

Board Gender Diversity and Corporate Green Innovation

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Abstract: More and more investors pay attention to corporate green innovation, but there is still little research on how the board gender characteristic affects corporate green innovation. Taking the data from 2009 to 2020 of China's stock market as a research sample, this paper examines whether and in what direction the gender diversity of the board of directors has an impact on corporate green innovation. It was found that a high proportion of female directors on the board significantly hindered the firm's green innovation performance. Furthermore, the negative effect of board gender diversity on corporate green innovation is more pronounced in SOEs and enterprises with large board sizes. The findings in this paper have significance on how to promote corporate green innovation.

1. Introduction

With the aggravation of global environmental issues, such as the rising sea level caused by excessive carbon dioxide emissions, which even threatens the survival of some countries, more and more enterprises have begun to realize the significance of green development and innovation. Green innovation can ease the resource and environmental constraints of enterprises. At the same time, corporate green innovation performance helps promote competitive advantage and environmental performance [1, 2]. Furthermore, corporate green innovation positively impacts its employment [3].

Recently, board gender diversity has become an increasingly popular research topic. It has been demonstrated that board gender diversity plays an important role in company performance. First, the presence of women on corporate boards significantly enhances firm profitability [4]. Additionally, the increase in the proportion of female directors helps reduce the company's financial risks and optimize investment decisions. [5]. Gender diversity also positively affects the effectiveness of corporate environmental responsibility [6]. Gender diversity is positively correlated with firm innovation performance [7].

However, topics on board gender and green innovation have received little attention from scholars. Only one paper found that female directors have a positive impact on corporate green innovation [8]. This article differs from the data the study used and the conclusions are inconsistent. This paper aims to illustrate the impact of board gender diversity on corporate green innovation and the findings will help enterprises promote corporate green innovation.

2. Literature review and hypothesis development

2.1 Literature Review

On the one hand, studies find that gender diversity and female participation in boards and management positively affect corporate innovations. Innovation is positively affected by board gender diversity [7], especially in nonfamily businesses [9]. Additionally, women's participation in the executive team significantly improves corporate innovation; human capital strengthens the relationship, and the positive influence is more significant among enterprises in the technology and telecommunications industries. CTO's gender diversity and firm innovation are positively correlated as well. Their empirical analysis further reveals that this influence plays a greater role in companies with stronger corporate innovation cultures, female CEOs, and powerful CTOs [10]. Some results

indicate a more complicated relationship between diversified gender on boards and corporate green innovation. A study using data from 44 countries reveals that increased gender diversity negatively affects R&D investments indirectly, but diversified boards indirectly encourage higher long-term R&D investments by having a positive effect on equity-based remuneration [11]. Another study from the French market shows that female independent directors had a negative impact on CVC investments, but the impact of appointing female directors with a management background was positive [12].

On the other hand, diversified gender on boards is revealed to have a negative influence on corporate innovation. Female-controlled firms are less innovative in a Vietnamese study [13]. A study in China also finds that female executives and R&D investment are significantly negatively correlated [14].

2.2 Hypothesis Development

Compared with men, women are more risk-averse due to inherent biological differences [15]. Female directors and executives are significantly less innovative than men due to lower risk tolerance [16]. Therefore, a lower risk-taking women board will hamper corporate green innovation, which is one type of innovation. The hypothesis is as follows:

H1: Diversified gender on boards harms corporate green innovation.

In state-owned enterprises (SOEs), the positive influence of male dominance on a firm's risk-taking is weaker [17]. The level of risk-taking negatively affects corporate green technological innovation progress [18]. The state's own nature indirectly promotes the negative impact of female dominance on corporate green innovation, and the negative relationship between board gender diversity and corporate green innovation will be more pronounced in state-owned enterprise samples. Therefore, this study hypothesizes that:

H2: The influence of boardroom gender diversity on corporate green innovation is more prominent in SOEs.

3. Data, sample, and methodology

3.1 Data source and sample selection

To study the impact of board gender diversity on corporate green innovation, this paper constructs panel data in 2009-2020. The primary output variable is corporate green innovation, measured by the number of green patent applications by companies. The input variable is board gender diversity, calculated by the number of female directors divided by the number of total directors on boards.

Two main data sets are used in this analysis. First, for corporate green innovation, this paper uses CNRDS green patent application data. CNRDS collects information on corporate green patent applications and authorizations of Chinese listed companies every year, which consists of the number of green innovation patents and green utility model patents independently applied by companies, and the number of green invention patents and utility model patents jointly applied by companies. This paper sums up the number of the above four green patent applications as a green innovation measurement variable. Second, the study constructs the input variable board gender diversity and some control variables using data from China Stock Market Accounting Research (CSMAR).

After merging CNRDS and CSMAR data, the author removes observations lacking key variables, such as the number of green innovation patent applications. Additionally, to eliminate the interference of extreme values on analysis results, this paper carries out 1% and 99% tail processing for all data. 29,297 firm-year observations on 4049 publicly traded Chinese firms per year are concluded in the final data set.

3.2 Regression model

Since fixed effects estimation is an effective approach to handle endogeneity issues in panel data, this paper uses the following fixed-time and fixed-industry panel data fixed-effects model to examine the influence of women participation in boards on corporate green innovation:

$$\text{Green}_{it} = \beta_1 \text{Female}_{it} + \beta_2 \text{lnSize}_{it} + \beta_3 \text{Age}_{it} + \beta_4 \text{TobinQ}_{it} + \beta_5 \text{Leverage}_{it} + \beta_6 \text{ROA}_{it} + \beta_7 \text{Growth}_{it} + \beta_8 \text{Year}_t + \beta_8 \text{Industry}_i + \varepsilon_{it}. \quad (1)$$

3.3 Main variable definitions

3.3.1 Dependent variable

The dependent variable is corporate green innovation. Some studies indicate that patent grants are more uncertain, as they require more testing and annual fees. It is more reliable to use the number of patent applications to measure the green innovation of enterprises than to use the number of patents granted, because the impact of innovation patents on enterprise performance is likely to occur in the application process, and the number of patent applications is more stable and timely. Therefore, this paper uses the sum of 4 types of corporate green innovation applications in Chinese Research Data Services (CNRDS).

3.3.2 Independent variable

The author uses the proportion of female directors' data in CSMAR for boardroom gender diversity as an independent variable [19]. The higher the proportion of women on boards, the higher the board gender diversity.

3.3.3 Control variables

Based on previous studies, we include several control variables that may potentially affect firm performance. lnSize is measured as the logarithm of the company's asset size. Age indicates the time since the company's establishment. TobinQ is calculated by dividing the sum of equity market value and debt book value by asset value. Leverage measures a company's debt ratio and is defined as total debt divided by total assets. ROA is profits per assets, reflecting the company's profitability. Growth is defined as the year-over-year growth rate of operating income. Inst is measured by institutional investors as a percentage of total shares. Moreover, fixed effects panel regression techniques are applied, and more key control variables, such as the proportion of institutional investors (Inst), the shareholding ratio of the largest shareholder (Top1), and the number of board directors (Board), are used to check the robustness of the results.

4. Empirical results

4.1 Summary Statistics

Table 1 illustrates the descriptive statistics of this paper. The mean of green innovation patent application (Green) is 0.675, and the max and min green innovation patent applications (Green) are 4.466 and 0, respectively, which shows that the application of green innovation patents in China is relatively inactive. The average board gender diversity (Female) is 0.133, which indicates that only 13.3 percent of board directors in a company are women on average. The participation of female members on boards is relatively low.

Table.1. Descriptive statistics

	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Median</i>	<i>Max</i>
Green	42136	0.675	1.073	0	0	4.466
Female	42001	0.133	0.124	0	0.111	0.5
lnSize	42136	21.898	1.260	19.702	21.717	25.782
Age	42136	1.956	0.894	0	2.079	3.258
TobinQ	41470	1.912	1.146	0.888	1.535	7.445
Leverage	42136	0.434	0.204	0.059	0.431	0.887
ROA	42132	0.041	0.062	-0.205	0.039	0.206

In addition, the firm's mean value (TobinQ) and the standard deviation are 1.912 and 1.146, respectively, which indicates that the fluctuation of the firm's value is relatively high. The mean logarithm of the firm's asset size (lnSize) is 21.898. The firm's average age is 1.62. The average leverage is 43.4%. The firm's average return of assets (ROA) is 4.1%, which shows that the firm's average profitability ability in China is relatively low.

Table 2 also illustrates the results of the Pearson correlation analysis. According to the analysis results in table 2, there is generally a significant and negative correlation between green innovation and board gender diversity. However, the correlations for all variables are weak, since the correlation coefficients of all variables are not greater than 0.40. Therefore, this study is without the perfect multicollinearity issue.

Table.2. Correlation matrix

	<i>Green</i>	<i>Female</i>	<i>lnSize</i>	<i>Age</i>	<i>TobinQ</i>	<i>Leverage</i>	<i>ROA</i>
Green	1						
Female	-0.029***	1					
lnSize	0.430***	-0.077***	1				
Age	0.105***	-0.037***	0.386***	1			
TobinQ	-0.071***	0.068***	-0.321***	0.043***	1		
Leverage	0.118***	-0.086***	0.417***	0.370***	-0.250***	1	
ROA	0.025***	0.018***	0.012**	-0.278***	0.150***	-0.402***	1

4.2 Baseline regression results

Table 3 presents the baseline results of this study. The results without and with control variables are presented in columns 1 and 2, respectively. Table 3 strongly supports hypothesis H1, which indicates that gender diversity has a significantly negative effect on green innovation. This result is consistent with the conclusions of some studies on the impact of female directors on corporate innovation. The reason why female directors hinder green innovation may be that women are less risk-taking than men, which hinders companies from taking risks to innovate.

Table.3. Baseline results

	(1) <i>Green</i>	(2) <i>Green</i>
Female	-0.294*** (0.0450)	-0.139*** (0.0459)
lnSize		0.381*** (0.00863)
Age		-0.0344*** (0.0118)
TobinQ		0.0254*** (0.00506)
Leverage		-0.00813 (0.0393)
ROA		0.0272 (0.0932)
Growth		-0.0135 (0.0109)
Constant	0.126 (0.0935)	-7.986*** (0.200)
Industry dummies	No	Yes
Year dummies	No	Yes
Observations	32,015	29,297
Number of Scode	4,045	3,692

4.3 Robustness checks

The main methods of robustness testing include adding more control variables and changing the measurement methods of the main variables. This paper adds some key variables to check the robustness of the model. Since external institutional pressure positively affects corporate green innovation [20], which is a key omitted variable, this paper incorporates the proportion of institutional investors (Inst) into this part. According to agency theory, a larger board size suffers from efficiency loss and will hamper corporate green innovation. On the other hand, resource dependence theory indicates that a larger board size benefits from easier access to information and resources, which will promote a firm's green innovation [21]. Therefore, this paper uses the number of board directors to control for board size effects. Ownership concentration (Top1), which has a significant negative impact on corporate environmental responsibility participation, is also controlled in the robustness check. The regression results are listed in Table 4. After controlling more key variables, the effects of board gender diversity on those firms' green innovation are still significant and negative in all columns, which indicates that the regression model is robust.

Table.4. The results of robustness checks

	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>	(4) <i>Green</i>
Female	-0.138*** (-3.01)	-0.140*** (-3.04)	-0.140*** (-3.04)	-0.139*** (-3.02)
lnSize	0.386*** (43.48)	0.382*** (43.77)	0.384*** (44.33)	0.388*** (43.26)
Age	-0.032*** (-2.71)	-0.034*** (-2.91)	-0.042*** (-3.51)	-0.040*** (-3.30)
TobinQ	0.028*** (5.37)	0.025*** (5.02)	0.025*** (4.93)	0.027*** (5.15)
Leverage	-0.007 (-0.17)	-0.008 (-0.21)	-0.004 (-0.11)	-0.003 (-0.08)
ROA	0.033 (0.35)	0.028 (0.30)	0.049 (0.52)	0.051 (0.55)
Growth	-0.014 (-1.27)	-0.014 (-1.25)	-0.014 (-1.25)	-0.014 (-1.27)
Inst	-0.054* (-1.91)			-0.041 (-1.43)
Board		-0.013 (-0.37)		-0.014 (-0.39)
Top1			-0.190*** (-3.39)	-0.176*** (-3.11)
Constant			-7.966*** (-39.90)	
Observations	29,272	29,297	29,297	29,272
Number of Scode	3,689	3,692	3,692	3,689
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes

4.4 Additional analysis

The regression results in SOEs and non-SOEs are shown in Table 5. The effects of gender diversity on corporate green innovation in column 1 and column 2 are both negative. However, only the results in column 1 are significant, which means that gender diversity significantly and negatively affects the SOEs green innovation process but has little impact on non-SOEs. The results support hypothesis H2. SOEs are more sensitive to risk-taking, so the negative influence of board gender diversity on corporate green innovation is more pronounced.

Table.5. The results of additional analysis

	SOE Green	non-SOE Green
Female	-0.356*** (-4.47)	-0.026 (-0.46)
lnSize	0.408*** (28.30)	0.364*** (32.50)
Age	-0.059** (-2.25)	0.001 (0.10)
TobinQ	0.028*** (2.94)	0.022*** (3.59)
Leverage	-0.069 (-0.99)	0.042 (0.88)
ROA	-0.129 (-0.71)	0.044 (0.40)
Growth	0.014 (0.79)	-0.032** (-2.38)
Observations	10,848	18,449
Number of Scode	1,225	2,747
Industry dummies	Yes	Yes
Year dummies	Yes	Yes

5. Conclusions

This study examines how gender diversity in the boardroom affects corporate green innovation in China. In addition, we consider the difference in the impact of board gender diversity on corporate green innovation between SOEs and non-SOEs. Based on a dataset of Chinese firms in 2009–2020, we conclude that (1) diversified gender on boards of directors has a significant and negative impact on firms' green innovation and (2) compared to non-SOE enterprises, the negative effect of female participation on boards of directors on corporate green innovation is more significant among SOEs. Although this finding makes a great contribution to academic studies on corporate governance and green innovation, it still has some limitations. This paper mainly focuses on the impact and direction of board gender diversity on corporate green innovation. The impact mechanism of board gender diversity on corporate green innovation is not yet clear. Future research may consider some mediating and moderating variables to further explore the impact mechanism of board gender diversity on corporate green innovation.

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