
Tang_exp			0.000137***	
			(4.42e−05)	
FF × Tang_exp			0.00201**	
			(0.000815)	
Intang				0.578***
				(0.114)
FF × Intang				2.370**
				(1.079)
Constant	−1.021***	−1.018***	−1.016***	−1.036***
	(0.149)	(0.148)	(0.148)	(0.148)
Observations	70,630	70,630	70,630	70,630
R-squared	0.009	0.010	0.010	0.010
Number of companies	12,221	12,221	12,221	12,221

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

terms for external innovation investment (FF × RD_inter) and tangible expansion capacity (FF × Tang_exp) are positive and statistically significant. These findings indicate that financial flexibility boosts firms' ability to support both innovation intensity (including internal R&D and external innovation investments) and innovation scalability (through tangible and intangible asset expansion).

The above results indicate that financial flexibility acts as a strategic enabler of innovation intensity and scalability. Companies with stronger financial resources are better equipped to maintain innovation investments, acquire complementary assets, and effectively convert innovation inputs into better performance outcomes. These findings therefore support H2.

4.3. The influence of boardroom gender diversity on innovation intensity, scalability, and firms' performance

Table 6 presents the regression results examining how boardroom gender diversity moderates the relationship between the intensity of business innovation strategies and firm performance. The findings support H3, emphasizing the significant role of corporate governance in influencing innovation outcomes.

The coefficient for Gender is positive and statistically significant across all models, indicating that firms with a higher proportion of female directors on their boards tend to achieve stronger financial performance. This finding is consistent with prior research suggesting that gender-diverse boards enhance governance quality, improve monitoring effectiveness, and contribute to better organizational outcomes (Griffin et al., 2021). More importantly, the interaction terms between boardroom gender diversity and the innovation variables are positive and significant. In particular, the interaction between gender diversity and R&D intensity (Gender × RD_intensity) is positive and statistically significant, indicating that gender-diverse boards strengthen the positive relationship between internal innovation investment and firm performance. Similarly, the interaction terms associated with external innovation investment (Gender × RD_inter) and tangible expansion capacity (Gender × Tang_exp) are also positive and significant, suggesting that board gender diversity enhances firms' ability to support innovation expansion and resource allocation. The moderating effect is particularly evident for intangible asset growth (Gender × Intang), which exhibits a positive and statistically significant coefficient ($\beta = 1.895$, $p < 0.05$). This result indicates that gender-diverse boards improve firms' ability to translate intangible innovation investments, such as patents and technological capabilities, into improved performance outcomes. The findings suggest that boardroom gender diversity functions as a strategic governance mechanism that strengthens the effectiveness of innovation intensity and innovation scalability in generating firm value. By introducing broader perspectives, improving strategic deliberation, and enhancing oversight of complex innovation investments, gender-diverse boards enable firms to more effectively translate innovation strategies into superior performance. These findings therefore support H3.

4.4. Integrated influence of financial flexibility and boardroom gender diversity on innovation intensity, scalability, and firms' performance

Table 7 presents the integrated model, in which financial flexibility and boardroom gender diversity are simultaneously included to examine their combined moderating influence on the relationships among innovation intensity, innovation scalability, and firm performance. The results provide empirical support for H4 and highlight the joint governance–financial conditions under which innovation strategies generate stronger performance outcomes.

The coefficient for R&D intensity (RD_intensity) remains positive and statistically significant, indicating that internal innovation investment

Table 6
The moderating effect of boardroom gender diversity on innovation intensity, scalability and firms' performance.

Variable	ROA			
RD_intensity	0.0235**			
	(0.0115)			
Gender	0.0915**	0.128***	0.114***	0.115***
	(0.0427)	(0.0420)	(0.0411)	(0.0409)
Gender × RD_intensity	0.101*			
	(0.0532)			
Age	−0.00585**	−0.00564**	−0.00591**	−0.00552**
	(0.00242)	(0.00242)	(0.00242)	(0.00242)
Size	0.140***	0.140***	0.140***	0.142***
	(0.0273)	(0.0273)	(0.0273)	(0.0273)
Turnover	0.0312***	0.0305***	0.0299***	0.0310***
	(0.0110)	(0.0110)	(0.0110)	(0.0110)
TA	−3.27e−06***	−3.26e−06***	−3.29e−06***	−3.11e−06***
	(5.44e−07)	(5.42e−07)	(5.44e−07)	(5.39e−07)
Employee	−0.0108	−0.0108	−0.0118	−0.00831
	(0.0177)	(0.0177)	(0.0177)	(0.0177)
RD_inter		0.00182***		
		(0.000389)		
Gender × RD_inter		0.00385*		
		(0.00196)		
Tang_exp			0.000106**	
			(5.29e−05)	
Gender × Tang_exp			0.00113**	
			(0.000505)	
Intang				0.426**
				(0.175)
Gender × Intang				1.895**
				(0.891)
Constant	−1.010***	−1.010***	−1.010***	−1.028***
	(0.149)	(0.149)	(0.149)	(0.149)
Observations	70,630	70,630	70,630	70,630
R-squared	0.009	0.009	0.009	0.010
Number of companies	12,221	12,221	12,221	12,221

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 7
The integrated moderating effect of financial flexibility and boardroom gender diversity on innovation intensity, scalability and firms' performance.

Variable	ROA			
RD_intensity	0.0229**			
	(0.0115)			
FF	0.0243**	0.0622***	0.0338***	0.0568***
	(0.0109)	(0.0132)	(0.0111)	(0.0112)
Gender	0.0948**	0.128***	0.117***	0.117***
	(0.0426)	(0.0421)	(0.0411)	(0.0409)
FF × RD_intensity	0.0537*			
	(0.0299)			
Gender × RD_intensity	0.0931*			
	(0.0522)			
Age	−0.00568**	−0.00538**	−0.00577**	−0.00532**
	(0.00242)	(0.00243)	(0.00243)	(0.00242)
Size	0.140***	0.140***	0.140***	0.142***
	(0.0273)	(0.0273)	(0.0273)	(0.0273)
Turnover	0.0311***	0.0302***	0.0297***	0.0310***
	(0.0111)	(0.0110)	(0.0110)	(0.0110)
TA	−3.29e−06***	−3.18e−06***	−3.35e−06***	−3.12e−06***
	(5.45e−07)	(5.54e−07)	(5.49e−07)	(5.39e−07)
Employee	−0.0106	−0.0107	−0.0118	−0.00823
	(0.0177)	(0.0177)	(0.0177)	(0.0177)
RD_inter		0.000870*		
		(0.000506)		
FF × RD_inter		0.0114***		
		(0.00404)		
Gender × RD_inter		0.00415**		
		(0.00205)		
Tang_exp			9.93e−05*	
			(5.28e−05)	
FF × Tang_exp			0.00190**	
			(0.000805)	
Gender × Tang_exp			0.000794*	
			(0.000476)	
Intang				0.390**
				(0.176)
FF × Intang				2.369**
				(1.079)
Gender × Intang				1.892**
				(0.891)
Constant	−1.015***	−1.015***	−1.013***	−1.033***
	(0.149)	(0.149)	(0.149)	(0.149)
Observations	70,630	70,630	70,630	70,630
R-squared	0.009	0.010	0.010	0.010
Number of companies	12,221	12,221	12,221	12,221

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

continues to contribute to firm performance even after accounting for governance and financial conditions. Both financial flexibility (FF) and boardroom gender diversity (Gender) are also positive and significant across the models, suggesting that firms with stronger financial adaptability and more gender-diverse boards tend to achieve better financial outcomes.

More importantly, the interaction terms reveal that the effects of innovation intensity and scalability become stronger when firms combine financial flexibility with inclusive governance structures. The interaction terms associated with financial flexibility (FF × RD_inter, FF × Tang_exp, FF × Intang) and boardroom gender diversity (Gender × RD_inter, Gender × Tang_exp, Gender × Intang) are positive and statistically significant. These results indicate that firms are better able to sustain innovation investments, support innovation scaling, and translate innovation efforts into improved performance when both financial resources and governance diversity are present.

This combined effect is both theoretically and practically significant. Financial flexibility enables firms to manage uncertainty, maintain long-term innovation commitments, and allocate resources to expand innovation efforts. Meanwhile, boardroom gender diversity enhances governance oversight and improves strategic decision-making by offering broader perspectives and a more balanced evaluation of complex investments. These factors together foster a supportive organizational environment that allows firms to deepen innovation activities, grow technological capabilities, and turn innovation investments into better performance results. Consequently, the findings support the main argument of this study: the performance outcomes of innovation strategies rely not only on the level of innovation investment but also on the organizational conditions that promote effective governance and sustainability of innovation intensity and scalability.

4.5. Robustness of the results

To evaluate the robustness of the empirical findings, the regression models are re-estimated using Tobin's Q as an alternative measure of firm performance. Tobin's Q reflects market-based firm valuation and thus complements the accounting-based performance measure (ROA) used in the baseline models. The robustness results shown in Table 8 remain largely consistent with the original findings. The core innovation intensity and scalability variables continue to show positive and statistically significant relationships with firm performance, indicating that business innovation strategies enhance both operational performance and market valuation.

In particular, R&D intensity (RD_intensity) and external innovation investment (RD_inter) remain positively linked to Tobin's Q, indicating

Table 8
Robustness test: Tobin's Q as an alternative measure of firm performance.

Variable	Tobin's Q			
RD_intensity	0.297**			
	(0.142)			
FF	−0.267*	0.0813	−0.0919	0.287*
	(0.155)	(0.141)	(0.132)	(0.160)
Gender	−0.310	0.248	0.0834	0.200
	(0.351)	(0.320)	(0.304)	(0.308)
FF × RD_intensity	0.870*			
	(0.450)			
Gender × RD_intensity	1.688**			
	(0.732)			
RD_inter		0.00859**		
		(0.00398)		
FF × RD_inter		0.0680**		
		(0.0296)		
Gender × RD_inter		0.0492***		
		(0.0176)		
Tang_exp			0.00160**	
			(0.000638)	
FF × Tang_exp			0.0155**	
			(0.00673)	
Gender × Tang_exp			0.0185**	
			(0.00741)	
Intang				9.892***
				(1.953)
FF × Intang				40.13***
				(12.11)
Gender × Intang				22.75**
				(11.47)
Constant	2.798***	2.865***	2.833***	2.809***
	(0.0356)	(0.0248)	(0.0242)	(0.0250)
Observations	70,630	70,630	70,630	70,630
R-squared	0.003	0.001	0.004	0.010
Number of firms	12,221	12,221	12,221	12,221

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

that firms investing more heavily in innovation activities tend to attract higher market valuations. Similarly, tangible expansion capacity (Tang_exp) and intangible assets (Intang) continue to show positive and significant relationships with firm performance, highlighting the importance of innovation scalability in boosting firm value. The moderating influences of financial flexibility and boardroom gender diversity also remain generally consistent. The interaction terms relating to financial flexibility (FF × innovation variables) and boardroom gender diversity (Gender × innovation variables) stay positive and statistically significant across several model specifications. These findings imply that firms with greater financial adaptability and more gender-diverse boards are better equipped to convert innovation investments into higher market valuation. The robustness analysis verifies that the main conclusions of this study do not rely on a single performance metric. Instead, the evidence shows that innovation intensity and scalability, supported by financial flexibility and inclusive governance structures, improve both internal operational performance (ROA) and external market valuation (Tobin's Q). These results further strengthen the reliability and stability of the empirical findings.

5. Discussion

This study explores a key question in the innovation and strategy literature: why does innovation strategy intensity boost firm performance in some contexts but result in weaker outcomes in others? While previous research recognizes innovation as a driver of competitiveness and growth, empirical evidence on the innovation–performance link remains inconsistent. By combining business innovation strategy intensity and scalability with financial flexibility and boardroom gender diversity, this study offers a more comprehensive explanation of how innovation investments lead to better firm performance.

In response to the conceptual breadth of the innovation-strategy construct, the discussion clarifies that intensity and scalability are not treated as identical mechanisms. The empirical story is deliberately organized around a commitment-to-conversion logic: firms first commit resources to innovation through internal R&D and external knowledge acquisition, and they then need scalable organizational capacity to transform those investments into tangible and intangible assets that improve performance. The integrated model is therefore retained because it captures this strategy-execution chain more directly than a fragmented model would.

A key contribution is distinguishing between innovation intensity and innovation scalability. Innovation intensity indicates the depth and persistence of firms' innovation efforts, usually measured by ongoing R&D investment and external knowledge gathering. Innovation scalability relates to the organizational ability to expand, reproduce, and commercialize innovation outcomes across markets and time frames (Nakatani, 2023; Karamchand, 2024; Chotia et al., 2025). In this study, innovation scalability is defined as the ability to convert innovation inputs into operational and knowledge-based assets. Empirically, it is measured by tangible asset expansion (Tang_exp) and intangible asset growth (Intang). Tangible expansion indicates a firm's capacity to scale innovation through increased production capacity and infrastructure, while intangible growth reflects the accumulation of intellectual property and technological capabilities that facilitate the spread of innovation results. The empirical results strongly support H1. Table 4 demonstrates that R&D intensity is positively linked to firm performance, indicating that ongoing innovation investment enhances operational results. External innovation investment through mergers and acquisitions (RD_inter) also shows a positive association with performance, suggesting that firms leverage both internal and external knowledge sources to boost innovation capabilities. These findings

endorse the open innovation approach, which highlights combining internal and external knowledge to improve innovation performance (Kong et al., 2023). Both tangible asset expansion and intangible asset growth are positively related to firm performance, with intangible assets showing the strongest effect. This underscores the importance of knowledge-based resources like intellectual property and technological capabilities in maintaining innovation-driven competitive advantage (Zheng and Iatridis, 2022; Y. Liu et al., 2023; M. Liu et al., 2023). Overall, the results indicate that innovation strategies impact performance not just through investment levels but also through the ability to expand innovation outcomes. The results further suggest that innovation intensity alone does not ensure superior performance. Its effectiveness depends on firms' financial resources. Table 5 shows that financial flexibility significantly enhances the connection between innovation strategy intensity, scalability, and firm performance, supporting H2. Firms with more financial flexibility are better equipped to maintain innovation investments during uncertain times and to reduce financing constraints. These findings are consistent with previous research emphasizing the importance of financial flexibility in supporting innovation investment (Denis and McKeon, 2012; Marchica and Mura, 2010; Han et al., 2021; Hao et al., 2022).

Corporate governance mechanisms also impact the effectiveness of innovation strategies. Table 6 shows that boardroom gender diversity positively influences the relationship between innovation strategies and firm performance, confirming H3. Companies with higher female representation on boards see greater performance gains from innovation investments. Gender-diverse boards bring broader strategic perspectives, better monitoring, and more balanced decision-making processes (Campbell and Mínguez-Vera, 2008; Griffin et al., 2021). Finally, the integrated model in Table 7 demonstrates that financial flexibility and boardroom gender diversity collectively enhance the effectiveness of innovation strategies, supporting Hypothesis 4 (H4). Financial flexibility supplies the necessary resources to maintain innovation investments, while gender-diverse boards improve governance oversight and strategic decision-making. Together, these mechanisms foster an organizational environment that allows firms to intensify and expand innovation strategies more effectively. Because the sample period ends in 2022, these findings should be interpreted as evidence from the pre-generative-AI diffusion period and from a macro-financial environment that differs from the post-2022 period. This does not undermine the validity of the results, but it suggests that the governance–financial flexibility–innovation scalability relationship should be reassessed when more recent data become available. The robustness analysis presented in Table 8 confirms the stability of these results. When Tobin's Q is used as an alternative measure of firm performance, the main relationships remain statistically significant. Table 9 provides a summary of the hypothesis testing outcomes.

Table 9
Summary of hypothesis testing results.

Hypothesis	Hypothesis statement	Main empirical evidence	Robustness (Tobin's Q)	Result
H1	Business innovation strategy intensity and scalability positively influence firms' performance	Positive and significant effects reported in Table 4	Confirmed in Table 8	Supported
H2	Firms' financial flexibility strengthens the relationship between business innovation strategy intensity and scalability and firms' performance	Significant moderating effects reported in Table 5	Confirmed in Table 8	Supported
H3	Corporate governance structure (boardroom gender diversity) moderates the relationship between business innovation strategy intensity and scalability and firms' performance	Positive moderating effects reported in Table 6	Confirmed in Table 8	Supported
H4	The combined influence of financial flexibility and boardroom gender diversity reinforces the relationship between business innovation strategy intensity and scalability and firms' performance	Significant combined effects reported in Table 7	Confirmed in Table 8	Supported

Note: Innovation strategy intensity is captured through internal and external innovation investments (RD_intensity and RD_inter), while innovation scalability is reflected through tangible and intangible asset expansion (Tang_exp and Intang).

6. Conclusion

This study investigates the organizational factors that influence how business innovation strategy intensity leads to better firm performance. It emphasizes the roles of financial flexibility and boardroom gender diversity as key factors. By combining these elements into a single framework, the research provides a clearer understanding of the relationship between innovation and performance, which has shown inconsistent results in past studies. The empirical results strongly support H1, confirming that the intensity of a business innovation strategy positively impacts firm performance. Companies that maintain higher levels of internal R&D investment and participate in external innovation activities such as mergers and acquisitions tend to achieve better operational results. These findings are consistent with the open innovation perspective and with previous studies emphasizing the importance of integrating internal and external knowledge sources to boost innovation capabilities and competitiveness (Kong et al., 2023; Zheng and Iatridis, 2022; Y. Liu et al., 2023; M. Liu et al., 2023). The results also suggest that innovation investments have a greater impact on performance when firms have the organizational capacity to scale innovation outputs through both tangible asset expansion and intangible asset development. The findings also support H2, demonstrating that financial flexibility enhances the link between innovation strategy intensity and firm performance. Firms with greater financial flexibility are better equipped to sustain long-term innovation investments, absorb financial uncertainties, and preserve strategic continuity. This evidence aligns with previous research emphasizing the importance of financial adaptability in facilitating investment decisions and bolstering organizational resilience (Wu et al., 2023; Marchica and Mura, 2010). In this context, financial flexibility acts as an enabling mechanism that helps firms to intensify and expand their innovation strategies more effectively.

Furthermore, the results support H3, showing that gender diversity in the boardroom positively influences the link between innovation strategies and firm performance. Companies with greater female representation on their boards see stronger performance improvements from innovation strategies. This aligns with studies suggesting that gender-diverse boards improve governance quality, broaden strategic views, and enhance decision-making (Campbell and Mínguez-Vera, 2008; Griffin et al., 2021). The findings also expand on the evidence from Khan et al. (2021), demonstrating that board diversity not only boosts innovation results but also amplifies the performance benefits of innovation strategy intensity and scalability.

Finally, the integrated model supports H4, showing that financial flexibility and boardroom gender diversity together strengthen the effectiveness of innovation strategies. The combination of strong financial capacity and inclusive governance creates an environment where firms can better initiate and expand innovation activities. Financial flexibility provides the necessary resources for sustaining innovation investments, while gender-diverse boards improve strategic oversight and governance quality. This interaction underscores the complementary role of financial adaptability and inclusive governance in enabling scalable innovation strategies and enhancing firm performance. Robustness tests using Tobin's Q as an alternative measure of firm performance confirm the stability of these findings, confirming the reliability of the results.

Our study adds to the literature by showing that innovation intensity alone is not enough to ensure better firm performance. Instead, the success of innovation strategies depends on supportive organizational conditions that allow companies to maintain and expand their innovation efforts over time. By combining governance mechanisms, financial flexibility, and innovation scalability within a single framework, the study enhances understanding of the organizational processes through which innovation strategies lead to a lasting competitive advantage.

6.1. Theoretical implications

This study advances the governance–innovation literature by explicitly integrating innovation scalability into the analysis of boardroom diversity, financial flexibility, and firm performance. First, the findings extend the RBV by conceptualizing boardroom gender diversity as a strategic resource that enables dynamic capabilities, rather than merely a governance attribute. While prior research has often treated diversity as a form of heterogeneous human capital, our results show that gender-diverse boards enhance firms' ability to integrate knowledge, evaluate risks, and support strategic decision-making processes that enable scalable innovation. In this regard, the study extends RBV by demonstrating how governance diversity contributes to the development of organizational capabilities that support sustained innovation and performance. Second, the study contributes to the literature by highlighting the role of financial flexibility as an enabling mechanism for innovation scalability. While previous studies emphasize the importance of financial slack or liquidity for innovation investment, our findings demonstrate that financial flexibility facilitates the translation of innovation intensity into scalable innovation outcomes. This insight complements the corporate finance literature by illustrating how financial adaptability functions as a dynamic capability that supports long-term innovation strategies in uncertain environments. Third, this study reframes the role of corporate governance in innovation strategy. Rather than viewing boardroom diversity primarily as a monitoring mechanism, the results position gender-diverse boards as strategic enablers of innovation intensity and scalability. Gender-diverse boards appear to enhance strategic deliberation, encourage balanced risk-taking, and facilitate knowledge integration, thereby strengthening firms' ability to seize and reconfigure resources over time. These findings extend the strategic management literature by demonstrating how governance diversity interacts with dynamic capabilities to support scalable innovation and sustained competitiveness. The study emphasizes the importance of scalability as a key aspect of innovation strategy. Innovation investments only create value when companies have the organizational and financial capacity to spread and commercialize innovation outputs across various markets and technologies. By differentiating between innovation intensity and innovation scalability, this research offers a more detailed understanding of how innovation strategies can lead to sustained long-term performance benefits.

6.2. Managerial implications

The findings of this study provide several important implications for managers, policymakers, and corporate stakeholders. First, the results highlight the importance of sustained investment in innovation strategies, particularly R&D activities, as a key driver of productivity and long-term competitiveness. Firms that maintain strong innovation intensity are better positioned to develop new technologies, improve products and services, and enhance customer value creation. Second, the findings underscore the critical role of financial flexibility in sustaining innovation investments. Firms with greater financial adaptability are better able to navigate uncertainty, maintain long-term innovation commitments, and allocate resources efficiently across innovation projects. Managers should therefore prioritise financial policies that preserve liquidity and maintain access to external financing in order to support scalable innovation strategies. Third, the results emphasize the strategic value of gender-diverse boardrooms. Greater representation of women on corporate boards enhances governance quality, improves decision-making processes, and strengthens the effectiveness of innovation strategies. Female directors contribute to inclusive innovation practices and sustainability-oriented strategies while improving the monitoring of investment decisions and resource allocation (Farooq et al., 2023; del Mar Fuentes-Fuentes et al., 2023; Bazel-Shoham et al., 2024). From a governance perspective, organisations may benefit from increasing the representation of women on corporate boards as part of broader efforts to improve strategic oversight and innovation management. Such governance structures not only strengthen innovation performance but also enhance organizational legitimacy and credibility among investors, regulators, and stakeholders.

6.3. Limitations and future research

While this study provides robust evidence on the interrelationships between innovation strategy intensity, financial flexibility, boardroom gender diversity, and firm performance, several limitations should be acknowledged.

First, the dataset ends in 2022. Although the 2010–2022 panel provides a large longitudinal setting and captures important variation across the post-financial-crisis and COVID-19 periods, it cannot fully reflect developments after 2022, including the rapid diffusion of generative AI, changes in interest-rate conditions, and more recent shifts in firms' innovation investment priorities. Future research should extend the sample period when consistent post-2022 data become available and examine whether the governance, financial flexibility, and innovation scalability relationships identified here remain stable in the newer technological and macro-financial environment.

Second, the empirical analysis focuses on U.S.-listed firms, operating within one of the world's most advanced innovation ecosystems characterised by deep capital markets, strong investor protection mechanisms, well-developed corporate governance frameworks, and substantial investments in R&D and technological development. These institutional conditions may facilitate firms' ability to sustain innovation investments, maintain financial flexibility, and implement governance practices that support scalable innovation strategies. Consequently, the strength and nature of the relationships identified in this study may differ in institutional environments where capital markets are less developed, governance mechanisms operate differently, or firms face stronger financing constraints. Therefore, while the findings provide important insights into the governance–innovation–performance nexus, their generalisability beyond the U.S. context should be interpreted with caution. Future research could extend this analysis by examining these relationships across different institutional settings, including emerging markets and coordinated market economies, to better understand how governance structures, financial systems, and innovation ecosystems shape innovation strategies and performance outcomes.

Third, further research could explore additional dimensions of business innovation strategies, such as marketing innovation, process innovation, and digital transformation, and assess how these forms of innovation interact with governance and financial mechanisms to influence firm performance. Finally, future research could adopt mixed-

methods approaches, combining econometric analysis with case studies or survey-based data, to provide deeper insights into how governance diversity and financial adaptability shape innovation strategies in practice. Such approaches would help capture the complex organizational processes through which firms intensify and scale innovation strategies under varying institutional conditions.

CRediT authorship contribution statement

Wei Wu: Writing – original draft, Resources, Formal analysis, Data curation. **Fadi Alkaraan:** Writing – original draft, Supervision, Conceptualization. **Chau Le:** Writing – review & editing, Resources. **Yulu Shi:** Writing – review & editing, Resources. **V.G. Venkatesh:** Writing – review & editing, Supervision. **Yangyan Shi:** Writing – review & editing, Supervision, Software, Resources.

Compliance with ethical standards

The authors declare no conflicts of interest. This research did not include human participants or animals.

Declaration of competing interest

None of the authors has a conflict of interest to disclose.

Appendix 1. Hausman test

	RD_intensity	RD_inter	Tang_exp	Intang
Test: Ho: difference in coefficients not systematic				
Hausman test chi2	130.7	200	129.7	140.1
Prob.	0.000	0.000	0.000	0.000

Data availability

Data will be made available on request.

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Wei Wu is currently working as Assistant Professor in the School of Finance and Accounting, Fuzhou University of International Studies and Trade, China. Research interests include the corporate finance, financial disclosure, ESG and sustainability, and artificial intelligence and digital transformation. His work has appeared in Annals of Tourism Research, Business Strategy and the Environment, Energy Economics, Technological Forecasting and Social Change, and International Review of Financial Analysis.

Fadi Alkaraan is Professor of Accounting, Governance & Sustainability and DBA/PhD Supervisor at the University of Gloucestershire (UK) (2020–present), Adjunct Professor at the University of Jordan (2025–2026), Visiting Professor at EM Normandie Business School, Dubai (2023–2024), and Affiliate Professor at both the Gulf Finance Centre, Gulf University for Science & Technology, Kuwait (2023–2025) and the Institute of Management Technology (IMT) Dubai, UAE (2022–2023). He served as Associate Professor at Lincoln International Business School, University of Lincoln (UK), and previously held academic positions at the University of Manchester (UK), Cork University Business School (Ireland), Abu Dhabi University, and United Arab Emirates University (UAE). A Certified Global Business Analyst and Certified Management Accountant (Institute of Certified Management Accountants, Australia and New Zealand), his research focuses on AI-powered innovation strategies, governance, and corporate business transformation toward ESG, the circular economy, and ecosystems. He has published widely, including in 3* ABS-ranked journals.

Chau Le is Associate Professor in Finance at Norwich Business School, University of East Anglia (UEA), UK. Her research lies at the intersection of financial economics, sustainable finance, and banking, with particular interests in climate-related financial risks and financial stability.

Yulu Shi is a research assistant in department of organizational behaviour and human resource at China Europe International Business School. She obtained her MBA in finance from the University of Massachusetts Dartmouth, USA. Her research interests include examining the relationship between, investment scale, investment efficiency, financial flexibility, overinvestment, underinvestment and organizational performances, financial distress. Also she focusses on the organizational behaviour area and business management.

V.G. Venkatesh is a Professor of Supply Chain Management at EM Normandie Business School in France. His academic and research interests include global supply chains, procurement, sustainability, and technology in supply chains. Additionally, he reviews for many prominent logistics and supply chain management journals and serves as an editorial board member and associate editor for ABDC/ABS-indexed journals. He regularly contributes to industry magazines such as Supply Chain Management Review and develops training programs for multinational companies across different continents.

Yangyan Shi is a Chartered Fellow of the Chartered Institute of Logistics and Transport. He is a faculty member of Macquarie Business School, Macquarie University. His research focuses on operations, logistics and supply chain management.