THE LEGAL AND CORPORATE GOVERNANCE PERSPECTIVE ON FEMALE DIRECTORS' EFFECT ON FIRM PERFORMANCE: AN ENDOGENEITY ANALYSIS

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Abstract

This study examines the influence of female directors on firm performance while addressing the endogeneity often overlooked in prior research. Using a panel dataset of 17,220 firm-year observations from publicly traded U.S. non-financial firms between 2000 and 2018, the study employs various econometric methods, including fixed effects (FE), two-stage least squares (2SLS), system generalized method of moments (GMM), and a control function approach, to determine the causal impact of board gender diversity. The findings show a positive link between female board representation and firm performance, even after accounting for endogeneity, reverse causality, and omitted variable bias. These results support the predictions of agency and resource dependency theories and suggest that gender diversity enhances governance and firm outcomes.

Keywords: Firms' Performance, Gender Diversity, Systematic Review, Endogeneity Problem

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1. INTRODUCTION

The implications of women's representation on boards for firm performance have been widely debated. Many recognize that boards influence firms' decision-making. Therefore, the boards' composition is likely to affect firms' performance. Based on this reasoning, several studies examine the impact of women's representation on boards on firms' performance (Adams & Ferreira, 2009; Carter et al., 2003). Importantly, at a time when gender-related legislation is proliferating, knowledge of its consequences remains too limited. Findings are mixed. Others maintain that, because women typically do not belong to the "old boys club", they correspond more closely to the concept of independent directors than their male counterparts, a feature emphasized in theory as a positive attribute of board structure (Hillman et al., 2007). On the other hand, there is also recognition of women's limited experience in managerial positions, their lesser drive to advance to the top, and their poor performance in competitive environments (Terjesen et al., 2009). These attributes are likely to turn their presence on boards ineffective. There are also suggestions that the presence of women triggers resentment to diversity and diminishes the quality of boards' working practices (Westphal & Milton, 2000). Some studies found that women's presence on boards positively affects firms' performance (Erhardt et al., 2003; Dang et al., 2020), whereas others show no discernible impact (Carter et al., 2010).

Although there is a view that gender diversity on boards enhances firms' performance, theoretical predictions regarding the impact of women directors on firms' performance remain conflicting. While women's presence may bring different talents, perceptions, behaviors, and communication styles, thereby enhancing firms' decision-making and performance (Adams & Ferreira, 2009), it may also have negative effects on firms' performance. Consequently, mixed findings regarding the impact of women's presence on boards on firms' performance have been established in the literature. Some studies found that women's presence on boards positively affects firms' performance (Carter et al., 2003), whereas others show no discernible impact (Solal & Snellman, 2019). Yet other studies show that, after controlling for endogeneity, women's board participation reduces firms' performance.

The empirical evidence is inconclusive, even in studies conducted in the same country. Some studies found that women's presence on boards positively affects firms' performance, whereas others show no discernible impact. It is also unsurprising that many studies examining the relationship between board gender diversity and firm performance fail to control for endogeneity (Wintoki et al., 2012; Adams, 2016). This serious technical shortcoming has not resolved the ongoing debate regarding the impact of female directors on firms' performance, almost two decades after the issue began to attract academic and public interest. Given the importance of this issue, it is disturbing that there is such a limited understanding of the impact of women's presence on boards on firms' performance. Additionally, many prior studies draw samples from developed countries only and neglect the contexts of developing countries (Terjesen et al., 2009), which is unfortunate, as women's opportunities to serve on large public boards in developing countries have come to be widely recognized. Moreover, as more governments introduce gender-related legislation governing board composition, it is critical to deepen understanding of the likely consequences of these policies. If women's participation harms performance, such policies would negatively affect firms and economies. The issue is particularly important in the contemporary business environment, in which boards increasingly assert their power and become more involved in firm management.

The empirical approach should entail greater effort to ensure the use of a valid method. This study focuses on the endogeneity issue in regression analysis, which has been largely neglected in prior research (Wooldridge, 2010; Wintoki et al., 2012). Our review of the literature indicates that differences in model specifications and performance measures largely account for the conflicting results (Adams et al., 2015). However, they did not explicitly address the endogeneity concern. There are reasons to assume that better-performing firms are more likely to appoint women to the board, such that the two are jointly determined, thereby violating the causal relationships considered in the model (Adams & Ferreira, 2009). Regarding the former, it is also possible that firms seeking to improve their performance appoint female directors, introducing reverse causality (Adams & Ferreira, 2009). Studies conducted in emerging markets found that high-performing firms were more likely than low-performing firms to make board appointments consistent with high governance practices (Dang et al., 2020), raising concerns that better-performing firms are subject to greater pressure to diversify their boards or have the resources to support such moves even when they are not in agreement with economic goals.

This study contributes to the literature in several ways. First, it uses a large panel dataset of publicly listed U.S. non-financial firms over 19 years (2000–2018), providing a comprehensive perspective on the evolution of gender diversity and its implications for firm performance. Second, unlike many prior studies, it applies multiple econometric methods, including a fixed effect (FE) panel regression that controls for unobservable factors that are constant over time, two-stage least squares (2SLS), system generalized method of moments (GMM), and a control function approach combined with correlated random effects (CRE), to explicitly address the endogeneity problem (Dang et al., 2020). These methods help mitigate concerns related to omitted variable bias, reverse causality, and dynamic endogeneity (Wintoki et al., 2012; Adams & Ferreira, 2009).

Third, the study goes beyond the general female director ratio by examining the role of independent female directors and using alternative diversity measures such as the Blau index, thereby capturing different dimensions of board gender composition (Terjesen et al., 2016; Campbell & Mínguez-Vera, 2008). Moreover, it explores industry-level variations and firm characteristics that influence board composition, providing additional robustness (Chen et al., 2017).

This study is highly relevant to both the scholarly literature on corporate governance and to managerial and regulatory practice. From an academic perspective, it contributes to a long-standing and unresolved debate on whether board gender diversity improves firm performance (Srinidhi et al., 2011; Nielsen & Huse, 2010). Prior empirical evidence remains mixed, largely due to differences in empirical settings, performance measures, and methodological approaches that often fail to adequately address endogeneity concerns (Hermalin & Weisbach, 2003). By explicitly addressing omitted variable bias, reverse causality, and dynamic endogeneity through multiple econometric techniques, this study enhances the methodological rigor of research in this field and responds to repeated calls in the literature for more robust causal inference. In doing so, it helps reconcile conflicting findings and provides clearer evidence on the performance implications of female board representation. From a practical standpoint, the findings are directly relevant to policymakers, regulators, investors, and corporate boards, particularly given the increasing adoption of gender diversity regulations and voluntary governance codes. Understanding whether and how female directors affect firm performance is crucial for evaluating the economic consequences of diversity initiatives and for guiding board composition decisions that balance regulatory compliance, governance quality, and firm value creation.

Overall, this study addresses a critical gap in the corporate governance literature by providing methodologically robust evidence on the relationship between board gender diversity and firm performance. The findings have significant implications for regulators, investors, and boards considering gender quotas or other diversity-enhancing initiatives.

The study is structured as follows. Section 2 overviews the theoretical basis for conducting the research. Section 3 describes the methodology used. Section 4 presents and explains the research findings. Finally, Section 5 finalizes the paper with a conclusion.

2. LITERATURE REVIEW

2.1. Theoretical background

Board of directors' roles, including monitoring and control, may partially influence a firm's performance, and board composition, including gender, may affect a board's effectiveness (Carter et al., 2010). Adams and Ferreira (2009) reported that board monitoring is greater when the board is heterogeneous than when it consists only of male directors. Possibly because board gender diversity benefits from different perspectives to board decision-making, such as understanding the marketplace (Carter et al., 2003), considering the interests of multiple shareholders (Amorelli & García-Sánchez, 2020), and allowing directors to find more alternatives to address and evaluate a firm's problems by enhancing innovation and creativity (Campbell & Mínguez-Vera, 2008).

The positive attributes that female directors bring to boards include serving as an effective internal corporate governance mechanism, reducing agency problems between shareholders and managers (Erhardt et al., 2003), and improving a firm's accountability and financial reporting quality (Gul et al., 2011; Srinidhi et al., 2011).

By contrast, according to social identity theory, individuals categorise themselves into subgroups on the basis of demographic attributes, such as gender or education (Tajfel, 1978), creating in-group and out-group networks that limit the influence that female directors have on firms' decisions (Westphal & Milton, 2000). In other words, female directors' voices would not be heard when male directors dominate the board. Similarly, Joecks et al. (2013) noted that a firm's performance may be adversely affected when female directors are appointed as "tokens" rather than for their intrinsic skills; in such cases, those female directors could, in turn, impede effective engagement in board decisions.

2.2. Endogeneity issue

It has been noted that board structures, including the presence of female directors, are not exogenous to a firm's performance (Hermalin & Weisbach, 2003). Therefore, endogeneity has become a well-known challenge in the corporate finance literature and can affect research inferences if not addressed (Adams & Ferreira, 2009). The first cause of this problem is "omitted variables" that could bias the results if they are not included in a research regression (Wooldridge, 2010). Adams and Ferreira (2009) clarified the link between female directors and a firm's performance as a "firm choice", meaning that a firm's characteristics could influence female directors' appointments. This point leads to the second cause of endogeneity, which is the issue of "reverse causality". Furthermore, Wintoki et al. (2012) stressed that the endogeneity problem of corporate governance and firms' performance is both complex and dynamic. In other words, firms' current outcomes are determined by their past performances, which could mean that female directors' appointments in year t rely on a firm's performance in year $t - 1$.

Omitted unobserved variables include factors relevant to the regression, such as a firm's characteristics, that could affect gender diversity and firm performance (Adams et al., 2009). Dang et al. (2020) noted that a firm's size effect may increase the likelihood of appointing female directors, as larger firms are exposed to greater stakeholder scrutiny. Beyond a firm's characteristics, there are unobserved variables, such as its culture or national institutional system, that could affect performance. However, these unobserved variables may be infeasible to collect or measure; hence, they are often omitted. This source of endogeneity has been addressed in the previous literature using panel data, which employs FE estimation (Wooldridge, 2010). Other research addressed this concern by using instrumental variables that are correlated with the endogenous variables (Adams & Ferreira, 2009).

Reverse causality is also referred to as "simultaneity", which exists between the dependent and independent variables. As noted earlier, Adams and Ferreira (2009) stated that successful firms would appoint more female directors to their boards, suggesting that the relationship between firms' performance and female directors may be a function of success and size, as well as of female directors. In other words, there would be two outcomes of such a relationship: either more female directors could affect their firms' performance, or vice versa. Therefore, to address this concern, the lagged (previous value) of the endogenous variables is used. Third, the "dynamic issue" is discussed by Wintoki et al. (2012), who explain that any changes, whether in current corporate governance or a firm's performance, are a result of past performances of that firm, suggesting that dynamic endogeneity is addressed with a GMM; an approach proposed by Arellano and Bond (1991).

2.3. Hypothesis development

The relationship between board gender diversity and firms' performance is commonly framed in the extant literature by the agency and/or resource dependency theories (Terjesen et al., 2009). Agency theory, as described by Jensen and Meckling (1976), frames the fundamental economic notions of the principal-agent relationship and asymmetric information. Managers can exploit such incomplete information and behave opportunistically to maximise their own wealth. Agency problems can be mitigated through effective internal control and monitoring. Board gender diversity can serve as a control mechanism for board activities, as diverse perspectives enhance board monitoring and independence (Carter et al., 2003). Female directors also contribute to better decision-making by being more involved in the process, for instance, by attending more board meetings than their male counterparts (Adams & Ferreira, 2009). Such engagement in effective monitoring is associated with positive firm outcomes, including the quality of financial reporting (Srinidhi et al., 2011) and the development of a board's strategic and operational control (Nielsen & Huse, 2010).

Resource dependency theory highlights the significance of social capital, which can increase organisational power through directors' networks, relations with various stakeholders, and the external environment (Pfeffer & Salancik, 1978). As this theory focuses on directors and their intrinsic value, it has been linked to human capital theory, given the gendered skills and experiences associated with directors (Terjesen et al., 2009). In terms of education and experience, female directors' education is considered equal to that of male directors, but their business executive experience is lower (Terjesen et al., 2009). In addition, a focal point in resource dependence theory is the benefit of independent female directors to a board's effectiveness, as they bring unique skills and prestige (Hillman et al., 2007). Firms can reduce external risk through the competencies of female directors, such as their advice, communication, and legitimacy. In general, these two theories treat director or board diversity (including gender) as predictors of firms' outcomes, which may increase their performance and value.

Gender diversity research has increased with respect to firms' performance due to inconclusive findings, with a positive relationship (Erhardt et al., 2003; Carter et al., 2003; Dang et al., 2020), a negative relationship (Adams & Ferreira, 2009; Solal & Snellman, 2019), and a non-significant relationship (Carter et al., 2010). These inconclusive results might result from different reasons, such as sample size, sample period, the methodology used, and empirical specifications (Adams et al., 2015), as well as endogeneity (Wintoki et al., 2012; Adams, 2016), such as omitted variables, reverse causality, and dynamic endogeneity.

This ambiguity in the findings on this relationship may affect policymakers' decisions about whether to require firms to increase the number of female directors on their boards, underscoring the importance of systematically reviewing prior findings and research methods.

H1: Female board of directors positively influences firm performance.

3. RESEARCH METHODOLOGY

3.1. Data and sample

This study covers all publicly listed U.S. firms included in the S&P index over 19 years, from 2000 to 2018. The period begins in 2000 because the BoardEX database, which contains information on board directors, has minimal data prior to that year. Financial data is obtained from Compustat. Following prior literature, all economic and utility firms are excluded from the sample because their regulations impose liability risks on their directors relative to those of non-financial firms (Adams & Mehran, 2012; Sila et al., 2016). The observations of non-financial firms total 17,220. Outliers of financial variables are winsorised at the 98% level (Bharath & Shumway, 2008).

3.2. Measurement of variables

3.2.1. Dependent variable

Firms' performance is measured with *Tobin's Q* and return on assets (*ROA*). *Tobin's Q* is calculated as total assets minus equity plus the market value of equity, over total assets. *ROA* is calculated as net income before extraordinary items to total assets (Adams & Ferreira, 2009; Terjesen et al., 2016). *ROA* reflects firms' abilities to generate accounting revenues in excess of expenses on a historical basis, whereas *Tobin's Q* indicates market expectations of a firm's future cash flow (Dezsö & Ross, 2012).

3.2.2. Independent variables

The female directors ratio (*Female proportion*) denotes the number of female directors divided by the total number of board directors (Adams & Ferreira, 2009). This variable is inter-exchanged with the ratio of independent female directors, measured by using the number of independent female directors, divided by the number of independent directors (Terjesen et al., 2016), and the Blau index[1], measured as $(1 - \sum p_i^2)$, where i represents a ratio of the board of directors in each category (categories are male and female directors) (Dang et al., 2020).

3.2.3. Control variables

Drawing on prior literature, common control variables encompassing both board and firm characteristics were employed. Regarding board characteristics, *Board size*, *Board independence*, and chief executive officer (CEO) duality (*CEO/Chair duality*) are included. *Board size* is measured as the logarithm of the total number of directors (Carter et al., 2010). *Board independence* is calculated as the ratio of total non-executive directors to total directors on the board (Pucheta-Martínez & Gallego-Álvarez, 2020). Pucheta-Martínez and Gallego-Álvarez (2020) found a positive association between board size and independence and a firm's performance, noting that these two factors increased the directors' board-monitoring function. *CEO/Chair duality* is a dummy variable, coded 1 if the CEO and the chairman are the same person, and 0 otherwise. CEO duality increases a CEO's power over board directors, which may negatively affect the firm's decisions and performance (Fama & Jensen, 1983). In contrast, Pucheta-Martínez and Gallego-Álvarez (2020) found a positive association between CEO duality and firm performance, highlighting potential benefits of enhancing shareholder value, such as the CEO's success and reputation.

Firm characteristics, such as *Dividends*, research and development (*R&D*), *Firm size, Firm age, Firm growth*, and *Leverage*, are additional variables used

[1] This index is an alternative measure for gender representation that range between 0 to 50% (when female directors number is equal to men directors).

to evaluate a firm's performance. *Dividends* is a dummy variable that equals 1 when firms pay dividends in the given year, and 0 otherwise. *Dividends* might have a positive impact on a firm's performance (Terjesen et al., 2016; Papangkorn et al., 2021). *R&D* is a ratio of R&D expenses over total assets. High R&D expenditure is associated with superior firm performance (Akbar et al., 2016). In addition, Vithessonthi and Racela (2016) noted that R&D investments helped firms build new knowledge, which is a unique resource that makes the firm different (and better) from its rivals. Therefore, Vithessonthi and Racela (2016) found that R&D investments are positively associated with a firm's long-term performance (Tobin's Q), but negatively with short-term measures of a firm's performance.

Firm size is measured by using the natural logarithm of total assets. Dang et al. (2020) noted that monitoring costs increase as firm size increases due to greater complexity. Therefore, a firm's size is expected to affect its performance negatively (Adams & Ferreira, 2009; Dang et al., 2020). A firm's age is measured by the total number of years of total assets reported in Compustat since 1977 (Srinidhi et al., 2011). An older firm's performance might deteriorate due to rent-seeking behaviour by directors (Dang et al., 2020). A *Firm growth* is the percentage growth between year t and $t - 1$. This growth rate is considered a significant determinant of the firm's performance, as noted by Green and Jame (2013), with a positive association expected between them. *Leverage* is measured as total debt divided by total assets. Leverage is a burden for managers, as it requires generating sufficient cash to meet the firm's interest and debt obligations. As a result, a high leverage ratio is expected to reduce a firm's financial performance (Campbell & Mínguez-Vera, 2008).

4. RESULTS AND DISCUSSION

4.1. Descriptive statistics

Table 1 reports means comparisons. *Tobin's Q* is slightly lower in firms with female directors (2.01) than in firms with all-male boards (2.09). The mean *Tobin's Q* for the total sample (2.04) is similar to the findings of Adams and Ferreira (2009) and Papangkorn et al. (2021), but larger than those of Carter et al. (2010) and Dezsö and Ross (2012). On the other hand, *ROA* is higher in firms with female directors (14%) than in firms without female directors (12%). With regard to the control variables, firms with female directors have larger boards, greater board independence, larger firm size, and higher dividend levels. These results are consistent with previous findings that report a positive correlation between female directors and these control variables (Terjesen et al., 2016).

Table 1. Mean difference test between gender-diverse firms and non-gender-diverse firms for the full sample

Variables	***Full sample***		***Firm years obs. with female directors***		***Firm years obs. without female directors***		***t-test diff***
	(1) Mean	***(2) Std. dev.***	***(3) Mean***	***(4) Std. dev.***	***(5) Mean***	***(6) Std. dev.***	***(5)–(3)***
No. of observations	17,220		11,275		5,945		
Tobin's Q	2.040	1.248	2.010	1.190	2.097	1.351	0.086***
ROA	0.131	0.097	0.138	0.088	0.119	0.111	-0.019***
Firm size	7.358	1.653	7.840	1.620	6.443	1.287	-1.396***
Leverage	0.475	0.200	0.512	0.190	0.406	0.199	-0.106***
Firm age	32.264	5.112	33.001	5.169	30.867	4.696	-2.134***
Firm growth	0.108	0.235	0.086	0.200	0.151	0.284	0.065***
R&D	0.034	0.056	0.028	0.049	0.045	0.065	0.016***
Dividends	0.505	0.499	0.591	0.491	0.341	0.474	-0.249***
Board size	2.152	0.263	2.243	0.228	1.981	0.237	-0.261***
Board independence	0.684	0.136	0.706	0.130	0.642	0.137	-0.064***
CEO/Chair duality	0.573	0.494	0.566	0.495	0.587	0.492	0.020***

*Note: *** p < 0.01.*

Table 2 presents the correlation among all variables. *ROA* has a positive and significant correlation with *Tobin's Q* and with the presence of female directors. Female directors have a negative but not significant correlation with *Tobin's Q*. In general, there is no strong correlation among the independent variables, except for a positive and significant correlation of approximately 0.60 between *Firm size* and *Board size*. To further assess multicollinearity, variance inflation factors (VIF) were calculated. All VIF values were below the critical value of 10 (i.e., below 1.98), indicating the absence of multicollinearity.

Table 2. Correlation matrix

Variables	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***	***(9)***	***(10)***	***(11)***
(1) *ROA*											
(2) *Tobin's Q*	0.385***										
(3) *Female proportion*	0.086***	-0.008									
(4) *Board size*	0.108***	-0.102***	0.337***								
(5) *Board independence*	0.009	-0.040***	0.213***	0.220***							
(6) *Dividends*	0.204***	-0.062***	0.220***	0.339***	0.138***						
(7) *Leverage*	-0.059***	-0.261***	0.228***	0.364***	0.153***	0.229***					
(8) *Firm growth*	0.157***	0.257***	-0.129***	-0.103***	-0.076***	-0.141***	-0.106***				
(9) *R&D*	-0.281***	0.300***	-0.122***	-0.214***	-0.005	-0.267***	-0.273***	0.071***			
(10) *Firm size*	0.125***	-0.159***	0.354***	0.608***	0.237***	0.361***	0.468***	-0.083***	-0.267***		
(11) *Firm age*	-0.026***	-0.045***	0.289***	0.045***	0.225***	0.087***	0.082***	-0.126***	-0.0410***	0.174***	
(12) *CEO/Chair duality*	0.074***	0.006	-0.010	0.016*	0.063***	0.058***	0.018*	0.010	-0.0784***	0.0934***	-0.239***

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

4.2. Main results

4.2.1. Return on assets as a dependent variable

Table 3 presents the regression results examining the relationship between the female directors' ratio and firm performance, measured by ROA. All estimations presented a positive and significant relationship among these variables. Columns (1) and (2) present results from ordinary least squares (OLS) and FE estimations, which do not address endogeneity concerns. Columns (3) and (4) present 2SLS estimations following Adams and Ferreira (2009) and Liu et al. (2014) with two instruments: male connected to female directors (i.e., male directors who are connected to female directors on other firms are more likely to bring female directors into their firms' boards) and the female industry ratio (e.g., if a firm has 12% of female directors in a particular industry, then other firms would increase female appointments to that same ratio). These two instruments meet the conditions for validity of being highly correlated with the proportion of female directors on the board [see Table 4, columns (1) and (3)] and that instruments are not weak, so preventing any bias in research inferences (i.e., the value of the Kleibergen-Papp-Wald statistic is higher than critical values, so confirming the absence of a weak instrument). As in Adams and Ferreira (2009), directors' seats in columns (3) and (4) are measured by all directors' seats and male directors' seats, respectively as the number of instruments is larger than the endogenous variables (female director ratio), a Hansen J-statistic validates the joint use of instruments (i.e., suggesting that instruments are not valid with a statistic of about 0.04). Therefore, the model is estimated with system-GMM in column (5). The AR2 statistic indicates whether the estimation exhibits second-order serial correlation; a p-value greater than 0.05 indicates no evidence of such correlation. This problem is addressed by using two lags of *ROA*, yielding a p-value greater than 0.10, as reported. For instrument validity, both the Hansen test and the difference in the Hansen test p-values are reported as 0.133 and 0.617, supporting the conclusion that all instruments are valid. However, using additional lags of the independent variables may weaken the instrument set, favouring the use of the control function as an estimation method (Dang et al., 2020).

Table 3. Female directors' effect on firm performance using *ROA* as a dependent variable

Variables	*OLS*	*FE*	*2SLS*		*GMM*	*Control function*	
			All seats	*Male seats*		*Exogenous*	*Endogenous*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Female proportion	0.0222***	0.0229***	0.0925**	0.0878***	0.0451**	0.0146***	0.0138***
	(0.0045)	(0.0075)	(0.0372)	(0.0304)	(0.0202)	(0.0043)	(0.0043)
Board size	0.0093***	0.0048	0.0091	0.0094	0.0289*	0.0054	0.0033
	(0.0022)	(0.0038)	(0.0084)	(0.0083)	(0.0162)	(0.0035)	(0.0036)
Board independence	0.0048	0.0027	0.0046	0.0049	0.0312	0.0017	-0.0020
	(0.0038)	(0.0063)	(0.0117)	(0.0116)	(0.0202)	(0.0057)	(0.0060)
Dividends	0.0094***	0.0050***	0.0299***	0.0300***	0.0079	0.0021	0.0012
	(0.0011)	(0.0018)	(0.0037)	(0.0037)	(0.0071)	(0.0017)	(0.0017)
R&D	-0.1043***	-0.2825***	-0.4753***	-0.4754***	-0.2522***	-0.2016***	-0.2006***
	(0.0186)	(0.0470)	(0.0520)	(0.0520)	(0.0667)	(0.0384)	(0.0384)
Firm size	-0.0006	-0.0153***	0.0041**	0.0041**	-0.0026	-0.0201***	-0.0203***
	(0.0004)	(0.0018)	(0.0017)	(0.0017)	(0.0024)	(0.0015)	(0.0015)
Firm age	0.0005***	0.0034*	-0.0018***	-0.0018***	0.0026	0.0023***	0.0016***
	(0.0002)	(0.0019)	(0.0004)	(0.0004)	(0.0019)	(0.0002)	(0.0003)
CEO/Chair duality	-0.0003	0.0022*	0.0056*	0.0056*	0.0029	0.0001	0.0005
	(0.0009)	(0.0013)	(0.0031)	(0.0031)	(0.0068)	(0.0012)	(0.0012)
Leverage	-0.0159***	-0.0475***	-0.1009***	-0.1008***	0.0164	-0.0290***	-0.0303***
	(0.0031)	(0.0065)	(0.0100)	(0.0099)	(0.0148)	(0.0055)	(0.0055)
Firm growth	0.1100***	0.1132***	0.0787***	0.0786***	0.1536***	0.1216***	0.1220***
	(0.0044)	(0.0046)	(0.0061)	(0.0061)	(0.0118)	(0.0048)	(0.0048)
Directors seats			-0.0010	-0.0012			
			(0.0011)	(0.0012)			
L.ROA	0.7931***	0.5807***	-	-	0.6972***	0.8052***	0.8039***
	(0.0099)	(0.0152)			(0.0200)	(0.0098)	(0.0099)
L2.ROA			-	-	-0.0276**		
					(0.0140)		
First-stage residual							0.2572***
							(0.0935)
Constant	-0.0173**	0.0399	0.1691***	0.1681***	-0.1592**	-0.0134	0.0626**
	(0.0079)	(0.0755)	(0.0218)	(0.0211)	(0.0790)	(0.0105)	(0.0306)
Observations	15,941	15,941	17,193	17,193	14,677	15,941	15,941
R-squared	0.7335	0.4750					
AR(2)					0.128		
Hansen test			0.036	0.039	0.133		
Difference-in-Hansen tests					0.617		
Initial condition						Yes	Yes
Within average variables						Yes	Yes
Industry dummies	Yes	No	No	No	Yes	No	No

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Table 4. First-stage results of 2SLS using all external seats and male external seats

Variables	All-female proportion			
	All external seats		Male external seats	
	ROA	Tobin's Q	ROA	Tobin's Q
	1st stage	1st stage	1st stage	1st stage
	(1)	(2)	(3)	(4)
Board size	0.0699***	0.0699***	0.0722***	0.0722***
	(0.0100)	(0.0100)	(0.0097)	(0.0097)
Board independence	0.0438***	0.0438***	0.0418***	0.0418***
	(0.0124)	(0.0124)	(0.0121)	(0.0121)
Dividends	0.0101***	0.0101***	0.0096***	0.0096***
	(0.0037)	(0.0037)	(0.0035)	(0.0035)
R&D	0.0028	0.0028	0.0071	0.0071
	(0.0334)	(0.0334)	(0.0315)	(0.0315)
Firm size	0.0070***	0.0070***	0.0071***	0.0071***
	(0.0015)	(0.0015)	(0.0014)	(0.0014)
Firm age	0.0241***	0.0051***	0.0218***	0.0046***
	(0.0022)	(0.0003)	(0.0021)	(0.0003)
CEO/Chair duality	0.0041	0.0041	0.0032	0.0032
	(0.0030)	(0.0030)	(0.0028)	(0.0028)
Leverage	0.0145	0.0145	0.0124	0.0124
	(0.0098)	(0.0098)	(0.0092)	(0.0092)
Firm growth	-0.0191***	-0.0191***	-0.0183***	-0.0183***
	(0.0035)	(0.0035)	(0.0033)	(0.0033)
All external seats	-0.0267***	-0.0267***		
	(0.0016)	(0.0016)		
Male external seats			-0.0424***	-0.0424***
			(0.0024)	(0.0024)
Male connectedness	0.3604***	0.3604***	0.4430***	0.4430***
	(0.0140)	(0.0140)	(0.0185)	(0.0185)
Female industries ratio	0.4848***	0.4848***	0.4134***	0.4134***
	(0.1171)	(0.1171)	(0.1064)	(0.1064)
Constant	-0.3357***	-0.3357***	-0.3111***	-0.3111***
	(0.0234)	(0.0234)	(0.0223)	(0.0223)
Observations	17,193	17,193	17,193	17,193
Kleibergen-Paap F-statistic	336.37	336.37	300.74	300.74

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

The approach of Dang et al. (2020) combines the control function with a CRE to address endogeneity in panel data. The problem of endogeneity arising from omitting time-invariant factors correlated with female directors is often addressed using FE estimation. However, some benefits of CRE outweigh the traditional approach (FE). First, with the addition of time-averaged independent variables, the heterogeneity of time-invariant factors would be controlled in the same way as FE, but without facing the problem of incidental parameters, which impact the estimation of FE. Second, CRE allows measurement of time-invariant variables, unlike FE.

Columns (6) and (7) follow this approach, combining the control function with CRE; therefore, they are considered alternatives to 2SLS and GMM estimations. An additional instrument for firms' visibility (Reguera-Alvarado et al., 2017) is included in the model, measured as a dummy variable equal to 1 if the firm is listed on the S&P 500 and 0 otherwise. This index captures the largest firms in our sample, which exhibit greater visibility regarding gender diversity due to their exposure to multiple external financial users (Dang et al., 2020).

Consistent with the 2SLS instrumental variables conditions, the association between the S&P 500 index and the female director ratio is valid, with a positive and significant effect (reported in Table 5). The F-test also supports the instrument's validity by rejecting the null hypothesis (H_0) of weak validity (F = 44.70, which exceeds the cutoff value of 10). Columns (6) and (7) present the results of an exogenous and endogenous estimation, respectively. These are fully identified models, as only one instrumental variable is used; therefore, the Jansen test cannot be performed in this case.

Table 5. First-stage result in using the control function approach

Variables	All-female proportion
	1st stage
	(1)
Board size	0.0179**
	(0.0072)
Board independence	0.0354***
	(0.0102)
Dividends	0.0076**
	(0.0032)
R&D	-0.0121
	(0.0382)
Firm size	0.0019
	(0.0028)
Firm age	0.0062***
	(0.0003)
CEO/Chair duality	-0.0032
	(0.0024)
Leverage	0.0109
	(0.0083)
Firm growth	-0.0038
	(0.0024)
Firm visibility (S&P 500)	0.0158***
	(0.0066)
Constant	-0.2731***
	(0.0417)
Observations	17,193
F-statistics (*ROA*)	44.70
F-statistics (*Tobin's Q*)	21.20

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Following Reguera-Alvarado et al. (2017), correlations between the instrumental variable and the residual terms in the main firms' performance equation were examined. The estimated correlation between the S&P 500 index and the residual is approximately 0.13 (not statistically significant) in the main regression, which includes lagged *ROA*, the female directors' ratio, and the control variables. This low statistic indicates the absence of a correlation and supports the exogeneity of firms' visibility as an instrument for board diversity. The residual from the first stage is significant at the 1% level in column (7), indicating the presence of endogeneity. With regard to the female directors' ratio, the result appears positive and significant for *ROA*, consistent with prior findings (Erhardt et al., 2003; Carter et al., 2003; Dang et al., 2020). Regarding the lagged *ROA*, it is positive and significant across all columns with current *ROA*, indicating dynamic endogeneity, as noted by Wintoki et al. (2012).

Board characteristics (i.e., *Board size, Board independence*, and *CEO/Chair duality*) do not significantly affect firms' performance (as in Dang et al., 2020). *Firm growth* significantly and positively affects *ROA* across all estimates (Green & Jame, 2013). *ROA* has a significant negative association with *R&D* and *Leverage*. The *R&D* results are consistent with those of Akbar et al. (2016) and Vithessonthi and Racela (2016), but inconsistent with those of Dang et al. (2020). *Leverage* results are similar to those reported by Shahzad et al. (2020) and Charles et al. (2018).

4.2.2. Tobin's Q as a dependent variable

It has been suggested that *Tobin's Q* is less affected by managerial decisions than accounting-based measures (Papangkorn et al., 2021). Therefore, we use it in our analysis to provide a clearer picture of how female directors would affect long-term operating outcomes and to represent market perceptions of this characteristic. In Table 6, we replicate the same analyses performed in Table 3 and find a positive relationship between female directors and *Tobin's Q*, albeit not significant in columns (1) and (2), suggesting that endogeneity problems might impact these regressions. Findings regarding the control variables are the same as described above, except for *R&D* and *Firm size*. *Tobin's Q* appears to have a positive and significant association with *R&D*, which is consistent with previous findings from Akbar et al. (2016), Vithessonthi and Racela (2016), and Green and Jame (2013). However, the opposite relationship appears between Tobin's Q and firms' sizes, consistent with the inference that firms' complexity is similar to that inferred by Adams and Ferreira (2009) and Dang et al. (2020).

Table 6. Female directors' effect on firm performance using *Tobin's Q* as a dependent variable

Variables	*OLS*	*FE*	*2SLS*		*GMM*	*Control function*	
			All seats	*Male seats*		*Exogenous*	*Endogenous*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Female proportion	0.1061	0.0897	1.9830***	1.7573***	0.4620**	0.1706***	0.1462**
	(0.0671)	(0.1111)	(0.4417)	(0.3542)	(0.1812)	(0.0658)	(0.0657)
Board size	0.1099***	0.0366	0.0612	0.0728	0.2466**	0.1062**	-0.1231**
	(0.0289)	(0.0515)	(0.1036)	(0.1020)	(0.1142)	(0.0460)	(0.0528)
Board independence	-0.0263	-0.0252	-0.0016	0.0075	0.2323**	-0.0800	-0.5186***
	(0.0467)	(0.0745)	(0.1470)	(0.1460)	(0.1184)	(0.0662)	(0.0871)
Dividends	0.1052***	0.0599**	0.1564***	0.1589***	0.1451**	0.0688***	-0.0261
	(0.0141)	(0.0262)	(0.0496)	(0.0492)	(0.0648)	(0.0207)	(0.0238)
R&D	1.3930***	1.2788**	5.6719***	5.6559***	2.3427***	1.2835**	1.4413***
	(0.2154)	(0.5754)	(0.4980)	(0.4977)	(0.4062)	(0.5360)	(0.5352)
Firm size	-0.0396***	-0.3082***	-0.0535**	-0.0527**	-0.0833***	-0.2815***	-0.3069***
	(0.0058)	(0.0223)	(0.0214)	(0.0214)	(0.0199)	(0.0177)	(0.0182)
Firm age	-0.0029	-0.2183***	-0.0250***	-0.0237***	0.0064*	0.0150***	-0.0618***
	(0.0030)	(0.0280)	(0.0054)	(0.0053)	(0.0036)	(0.0031)	(0.0095)
CEO/Chair duality	0.0070	0.0317*	0.0792**	0.0803**	0.0514	0.0044	0.0460***
	(0.0120)	(0.0163)	(0.0382)	(0.0381)	(0.0516)	(0.0143)	(0.0147)
Leverage	-0.0909**	-0.2673***	-1.1853***	-1.1820***	0.0269	-0.0488	-0.1955***
	(0.0388)	(0.0712)	(0.1320)	(0.1319)	(0.1045)	(0.0628)	(0.0649)
Firm growth	0.2461***	0.3949***	1.2692***	1.2638***	0.5343***	0.2224***	0.2798***
	(0.0382)	(0.0390)	(0.0827)	(0.0824)	(0.0789)	(0.0362)	(0.0374)
Directors seats			-0.0059	-0.0026			
			(0.0124)	(0.0144)			
L.Tobin's Q	0.7706***	0.5205***			0.6016***	0.7703***	0.7579***
	(0.0109)	(0.0150)			(0.0184)	(0.0111)	(0.0110)
First-stage residual							12.4828***
							(1.4893)
Constant	0.4736***	12.2053***	3.1330***	3.0785***	0.3088	0.2167	3.9187***
	(0.1261)	(1.1388)	(0.2771)	(0.2668)	(0.2502)	(0.1601)	(0.4672)
Observations	15,941	15,941	17,193	17,193	15,941	15,941	15,941
R-squared	0.7191	0.4335					
AR(2)					0.935		
Hansen test			0.264	0.234	0.321		
Difference-in-Hansen tests					0.915		
Initial condition						Yes	Yes
Within average variables						Yes	Yes
Industry dummies	Yes	No	No	No	Yes	No	No

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

4.3. Robustness checks

4.3.1. The Blau index

The Blau index is used as a robustness check, following Campbell and Mínguez-Vera (2008) and Dang et al. (2020). This index is commonly used to measure board heterogeneity and evenness. Therefore, the index ranges from 0% (no female directors) to 50% (an equal number of men and women on the board). The mean (median) of the Blau index is 17% (19%), which is significantly higher than the level reported by Campbell and Mínguez-Vera (2008), yet lower than the average reported by Dang et al. (2020).

The results for both performance measures (i.e., *ROA* and *Tobin's Q*) are presented in Tables 7 and 8. They are consistent with previous findings (the results of the first stage of both 2SLS and control function are reported in Tables 3 and 6, respectively).

Table 7. Female directors' (using the Blau index) effect on firm performance using *ROA* as a dependent variable

Variables	***OLS***	***FE***	***2SLS***		***GMM***	***Control function***	
			All seats	***Male seats***		***Exogenous***	***Endogenous***
	(1)	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***
Blau index	0.0166***	0.0175***	0.0548**	0.0553***	0.0377**	0.0114***	0.0109***
	(0.0033)	(0.0055)	(0.0229)	(0.0196)	(0.0149)	(0.0031)	(0.0031)
Board size	0.0088***	0.0044	0.0087	0.0087	0.0272*	0.0051	-0.0042
	(0.0022)	(0.0038)	(0.0084)	(0.0084)	(0.0162)	(0.0035)	(0.0048)
Board independence	0.0046	0.0027	0.0052	0.0052	0.0316	0.0017	-0.0077
	(0.0038)	(0.0063)	(0.0116)	(0.0116)	(0.0200)	(0.0057)	(0.0068)
Dividends	0.0094***	0.0050***	0.0301***	0.0301***	0.0074	0.0021	0.0004
	(0.0011)	(0.0018)	(0.0037)	(0.0037)	(0.0070)	(0.0017)	(0.0018)
R&D	-0.1042***	-0.2831***	-0.4756***	-0.4753***	-0.2506***	-0.2019***	-0.2050***
	(0.0186)	(0.0470)	(0.0520)	(0.0520)	(0.0658)	(0.0384)	(0.0384)
Firm size	-0.0006	-0.0153***	0.0042**	0.0042**	-0.0029	-0.0202***	-0.0214***
	(0.0004)	(0.0018)	(0.0017)	(0.0017)	(0.0024)	(0.0015)	(0.0015)
Firm age	0.0005***	0.0034*	-0.0017***	-0.0017***	0.0024	0.0023***	0.0007
	(0.0002)	(0.0019)	(0.0004)	(0.0003)	(0.0018)	(0.0002)	(0.0006)
CEO/Chair duality	-0.0003	0.0022*	0.0058*	0.0058*	0.0043	0.0002	0.0014
	(0.0009)	(0.0013)	(0.0031)	(0.0031)	(0.0068)	(0.0012)	(0.0013)
Leverage	-0.0159***	-0.0474***	-0.1005***	-0.1005***	0.0182	-0.0289***	-0.0307***
	(0.0031)	(0.0065)	(0.0099)	(0.0099)	(0.0148)	(0.0055)	(0.0055)
Firm growth	0.1101***	0.1133***	0.0784***	0.0784***	0.1547***	0.1216***	0.1230***
	(0.0044)	(0.0046)	(0.0061)	(0.0060)	(0.0117)	(0.0048)	(0.0048)
Directors seats			-0.0010	-0.0012			
			(0.0011)	(0.0012)			
L.ROA	0.7930***	0.5807***			0.6981***	0.8051***	0.8039***
	(0.0099)	(0.0152)			(0.0200)	(0.0098)	(0.0099)
L2.ROA					-0.0263*		
					(0.0140)		
First-stage residual							0.1905***
							(0.0693)
Constant	-0.0164**	0.0400	0.1660***	0.1665***	-0.1528*	-0.0125	0.0735**
	(0.0080)	(0.0755)	(0.0215)	(0.0209)	(0.0786)	(0.0104)	(0.0341)
Observations	15,941	15,941	17,193	17,193	14,677	15,941	15,941
R-squared	0.7336	0.4750					
AR(2)					0.114		
Hansen test			0.031	0.035	0.126		
Difference-in-Hansen tests					0.651		
Initial condition						Yes	Yes
Within average variables						Yes	Yes
Industry dummies	Yes	No	No	No	Yes	No	No

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Table 8. Female directors' (using the Blau index) effect on firm performance using *Tobin's Q* as a dependent variable (Part 1)

Variables	***OLS***	***FE***	***2SLS***		***GMM***	***Control function***	
			All seats	***Male seats***		***Exogenous***	***Endogenous***
	(1)	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***
Blau index	0.0777*	0.0676	1.2152***	1.1233***	0.2699**	0.1281***	0.1123**
	(0.0471)	(0.0785)	(0.2721)	(0.2270)	(0.1332)	(0.0463)	(0.0463)
Board size	0.1073***	0.0348	0.0484	0.0571	0.2576**	0.1030**	-0.3510***
	(0.0290)	(0.0515)	(0.1041)	(0.1026)	(0.1140)	(0.0461)	(0.0700)
Board independence	-0.0270	-0.0255	0.0060	0.0116	0.2278*	-0.0798	-0.5385***
	(0.0465)	(0.0744)	(0.1464)	(0.1457)	(0.1171)	(0.0662)	(0.0886)
Dividends	0.1050***	0.0597**	0.1608***	0.1621***	0.1344**	0.0689***	-0.0161
	(0.0141)	(0.0262)	(0.0493)	(0.0490)	(0.0662)	(0.0207)	(0.0232)
R&D	1.3885***	1.2671**	5.6578***	5.6480***	2.3536***	1.2796**	1.1517**
	(0.2143)	(0.5717)	(0.4964)	(0.4965)	(0.4073)	(0.5360)	(0.5357)
Firm size	-0.0395***	-0.3079***	-0.0520**	-0.0516**	-0.0823***	-0.2820***	-0.3440***
	(0.0058)	(0.0222)	(0.0213)	(0.0213)	(0.0202)	(0.0177)	(0.0195)

Table 8. Female directors' (using the Blau index) effect on firm performance using *Tobin's Q* as a dependent variable (Part 2)

Variables	OLS	FE	2SLS		GMM	Control function	
			All seats	Male seats		Exogenous	Endogenous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firm age	-0.0029	-0.2178***	-0.0227***	-0.0220***	0.0072**	0.0150***	-0.0617***
	(0.0029)	(0.0280)	(0.0052)	(0.0051)	(0.0036)	(0.0031)	(0.0095)
CEO/Chair duality	0.0071	0.0318*	0.0834**	0.0837**	0.0577	0.0048	0.0666***
	(0.0119)	(0.0163)	(0.0381)	(0.0380)	(0.0518)	(0.0143)	(0.0155)
Leverage	-0.0905**	-0.2663***	-1.1764***	-1.1748***	0.0396	-0.0484	-0.1418**
	(0.0387)	(0.0710)	(0.1314)	(0.1314)	(0.1043)	(0.0628)	(0.0636)
Firm growth	0.2453***	0.3939***	1.2609***	1.2577***	0.5300***	0.2227***	0.3029***
	(0.0381)	(0.0389)	(0.0821)	(0.0819)	(0.0789)	(0.0362)	(0.0382)
Directors seats			-0.0059	-0.0043			
			(0.0124)	(0.0143)			
L.Tobin's Q	0.7712***	0.5209***			0.6021***	0.7702***	0.7578***
	(0.0109)	(0.0149)			(0.0184)	(0.0111)	(0.0110)
First-stage residual							
Constant	0.4791***	12.1859***			0.2543	0.2239	4.4258***
	(0.1259)	(1.1356)			(0.2483)	(0.1603)	(0.5234)
Observations	15,941	15,941				15,941	15,941
R-squared	0.7196	0.4337					
Hansen J-statistic							
AR(2)					0.933		
Hansen test			0.214	0.201	0.337		
Difference-in-Hansen tests					0.935		
Initial condition						Yes	Yes
Within average variables						Yes	Yes
Industry dummies	Yes	No	No	No	Yes	No	No

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

4.3.2. Independent female directors

Because female directors in U.S. firms are predominantly independent (non-executive) directors, accounting for approximately 88% of all female board appointments, we further examine the effect of independent female directors on firm performance. This distinction is important because independent directors are expected to play a stronger monitoring and governance role, consistent with agency and resource-dependence theories. The ratio of independent female directors to independent directors is calculated as the number of independent female directors divided by the number of independent directors (Terjesen et al., 2016). The results are presented in Tables 9 and 10 for *ROA* and *Tobin's Q*, respectively (the first-stage results for both 2SLS and the control function are reported in Tables 3 and 6, respectively). The findings are similar to the female directors' ratio and the Blau index results. Therefore, a higher ratio of female directors enhances firms' performance.

Table 9. Female directors' (using the independent female ratio) effect on firm performance using *ROA* as a dependent variable (Part 1)

Variables	OLS	FE	2SLS		GMM	Control function	
			All seats	Male seats		Exogenous	Endogenous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Independent female ratio	0.0057***	0.0063**	0.0582***	0.0509***	0.0126***	0.0124**	0.0115**
	(0.0017)	(0.0026)	(0.0220)	(0.0169)	(0.0045)	(0.0048)	(0.0049)
Board size	0.0103***	0.0054	0.0106	0.0111	0.0238**	0.0054	0.0020
	(0.0022)	(0.0038)	(0.0083)	(0.0082)	(0.0094)	(0.0035)	(0.0037)
Board independence	0.0066*	0.0045	0.0123	0.0120	0.0248**	0.0013	-0.0243**
	(0.0039)	(0.0063)	(0.0114)	(0.0114)	(0.0105)	(0.0058)	(0.0110)
Dividends	0.0095***	0.0050***	0.0296***	0.0298***	0.0212***	0.0021	-0.0003
	(0.0011)	(0.0018)	(0.0037)	(0.0037)	(0.0056)	(0.0017)	(0.0019)
R&D	-0.1029***	-0.2826***	-0.4724***	-0.4733***	-0.1760***	-0.2014***	-0.1927***
	(0.0186)	(0.0471)	(0.0523)	(0.0523)	(0.0524)	(0.0384)	(0.0387)
Firm size	-0.0005	-0.0152***	0.0038**	0.0039**	-0.0010	-0.0201***	-0.0206***
	(0.0004)	(0.0018)	(0.0017)	(0.0017)	(0.0020)	(0.0015)	(0.0015)
Firm age	0.0005***	0.0036*	-0.0021***	-0.0020***	0.0018	0.0023***	0.0007
	(0.0002)	(0.0019)	(0.0004)	(0.0004)	(0.0019)	(0.0002)	(0.0006)
CEO/Chair duality	-0.0003	0.0023*	0.0058*	0.0058*	-0.0027	0.0001	0.0016
	(0.0009)	(0.0013)	(0.0031)	(0.0031)	(0.0043)	(0.0012)	(0.0013)
Leverage	-0.0157***	-0.0476***	-0.1017***	-0.1014***	0.0083	-0.0290***	-0.0347***
	(0.0031)	(0.0065)	(0.0100)	(0.0100)	(0.0097)	(0.0055)	(0.0060)
Firm growth	0.1097***	0.1132***	0.0790***	0.0787***	0.1219***	0.1216***	0.1222***
	(0.0044)	(0.0045)	(0.0061)	(0.0060)	(0.0070)	(0.0048)	(0.0048)
Directors seats			-0.0010	-0.0010			
			(0.0011)	(0.0012)			
L.ROA	0.7933***	0.5807***			0.6472***	0.8054***	0.8041***
	(0.0099)	(0.0152)			(0.0206)	(0.0097)	(0.0099)
L2.ROA					-0.0359**		
					(0.0144)		

Table 9. Female directors' (using the independent female ratio) effect on firm performance using *ROA* as a dependent variable (Part 2)

Variables	OLS	FE	2SLS		GMM	Control function	
			All seats	Male seats		Exogenous	Endogenous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
First-stage residual							0.2786***
							(0.1006)
Constant	-0.0215***	0.0301	0.1686***	0.1659***	-0.1110	-0.0138	0.0752**
	(0.0079)	(0.0755)	(0.0214)	(0.0206)	(0.0807)	(0.0104)	(0.0348)
Observations	15,941	15,941	17,193	17,193	14,677	15,941	15,941
R-squared	0.7333	0.4748					
Hansen J-statistic			0.051	0.052			
AR(2)					0.230		
Hansen test					0.404		
Difference-in-Hansen tests					0.896		
Initial condition						Yes	Yes
Within average variables						Yes	Yes
Industry dummies	Yes	No	No	No	Yes	No	No

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Table 10. Female directors' (using the independent female ratio) effect on firm performance using *Tobin's Q* as a dependent variable

Variables	OLS	FE	2SLS		GMM	Control function	
			All seats	Male seats		Exogenous	Endogenous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Independent female ratio	-0.0094	-0.0163	1.1629***	0.9808***	0.1279**	0.1288*	0.0976*
	(0.0238)	(0.0368)	(0.2628)	(0.1976)	(0.0622)	(0.0694)	(0.0688)
Board size	0.1166***	0.0376	0.1026	0.1118	0.3153***	0.1076**	-0.0637
	(0.0286)	(0.0514)	(0.1027)	(0.1012)	(0.1183)	(0.0459)	(0.0497)
Board independence	-0.0174	-0.0214	0.1609	0.1474	0.3097***	-0.0840	-1.3154***
	(0.0467)	(0.0743)	(0.1470)	(0.1463)	(0.1186)	(0.0665)	(0.1648)
Dividends	0.1065***	0.0610**	0.1521***	0.1562***	0.1461**	0.0689***	-0.0453*
	(0.0141)	(0.0263)	(0.0504)	(0.0497)	(0.0647)	(0.0207)	(0.0250)
R&D	1.4010***	1.2786**	5.7282***	5.6962***	2.4000***	1.2839**	1.7253***
	(0.2149)	(0.5746)	(0.5052)	(0.5030)	(0.4145)	(0.5359)	(0.5367)
Firm size	-0.0382***	-0.3078***	-0.0580***	-0.0564***	-0.0864***	-0.2814***	-0.3063***
	(0.0058)	(0.0223)	(0.0216)	(0.0215)	(0.0201)	(0.0177)	(0.0182)
Firm age	-0.0021	-0.2152***	-0.0291***	-0.0266***	0.0070*	0.0153***	-0.0610***
	(0.0029)	(0.0281)	(0.0060)	(0.0056)	(0.0036)	(0.0031)	(0.0094)
CEO/Chair duality	0.0073	0.0312*	0.0836**	0.0845**	0.0598	0.0045	0.0766***
	(0.0120)	(0.0163)	(0.0385)	(0.0384)	(0.0510)	(0.0143)	(0.0161)
Leverage	-0.0881**	-0.2660***	-1.1985***	-1.1920***	0.0221	-0.0486	-0.3279***
	(0.0387)	(0.0711)	(0.1352)	(0.1343)	(0.1059)	(0.0629)	(0.0706)
Firm growth	0.2423***	0.3942***	1.2706***	1.2630***	0.5190***	0.2216***	0.2620***
	(0.0381)	(0.0390)	(0.0833)	(0.0826)	(0.0764)	(0.0361)	(0.0369)
Directors seats			-0.0053	0.0001			
			(0.0125)	(0.0147)			
L.Tobin's Q	0.7713***	0.5206***			0.6006***	0.7709***	0.7585***
	(0.0109)	(0.0150)			(0.0185)	(0.0111)	(0.0110)
First-stage residual							13.4088***
							(1.6023)
Constant	0.4353***	12.0923***	3.0814***	3.0144***	0.1440	0.2051	4.5053***
	(0.1238)	(1.1389)	(0.2741)	(0.2627)	(0.2571)	(0.1609)	(0.5334)
Observations	15,941	15,941	17,193	17,193	15,941	15,941	15,941
R-squared	0.7190	0.4334					
AR(2)					0.921		
Hansen test			0.41	0.33	0.367		
Difference-in-Hansen tests					0.992		
Initial condition						Yes	Yes
Within average variables						Yes	Yes
Industry dummies	Yes	No	No	No	Yes	No	No

*Note: Robust standard errors clustered by firm are in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Table 11. Table of first-stage results using two instrumental variables for both the Blau index and independent female directors

Variables	*Blau index*				*Independent female ratio*			
	All external seats		*Male external seats*		*All external seats*		*Male external seats*	
	ROA	*Tobin's Q*	*ROA*	*Tobin's Q*	*ROA*	*Tobin's Q*	*ROA*	*Tobin's Q*
	1st stage	*1st stage*	*1st stage*	*1st stage*	*1st stage*	*1st stage*	*1st stage*	*1st stage*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Board size	0.1255***	0.1255***	0.1275***	0.1275***	0.0809***	0.0809***	0.0872***	0.0872***
	(0.0121)	(0.0121)	0.0116	0.0116	(0.0228)	(0.0228)	(0.0221)	(0.0221)
Board independence	0.0639***	0.0639***	0.0608***	0.0608***	-0.0617*	-0.0617*	-0.0651**	-0.0651**
	(0.0177)	(0.0177)	0.0172	0.0172	(0.0328)	(0.0328)	(0.0319)	(0.0319)
Dividends	0.0129***	0.0129***	0.0122***	0.0122***	0.0212**	0.0212**	0.0202**	0.0202**
	(0.0049)	(0.0049)	0.0046	0.0046	(0.0092)	(0.0092)	(0.0089)	(0.0089)
R&D	0.0029	0.0029	0.0061	0.0061	-0.0295	-0.0295	-0.0166	-0.0166
	(0.0462)	(0.0462)	0.0435	0.0435	(0.0775)	(0.0775)	(0.0745)	(0.0745)
Firm size	0.0102***	0.0102***	0.0102***	0.0102***	0.0160***	0.0160***	0.0165***	0.0165***
	(0.0020)	(0.0020)	0.0018	0.0018	(0.0036)	(0.0036)	(0.0035)	(0.0035)
Firm age	0.0067***	0.0067***	0.0059***	0.0059***	0.0123***	0.0123***	0.0112***	0.0112***
	(0.0004)	(0.0004)	0.0004	0.0004	(0.0008)	(0.0008)	(0.0008)	(0.0008)
CEO/Chair duality	0.0035	0.0035	0.0021	0.0021	0.0025	0.0025	0.0008	0.0008
	(0.0042)	(0.0042)	0.0039	0.0039	(0.0071)	(0.0071)	(0.0068)	(0.0068)
Leverage	0.0175	0.0175	0.0143	0.0143	0.0368	0.0368	0.0329	0.0329
	(0.0130)	(0.0130)	0.0122	0.0122	(0.0256)	(0.0256)	(0.0246)	(0.0246)
Firm growth	-0.0272***	-0.0272***	-0.0261***	-0.0261***	-0.0331***	-0.0331***	-0.0313***	-0.0313***
	(0.0049)	(0.0049)	0.0047	0.0047	(0.0078)	(0.0078)	(0.0076)	(0.0076)
All external seats	-0.0433***	-0.0433***			-0.0459***	-0.0459***		
	(0.0023)	(0.0023)			(0.0037)	(0.0037)		
Male external seats			-0.0645***	-0.0645***			-0.0788***	-0.0788***
			0.0035	0.0034			(0.0051)	(0.0051)
Male connectedness	0.5845***	0.5845***	0.6893***	0.6893***	0.6125***	0.6125***	0.7959***	0.7959***
	(0.0199)	(0.0199)	0.0265	0.0265	(0.0358)	(0.0358)	(0.0419)	(0.0419)
Female industries ratio	0.6438***	0.6438***	0.5394***	0.5394***	1.1697***	1.1697***	1.0307***	1.0307***
	(0.1530)	(0.1530)	0.1383	0.1383	(0.3436)	(0.3436)	(0.3299)	(0.3299)
Constant	-0.4938***	-0.4938***	-0.4540***	-0.4540***	-0.5630***	-0.5630***	-0.5209***	-0.5209***
	(0.0294)	(0.0293)	0.0279	0.0279	(0.0582)	(0.0582)	(0.0562)	(0.0562)
Observations	17,193	17,193	17,193	17,193	17,193	17,193	17,193	17,193
Kleibergen-Paap F-statistic	439.70	439.70	359.67	359.67	147.70	147.70	186.11	186.11

*Note: Robust standard errors clustered by firm are in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

5. CONCLUSION

This study contributes to the ongoing discourse on gender diversity in corporate governance by empirically examining the impact of female directors on firm performance, with particular attention to addressing endogeneity, a major shortcoming in much of the existing literature. Using a large panel dataset of publicly listed U.S. non-financial firms for 2000–2018, the findings consistently indicate a positive and statistically significant relationship between female board representation and firm performance, particularly when accounting-based performance (ROA) is considered. These results hold across various econometric techniques, including FE, 2SLS, system-GMM, and the control function approach.

Our analysis underscores that the effect of female directors is not only present but robust, even after controlling for key firm-level and board-level variables and correcting for potential reverse causality and omitted variable bias. Notably, the use of alternative gender diversity measures, such as the Blau index and the proportion of independent female directors, reaffirms the strength of the relationship, suggesting that it is not limited to a single dimension of board diversity.

The findings challenge the notion that female presence on boards is merely symbolic or detrimental to firm performance. Instead, they support the theoretical perspectives of agency and resource dependency theories, which argue that gender-diverse boards can enhance governance quality, broaden perspectives, and improve decision-making outcomes.

These results have important implications for policymakers, regulators, and corporate stakeholders. As countries increasingly consider or implement gender quota regulations, our evidence suggests that such reforms may indeed yield positive performance outcomes. At the same time, the findings call for more nuanced evaluations that consider firm heterogeneity, board structure, and market context. Future research could expand by conducting comparative cross-country analyses, examining sector-specific dynamics, or investigating the role of other diversity dimensions, such as ethnicity and age.

Despite its contributions, this study has several limitations that should be acknowledged. First, the analysis focuses on publicly listed U.S. non-financial firms, which may limit the generalisability of the findings to privately held firms, financial institutions, or firms operating in different institutional and regulatory environments. Second, although multiple econometric techniques are employed to address endogeneity concerns, including 2SLS, system-GMM, and a control function approach, no empirical strategy can fully eliminate all sources of endogeneity. Third, the study concentrates on gender diversity as a single dimension of board diversity and does not account for other potentially relevant characteristics, such as directors' ethnicity, age, tenure, or professional background, which may also influence board effectiveness and firm performance. Finally, while the study examines overall firm performance, it does not explore specific channels through which female directors affect outcomes, such as risk-taking, innovation, or strategic decision-making. These limitations provide opportunities for future research to extend the analysis across countries, industries, and additional dimensions of board diversity.

In conclusion, this study provides rigorous and comprehensive evidence that gender diversity, particularly the inclusion of female directors, positively influences firm performance when methodological concerns such as endogeneity are properly addressed. This contributes to a more informed and balanced debate on gender representation at the highest levels of corporate leadership.

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