ORIGINAL SCIENTIFIC PAPER

Empowering Female Leadership for Enhanced Innovation Performance of Companies in Vietnam

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A B S T R A C T

This study examines the relationship between female board representation and firm innovation within Vietnam's private sector. It applies panel data from the World Bank Enterprise Survey for the years 2009, 2015, and 2023 to examine how having women on company boards influences innovation at the firm level. It employs a bivariate probit model and considers distinct characteristics of firms and industries. The findings reveal a significant positive association between female board representation and innovation, particularly in the initial stages of female board membership. However, the impact of female ownership on innovation is more complex, with higher levels of female ownership potentially leading to increased risk aversion. Additionally, firm size, growth, industry affiliation, and export orientation are identified as key determinants of innovation. This study contributes to the growing literature on gender diversity and innovation by providing empirical evidence from the Vietnamese context. It offers actionable insights for Vietnamese policymakers aiming to enhance private sector innovation and competitiveness by promoting gender diversity in corporate governance.

KEYWORDS: *female board representation, firm innovation, bivariate probit model*

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Introduction

In recent years, the Vietnamese government has introduced numerous policies to promote gender equality. Complementing these efforts, research highlights the benefits of gender diversity on corporate boards, linking it to improved financial performance, innovation, and corporate social responsibility (Byron & Post, 2016; Schiebinger, 2017; Griffin, Li, & Xu, 2021). Companies with higher gender diversity, particularly in leadership, tend to outperform their less diverse counterparts, achieving better innovation outcomes and financial results (Opstrup & Villadsen, 2015; Moreno-Gómez et al., 2018). This relationship arises from diverse perspectives that foster creative solutions and innovative ideas. Bernile et al. (2018) further demonstrate that greater board diversity, including gender diversity, reduces stock return volatility, lowers financial leverage, and increases investment in research and development, indicating more prudent decision-making.

In the context of corporate innovation, striking a balance between creativity and risk management is crucial. Excessive managerial risk-taking can lead to poor project selection, undermining long-term value (Adam et al., 2015). Female directors can play a pivotal role in mitigating excessive risk-taking and short-termism, contributing to sustainable innovation strategies. However, some theories, such as Similarity Attraction Theory (Byrne, 1971) and Social Identity Theory (Hogg, 2016), suggest potential challenges of diversity. Individuals are naturally drawn to those with similar demographics and values, which may hinder collaboration and cohesion on diverse boards. Women and members of minority groups may face biases, which can limit their participation and hinder idea sharing, ultimately negatively affecting board performance (Ely et al., 2011). These challenges highlight the complexity of fostering diversity without compromising cohesion.

Despite these theoretical concerns, empirical research on the impact of gender diversity on innovation is limited. Most studies emphasize racial or ethnic diversity, leaving a gap in understanding the specific role of gender dynamics in innovation. Nonetheless, recent studies, such as Ruiz-Jiménez and Fuentes-Fuentes (2016), explore how gender composition influences a firm's innovation capacity. This research gap also extends to the influence of firm size on the relationship between gender diversity and innovation. Large firms with greater resources may better harness gender diversity,

while smaller firms could struggle due to limited structures. Addressing these gaps could help managers and policymakers design tailored diversity initiatives to optimize innovation across firms of varied sizes.

The relationship between gender diversity and company innovation has received more attention in recent academic discourse. This study contributes to the growing body of research on the impact of gender diversity on firm innovation by examining the specific context of Vietnam. Utilizing a panel dataset from the World Bank Enterprise Survey for the years 2009, 2015, and 2023, this paper applies a bivariate probit model to analyze the relationship between female board representation and firm-level innovation, while accounting for potential endogeneity issues. The dataset includes observations from 2009, 2015, and 2023. These years were chosen to highlight important economic and regulatory changes in Vietnam. Specifically, 2009 follows the global financial crisis, 2015 marks increased economic integration due to trade agreements, and 2023 indicates the recovery from the pandemic and the rise of digital transformation. As detailed in Section 3, the dataset provides comprehensive firm-level and industry-level information, enabling a robust analysis of the interplay between gender diversity and innovation outcomes. The findings provide novel insights into the complex interplay between gender diversity, firm characteristics, and innovation outcomes. By exploring the differential impact of female board membership on innovation, this study adds to the existing literature and highlights the potential mechanisms through which gender diversity can enhance firm performance. Based on the theoretical framework and empirical evidence reviewed, the following hypothesis is proposed:

Hypothesis: Increased female representation on company boards in Vietnam is positively associated with enhanced firm-level innovation.

The paper is organized as follows. Section 2 presents a literature review of the relationship between gender equality in board composition and firm innovation. The following section explains the econometric methodology and the data. Section 4 presents the results, and the final section contains the conclusions.

Literature Review

The relationship between gender diversity and firm innovation is grounded in agency theory, upper echelons theory, and gender socialization theory (Ting et al., 2015; Lewellyn & Muller-Kahle, 2016; Amin, Ur Rehman, Ali, & Ntim, 2022). As highlighted by recent studies by Poletti-Hughes and Briano-Turrent (2019) and Amin et al. (2022), agency theory suggests that gender-diverse boards can mitigate agency problems by broadening perspectives and enhancing governance. This is achieved through improved monitoring and transparent decision-making processes. Upper echelons emphasize how the demographic composition of top management teams, including gender diversity, shapes organizational outcomes. (Ting et al., 2015; Tonoyan & Olson-Buchanan, 2023). Gender socialization theory highlights the distinct skills and experiences that women bring to boardrooms, thereby fostering more informed and innovative decision-making (Cronqvist & Yu, 2017; Nadeem et al., 2020).

Recent research has consistently demonstrated the positive impact of female directors on board effectiveness (Boivie et al., 2016; Katmon et al., 2019; Tran et al., 2024). These attributes contribute to better innovation and strategic decision-making. However, challenges arise when managing diversity. While diverse perspectives can drive creativity, they may also reduce group cohesiveness and employee satisfaction if conflicts are poorly managed (Nishii, 2013; Schwab et al., 2016). Differences in viewpoints or approaches may generate tension, potentially undermining group harmony.

The growing body of literature underscores the significance of gender diversity in driving innovation and enhancing organizational performance. Research by Opstrup and Villadsen (2015) and newer studies by Tran et al. (2024) suggest that gender-diverse organizations are more likely to consider environmental, social, and governance reputational risks in their strategic decision-making. However, the relationship remains complex and context-dependent. Evidence suggests that the impact of gender diversity varies based on industry type, firm size, organizational culture, and technological intensity, making broad generalizations challenging. This study examines the complex relationship between gender diversity and firm innovation, drawing on insights from agency, upper echelons, and gender socialization theories. It hypothesizes that female board representation has a positive influence on firm innovation by enhancing decision-making, risk-taking, and long-term strategic thinking. However, the extent of this impact is

moderated by firm-specific factors, such as size, industry characteristics, and technological intensity. This study aims to examine the complicated relationship between gender diversity and firm innovation within the context of Vietnam, considering the unique socio-economic and institutional factors that characterize this emerging market.

Data and Methodology

Methodology

A well-specified empirical model should align with both the data and the underlying theory (Box, Hunter, & Hunter, 2005). To examine the determinants of various innovation activities, this study employs a bivariate probit (MVP) model, a suitable technique for analyzing multiple correlated binary choices (Calia & Ferrante, 2013; Agwuet al., 2020). By accounting for the potential interdependence among different innovation types, such as the decision to engage in product innovation or process innovation, the bivariate model provides a more nuanced understanding of the factors influencing firm-level innovation. Following the methodological approach of Chib and Greenberg (1998) and Donkoh et al. (2019), this study utilizes a bivariate probit model to investigate the impact of female board presence on firm innovation.

$$Y^*_{ik} = \beta_k X_{ik} + \alpha_k A_{ik} + \varepsilon_k \qquad (1)$$

$$Y_{ik} = 1 \text{ if } Y^*_{ik} > 0 \text{ and } 0 \text{ otherwise} \qquad (2)$$

In this model, the latent variable Y^*_{ik} represents the unobserved propensity of firm i to adopt innovation type k ($k = 1$ denotes product innovation, $k = 2$ denotes process innovation). The observed binary variable Y_{ik} indicates whether firm i has adopted innovation type k (1 for adoption, 0 otherwise). The model assumes that the two innovation types are correlated, suggesting that unobserved firm-specific factors may simultaneously influence decisions across different innovation domains. The bivariate probit (MVP) model is well-suited for analyzing such correlated binary choices. The model specification includes a set of observed firm characteristics (X_{ik}) and unobserved factors (A_{ik}), such as unobserved heterogeneity across industries and time periods that may influence

innovation decisions. The parameters to be estimated are the coefficients associated with the observed and unobserved factors (β_k and α_k, respectively). The error terms (ε_k) are assumed to follow a bivariate normal distribution. For two types of innovations, the error terms (ε_1, ε_2) are jointly distributed as: (ε_1, ε_2) ~MVN (0, V). After controlling for firm characteristics, if the correlation coefficient between two innovation decisions is statistically significant, it implies that unobserved firm-specific factors, such as firm size, ownership structure, firm age, firm growth, and export incentives, may simultaneously affect the likelihood of adopting both innovations. Firms' adoption of each of the innovation types follows the empirical model specified below:

$$Y_{ik} = \beta_0 + \textstyle\sum_{i=1}^{m}\beta_{ik}\, FC_{ik} + \textstyle\sum_{i=1}^{m}\beta_{ik}\, SC_{ik} + \textstyle\sum_{i=1}^{m}\beta_{ik}\, TE_i + \varepsilon_i \qquad (3)$$
$$\forall = 1 \ldots m \text{ regressors}$$

where β' is a vector of parameters to be estimated. FC_{ik} denotes firm characteristics such as firm size, ownership structure, firm age, firm growth, and export incentives. SC_{ik} denotes sector characteristics, TE_i denotes time effect an ε_i denotes the error term. The Geweke-Hajivassiliou-Keane (GHK) simulator provides unbiased estimates of bivariate normal probabilities, crucial for analyzing complex models with correlated decisions (Gates, 2006; Abay, 2015). By simulating the bivariate normal distribution, GHK accurately estimates model parameters and marginal effects, addressing endogeneity and capturing interdependence among innovation decisions. The error term variance-covariance matrix reflects correlations among unobserved factors influencing these decisions, highlighting interdependence among different innovation types (Gebremariam & Tesfaye, 2018). Cross-equation correlation coefficients, as emphasized by Calia and Ferrante (2013), offer insights into these interdependencies. While reverse causality between firm performance (including innovation) and female board membership lacks empirical support, endogeneity remains a concern, as high-performing firms may be more inclined to appoint female directors. A bivariate probit model, suitable for binary outcomes, addresses potential correlations between innovation types and controls for unobserved heterogeneity. A likelihood ratio test validates the model's use by confirming the significance of error term correlations. While the Hausman test is traditionally used for endogeneity detection, it is less reliable with binary explanatory variables in probit models. Therefore, following Arendt

and Larsen (2006) and Giles et al. (2009), the Wald test is employed as a more robust alternative for assessing endogeneity in this context.

Data

The empirical analysis in this study applies the Vietnamese World Bank Enterprise Surveys (WBES) for the years 2009, 2015, and 2023. This dataset, collected through a thorough categorized random sampling methodology, provides a comprehensive overview of the Vietnamese business landscape. By surveying a diverse range of firms across various sectors and regions, the WBES ensures the representativeness of the sample. The surveys capture essential firm-level information, including characteristics such as size, ownership, sector, and innovation activities. This longitudinal dataset allows for a robust analysis of the determinants and outcomes of innovation activities in Vietnam. Previous studies, including Coluccia et al. (2020), often use R&D expenditures as a proxy for innovation, but this study considers a firm's patenting activities to provide a more comprehensive measure of innovation. Because R&D expenditures only represent one type of observable input to innovation, while there are many other unobservable inputs, such as organizational culture, employee skills, and knowledge management processes. Patenting reflects the tangible outcomes and productivity of a firm's innovation efforts extending beyond the mere inputs.

The Specification of the Model's Explanatory Variables

This study employs two proxies to measure the independent variable of gender diversity. The first is a binary indicator reflecting whether a firm has at least one female director on its board (Rasheed et al., 2021). The second is a continuous variable representing the proportion of female directors on the board, used as a robustness check. Covariate selection, informed by prior research on firm innovation, is summarized in Table 1. These covariates include firm-level characteristics such as age, size, growth, ownership structure, industry, and export status (Stock et al., 2002; Liu et al., 2010; Yildiz et al., 2013; Coad & Segarra, 2014; Gërguri-Rashiti et al., 2017; Brunswicker & Chesbrough, 2018; Anand et al., 2021). Ownership structure significantly impacts innovation. Foreign ownership often enhances innovation through access to advanced technologies, managerial expertise, and global markets (Yiu et al., 2007; Dong et al., 2022).

Conversely, state-owned enterprises (SOEs) may prioritize non-commercial objectives, which can hinder innovation. However, SOEs can leverage government support and resources for large-scale R&D. Strategic partnerships between SOEs and foreign-owned firms combine policy support with technological and managerial expertise (Dong et al., 2022). Firm age and growth also influence innovation. Larger firms have more resources for R&D but may lack the agility of younger firms, which are often more entrepreneurial and innovative (Protogerou et al., 2017). Rapidly growing firms, particularly those in high-growth sectors, are incentivized to innovate to maintain competitiveness (Akcigit & Kerr, 2018). Exporting firms, exposed to global competition and technological advancements, tend to be more innovative, while innovation can also stimulate exports (Siedschlag & Zhang, 2015; Ribau, Moreira, & Raposo, 2017). This study categorizes industries based on the Economic Foundations Sectors framework (Rennings & Rammer, 2011; Blind, 2016), emphasizing sectors with high innovation potential due to regulatory incentives and structural characteristics.

Table 1: The Variables and Their Descriptions

Variables	Description
Product Innovation	New products/services introduced over the last 3 years.
Process Innovation	New establishments / improved processes introduced in the past 3 years.
Female Owner	The firm has at least one female owner on its board (1: Yes; 0: No).
Female Ownership Proportion	The proportion of female ownership in the firm.
Firm Growth	Real annual sales growth is measured as a percentage change in sales between the last completed fiscal year and a previous period.
Foreign Ownership	Percentage of the firm owned by foreign individuals, companies or organizations.
State Ownership	Percentage of the firm owned by the government or state.
Domestic Ownership	Percentage of the firm owned by domestic individuals, companies or organizations.
Age	The age of the firm is based on the year in which the firm began operations.

Variables	Description
Size	Firm size: Categorized based on the number of employees: large (100 or more), medium (20-99), or small (5-19).
Export Status	1 if the percentage of sales (direct export) or the percentage of sales (indirect export) is greater than 0.
Economic Foundations Sector	1 if the firm belongs to one of the following industries: Construction, Retail, Manufacturing, Wholesale, Accommodation / Food Services, or Finance and Insurance; 0 otherwise.

Source: Vietnamese World Bank Enterprise Survey

Result and Analysis

Summary Statistics

The panel dataset incorporates time-series and cross-sectional dimensions, examining variations in female board representation and innovation measures across three years (2009, 2015, and 2023). Given the dataset's limited time-series aspect, the paper emphasizes cross-sectional differences among firms, highlighting firm-specific factors like size, ownership structure, and industry type in shaping board composition and innovation outcomes. Larger firms consistently demonstrate higher innovation levels, while high-tech industries exhibit diverse effects, underscoring the interplay between corporate governance and firm characteristics.

Table 2 presents descriptive statistics for key variables. It reveals that 54.8% of firms report product innovation, measured by new or improved products/services (SD = 0.498), while 46.1% achieve process innovation, reflecting improved processes or establishments (SD = 0.499). Female ownership is notable, with 50.3% of firms having at least one female owner and an average ownership stake of 51.92%. The ownership structure is predominantly domestic (88.8%; SD = 28.86), with limited foreign ownership (8.562%; SD = 26.99). Although foreign ownership can foster innovation via technological and managerial expertise (Liu et al., 2010; Anand et al., 2021), its low representation may constrain these benefits. Domestic firms, often family-operated, prioritize sustainability and market-specific innovations, encouraging calculated risk-taking (Rondi et al., 2019).

Firm characteristics are critical determinants of innovation. Larger firms leverage financial and human resources to drive R&D (Brunswicker & Chesbrough, 2018), while rapid growth, averaging 35.8% (SD = 0.776), often fuels innovation to sustain competitiveness. Younger firms excel in radical innovation due to their agility, while older firms capitalize on experience to achieve incremental advancements (Coad & Segarra, 2014). The dataset's average firm age of 23.494 years (SD = 10.478) reflects this balance. Export activity, averaging 31.7% (SD = 0.465), highlights moderate international market engagement. Exporting firms innovate to meet global standards, reinforcing the innovation-export nexus (Ribau et al., 2017). Additionally, 46.5% of firms belong to Economic Foundations Sectors (SD = 0.498), benefiting from regulatory frameworks and government partnerships that support R&D and innovation (Rennings & Rammer, 2011; Blind, 2016). This sample composition allows for a thorough analysis of the factors driving innovation across different firms and sectors.

Table 2: Descriptive Statistics

Variables	Obs.	Mean	SD	Min	Max
Product Innovation	3,029	0.548	0.498	0.00	1.00
Process Innovation	3,039	0.461	0.499	0.00	1.00
Female Owner	3,045	0.503	0.500	0.00	1.00
Female Ownership Proportion	914	51.92	35.84	1.00	100.00
Foreign Ownership Proportion	3,040	8.562	26.99	0.00	100.00
State Ownership Proportion	3,043	2.181	10.40	0.00	99.00
Domestic Ownership Proportion	3,041	88.80	28.86	0.00	100.00
Firm Age	3,033	23.494	10.478	10	122
Size	3,031	1.931	0.7997	1.00	3.00
Firm Growth Rate	3,045	0.358	0.776	-2.00	2.00
Export Status	3,045	0.317	0.465	0.00	1.00
Economic Foundations Sector	3,045	0.465	0.498	0.00	1.00

Source: Vietnamese World Bank Enterprise Survey and Author's calculations

Marginal Probabilities

Table 3 presents the results of bivariate probit models examining the relationship between female ownership and firm innovation strategies, using two independent variables: Female Owner and Female Owner Proportion.

The findings reveal how female leadership influences innovation and reflect the heterogeneity in firms' innovation strategies. Rather than adhering to a uniform innovation model, firms adopt diverse approaches, either focusing on one type of innovation or combining multiple types. Firms with at least one female owner positively influence process innovation (Marginal Effect (ME) = 0.0416, $p < 0.001$) and joint innovation (ME = 0.0280, $p < 0.05$). These results suggest that innovations are complementary for female-led firms, with strategies emphasizing process and collaborative innovation. However, the percentage of female ownership negatively impacts all innovation types, with the strongest effect on joint innovation (ME = -0.0010, $p < 0.001$). This implies that while female leadership supports innovation, higher proportions of female ownership may indicate structural challenges, such as limited resources or risk-averse tendencies, which constrain broader innovation strategies. Thus, having at least one female owner is beneficial, but a high percentage of female ownership might reflect resource constraints or institutional barriers.

Firms with female owners may also benefit from positive societal perceptions, aligning with expectations of diversity and inclusion. This alignment can enhance their reputation, attract diverse talents, and provide access to innovative-related resources such as grants for diversity-forward companies. These findings partially align with studies by Abdullah et al. (2016) and Chen et al. (2018), which emphasize the role of gender diversity in corporate governance and innovation by introducing different perspectives into decision-making. Regarding ownership structure, foreign ownership positively impacts product innovation (ME = 0.0048, $p < 0.05$) but does not significantly influence process or joint innovation. Foreign firms tend to focus on product innovation to establish market presence and brand identity, often prioritizing proprietary technologies over collaborative efforts. State ownership has a significant impact on joint innovation (ME = 0.0100, $p < 0.05$), likely due to the government's encouragement of strategic collaborations and technological development in key industries. Conversely, domestic ownership shows no significant effect across innovation types, suggesting a focus on short-term profitability over long-term innovation.

Firm growth has a strong influence on all types of innovation, particularly product innovation (ME = 0.0736, $p < 0.001$), as growing firms prioritize innovation to capture market share and enhance their competitiveness. Similarly, older firms exhibit a higher probability of engaging in joint innovation (ME = 0.1235, $p < 0.001$), leveraging their

accumulated experience and resources. These findings are consistent with the study of Akcigit and Kerr (2018), which emphasize the role of growth and age in fostering innovation. Firm size significantly enhances innovation, especially process innovation (ME = 0.3118, p < 0.001). Larger firms benefit from superior R&D capabilities and access to resources, enabling them to scale innovations efficiently. Exporting firms also exhibit significant positive effects on all innovation types, particularly product innovation (ME = 0.0624, p < 0.001), driven by the competitive demands of global markets. These results align with those of Ribau et al. (2017) and Dong et al. (2022), who also highlight the importance of innovation for export performance.

Operating in foundational sectors strongly promotes innovation, particularly process innovation (ME = 0.0716, p < 0.001). Foundational sectors provide critical infrastructure and resources for innovation, as emphasized by Rennings and Rammer (2011). Additionally, the year 2009 shows a significant positive impact on all innovation types, with the strongest effect on process innovation (ME = 0.4307, p < 0.001), reflecting policy-driven recovery measures post-2008 financial crisis (Brancati et al., 2022). The model's statistical validity was confirmed through a Wald test, rejecting the null hypothesis that all coefficients are simultaneously zero. Significant correlations between innovation types validate the use of the bivariate probit model over a standard probit model, confirming the nuanced relationships between ownership, firm characteristics, and innovation strategies.

Table 3: Marginal effects (ME) of covariates on innovation types

Variable	Product Innovation	Process Innovation	Joint Innovation	Product Innovation	Process Innovation	Joint Innovation
Firm with female ownership	0.0028	0.0416***	0.0280*			
Female Ownership Percentage				-0.0009*	-0.0016**	-0.0010***
Foreign Ownership	0..0048*	-0.0009	0.00008	0.0052	-0.0026	0.0001
State Ownership	0.0019	0.00005	0.0017	0.0100*	-0.0037	0.0006
Domestic Ownership	0.0023	-0.0008	0.0003	0.0059	-0.0020	0.0006
Firm Growth	0.0736***	0.0567***	0.062***	0.0167	-0.0169	-0.0028
Age of firm (log)	0.1538***	0.1084***	0.1235***	0.1202**	-0.0047	0.0285
Small Firm	0.0444	0.2431*	0.1728	-0.0065	1.014**	0.5427***
Medium Firm	0.0793	0.3118***	0.2295*	0.0901	1.1211**	0.6162***

Variable	Product Innovation	Process Innovation	Joint Innovation	Product Innovation	Process Innovation	Joint Innovation
Large Firm	0.0683	0.3122***	0.2260*	0.0878	1.1078**	0.6121***
Export Status	0.0624***	0.0488***	0.0532***	0.0278	0.0395	0.0257
Economic Foundations Sector	0.0680***	0.0716***	0.0670***	0.0305	0.0504*	0.0327*
Year 2009	0.3826***	0.4307***	0.4117***	-0.01186	-0.0494	-0.0259
Observations		3,008			900	
The arctangent of the correlation coefficient		0.962***			0.516***	
Wald test of rho=0: chi^2		478.519***			58.4112***	

Note: *** $p<0.001$, ** $p<0.01$, * $p<0.05$

Source: Author's calculations

Discussion and Robustness Tests

The findings of this study provide sophisticated insights into the relationship between female ownership and firm innovation. The hypothesis, which posited that female ownership would positively influence firm innovation, is partially confirmed. Specifically, having at least one female owner significantly enhances process and joint innovation. This aligns with the study by Abdullah et al. (2016), Chen et al. (2018), and Griffin et al. (2021). Female leadership brings diverse perspectives and collaborative approaches, fostering these specific types of innovation. However, the negative impact of higher female ownership percentages suggests that beyond a certain threshold, structural limitations, such as resource constraints or risk aversion, may impede broader innovation strategies. The positive impact of foreign ownership on product innovation is consistent with the established literature. For example, Dong et al. (2022) emphasize the focus of foreign firms on establishing a market presence through product differentiation. Similarly, the authors also discuss the positive effect of state ownership on joint innovation. It reflects the government's role in promoting strategic collaborations, as seen in various national innovation policies. The strong positive influence of firm growth, age, size, and exporting status on innovation aligns with the findings of Ribau et al. (2017), Akcigit et al. (2018), and Dong et al. (2022). These factors provide firms with the necessary resources, experience, and market pressures to innovate. The significant impact of foundational sectors and the year 2009 underscores the importance of sectoral context and

macroeconomic factors in driving innovation, as highlighted by Brancati et al. (2022).

Furthermore, this study examines the potential endogeneity in the impact of female board representation on innovation using an instrumental variables (IV) approach. Director appointments are influenced by internal firm dynamics, including strategic goals, operational needs, and organizational culture. Male-dominated sectors, such as heavy industry, construction, and manufacturing, exhibit a lower propensity for female director appointments (Arena et al., 2015). Furthermore, self-selection bias may exist, with innovative firms potentially attracting more female directors due to their alignment with the values or career aspirations of these individuals. Following Nadeem et al. (2020), this study employs the system-generalized method of moments (SGMM) and IV-Probit to account for this endogeneity. As suggested by Nadeem et al. (2020), average industry gender diversity is used as an instrument. This instrument is likely correlated with a firm's gender diversity, as firms in gender-diverse industries may face social or competitive pressures to conform to industry norms, which in turn influence their board composition and leadership diversity. This approach aims to isolate the exogenous component of female board representation to assess its impact on innovation outcomes accurately.

The key assumption in using an instrument is that it should not directly affect the dependent variable—in this case, a firm's innovation. Industry average gender diversity reflects broader trends and norms rather than specific firm-level factors, making it less likely to have a direct impact on a focal firm's innovation capabilities or outputs. Once again, the presence of female board members is positively significant in all specifications, indicating that the main results are robust to endogeneity from omitted variable bias and reverse causality. The unreported results of the specification tests of GMM and 2SLS indicated that our instruments were valid and correctly identified.

Table 4: Endogeneity tests

Independent Variables	IV-Probit		SGMM	
	Product Innovation	Process Innovation	Product Innovation	Process Innovation
Firm with female ownership	0.863***	0.779***	1.691***	1.743***
	(0.281)	(0.262)	(0.191)	(0.201)
Foreign Ownership	0.00522*	0.00252	0.0103**	0.00571
	(0.00292)	(0.00237)	(0.00524)	(0.00476)
State Ownership	0.00340	-0.000522	0.00707	-0.00108
	(0.00299)	(0.00247)	(0.00631)	(0.00541)
Domestic Ownership	0.00208	-0.000527	0.00413	-0.00115
	(0.00259)	(0.00205)	(0.00521)	(0.00454)
Firm Growth	0.0774***	0.0605***	0.147***	0.127***
	(0.0150)	(0.0135)	(0.0395)	(0.0389)
Age of firm (log)	0.0851*	0.0575	0.148	0.101
	(0.0443)	(0.0410)	(0.107)	(0.106)
Medium Size	0.00960	0.0357	0.0138	0.0819
	(0.0291)	(0.0266)	(0.0565)	(0.0690)
Large Size	-0.0690	-0.0313	-0.142**	-0.0738
	(0.0466)	(0.0441)	(0.0718)	(0.0874)
Export Status	0.0211	0.0164	0.0367	0.0366
	(0.0348)	(0.0296)	(0.0719)	(0.0708)
Economic Foundations Sector	0.157***	0.156***	0.297***	0.338***
	(0.0266)	(0.0236)	(0.0595)	(0.0691)
Year 2009	-1.065***	-1.210***	0.597***	0.796***
	(0.0907)	(0.0922)	(0.157)	(0.208)
Constant	-0.664**	-0.418*	-2.153***	-1.838***
	(0.296)	(0.244)	(0.655)	(0.590)
Observations	2,758	2,768	2,758	2,768
Pseudo-R^2	0.2012	0.2284	0.2824	0.0490

Note. This table presents the system generalized method of moments (SGMM) and IV -Probit estimations of the impact of female board presence on process and product innovation. The instrumental variable is the industry average gender diversity. For brevity, the results of the first stage of 2SLS are not reported. Robust standard errors are in parentheses. All variables are defined in Table 1. *** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculations

Conclusion

This study contributes to the growing body of research on the impact of gender diversity on firm innovation by employing a bivariate probit model.

This approach enables simultaneous analysis of multiple innovation types, accounting for both observed and unobserved firm characteristics. The findings confirm that the appointment of female directors, particularly the first female director, significantly enhances firm innovation. This effect is likely driven by increased cognitive diversity, improved decision-making through diverse perspectives, a greater propensity for exploring innovation, and greater openness to risk-taking. However, the relationship between female ownership and innovation is more complex. While the initial presence of a female owner can foster inclusivity and spark novel ideas, higher proportions of female ownership may indicate resource constraints or a tendency towards risk aversion, which can hinder broader innovation strategies. Firm-level characteristics also play a critical role in innovation. Larger, high-growth firms and those in knowledge-intensive industries are more likely to engage in innovative activities. Foreign ownership and involvement in foundational economic sectors further enhance innovation capabilities. These findings suggest that innovation outcomes are shaped by a complex interplay of gender diversity, firm attributes, and industry context.

Based on the findings, it is recommended that companies actively pursue the inclusion of female directors on their boards to enhance diversity and innovation. Appointing the first female director is particularly impactful, and companies should prioritize identifying qualified female candidates to bring diverse perspectives. However, simply increasing female representation is not enough. Companies must foster an inclusive board culture through training, mentorship, and open communication. Additionally, firms with high female ownership should address potential resource constraints and risk aversion tendencies by leveraging strategic partnerships, securing funding, and encouraging calculated risk-taking. A well-balanced board composition is essential, ensuring that gender diversity is optimized in accordance with industry- and company-specific needs.

Policymakers can promote gender diversity on corporate boards by offering targeted incentives, such as tax benefits or subsidies, to companies that meet specific diversity targets. Mandatory disclosure requirements can further enhance transparency and accountability by requiring firms to report their board composition and gender diversity policies. While gender quotas can effectively increase female representation, they should be implemented cautiously to prevent unintended consequences, such as tokenism, ensuring that diversity efforts lead to meaningful inclusion and improved corporate

governance. This study is subject to certain limitations. It focuses solely on product and process innovation, neglecting other innovation dimensions, such as organizational and marketing innovation, thereby limiting a holistic understanding of the impact of gender diversity. The dataset's limited timeframe restricts the analysis of long-term trends. Future research should expand the dataset's temporal scope and size for greater robustness. Incorporating qualitative methods, such as case studies and interviews, could provide richer insights into the mechanisms linking gender diversity and innovation. Furthermore, cross-country and industry-specific analyses are recommended for a more comprehensive understanding of this complex relationship.

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