

Research Article

Application of BP Neural Network and Fixed Effect in the Relationship between CSR and Female Directors

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This study is to illustrate the two-way influencing mechanism of female directors' gender and corporate social responsibility (CSR) of China's listed companies. According to an empirical test of 3723 enterprises from 2013 to 2020, it reveals that the presence of female directors—especially female executive directors—contributes to the improvement of CSR. In the stage of back propagation (BP) neural network, the model included the overalls of CSR and macroscopic strategic, fulfillment content, and disclosed technology three dimensions. It randomly selects 100 samples, and via BP neural network, it predicts that the RKS-CSR rating can effectively show that high-CSR lever enhances the presence of female directors in Chinese listed companies and promotes gender balance in directors' team, thus achieving gender balance and CSR two-way sustainable development.

1. Introduction

The signing of a 2018 California bill requiring at least one female member to be on the board of directors of a state-based public company has reignited the international debate about the value of women directors. With the increasing participation of women in business and society, the business ethics and corporate governance issues of gender diversity on boards of directors are receiving increasing attention [1–3].

However, the proportion of female directors remains very low worldwide [4], especially in the Asia Pacific region. According to Deloitte's June 2017 report [5], female makes up only 15% of corporate boards around the world. China is already one of the countries with the highest female employment rate in the world. According to Lai et al. [6] the female labor participation rate in China was about 64%, higher than the world average (50.3%), which was not only higher than other Asian countries, such as India and Japan, but also higher than the United States. However, Chinese female executives and gender ratio were not prominent in relevant international studies.

What is more the proportion of female directors has been increasing very slowly. The proportion of female

directors of listed companies in China rose from 9.2% in 1999 to 11.7% in 2010 [7], an increase of only 2.5% in 12 years, which is very low compared with 34.4% in France and 17.9% in the United States. Gender equality has become an increasingly important factor to evaluate an enterprises' sustainable development ability. However, the overall practice of gender equality in Chinese enterprises was still in the "primary stage" [8].

In addition, some scholars [9] argue that CSR may also be used as a competitive advantage. The goal of corporate strategy is to gain a long-term competitive edge that will allow businesses to grow sustainably [10]. Corporate social responsibility may help businesses get low-cost or differentiated competitive advantages by gaining stakeholder support, developing a positive image in society, and so on, thus resulting in the collaborative and sustainable growth of the organization, society, and environment [11, 12]. Nevertheless, over the past 30 years of reform and opening-up, China's economic and social development has made great achievements; however, it has also brought serious social problems, such as resource depletion, environmental pollution, major food safety incidents, product quality issues, labor rights and interest issues, accounting fraud, unfair

competition, and so on. The 2018 CSR Development Index averages 34.4 points, and the overall value is still in the start-up stage, with more than 40% of enterprises scoring less than 20 points, still in the onlooker stage [13]. As a result, the long-term viability of CSR in these nations must be investigated further [14–16].

Specifically, the definition of corporate social responsibility (CSR) is suggested to be “promoting social welfare behaviours beyond the interests and legal requirements of the business” [17]. Many previous studies have analyzed the correlation between female directors and CSR [18, 19]. In addition, executive team members’ characteristics (age, gender, etc.) are associated with CSR decisions [20], especially, women in executive teams and team heterogeneity have a positive impact on CSR [21, 22]. Some studies [23–25] found that gender diversity on boards and the presence and proportion of female directors have an impact on CSR. The above studies conclude that female directors have a positive impact on CSR. However, many authors support the positive influence while others such as Shleifer et al. [26] support the opposite and Zhai and Liu [27] show a strong U-shaped association between the proportion of female executives and the level of CSR. This is because the implementation of CSR will lead to an increase in costs and a decrease in profits in the short term, and female risk preference [28] affects their CSR decisions.

Although empirical evidence generally supports the positive influence of female board representatives on CSR, how female directors are related to CSR is still the focus of the corporate governance debate [1, 26]. Previous studies believed that [3] whether female directors can effectively promote CSR depends on two key factors: the extent to which female directors influence the board and the extent to which companies are motivated to make full use of female directors [29]. According to agency theory, the independent board members are best suited to carry out the monitoring function of the board in a listed company [30]; however, executive directors are more involved in business decisions. Therefore, we hypothesize that a key factor in the impact of female directors on CSR is the power of female directors, which are reflected in the number of female directors on the board and the position role of female directors. Studies in developed countries showed that [31] more than three female directors can have a major impact on CSR. Whether this magic number also applies to developing countries such as China has not been verified yet.

Previous studies have focused on the impact of gender diversity on CSR. However, from the perspective of BP, this study additionally proposed whether improving CSR levels can promote gender balance on the board and increase the number of female directors in the Chinese context. An artificial neural network is a parallel distributed information processing system that consists of a large number of simple processing units interconnected in different ways. These processing units are also called neurons or neural nodes. It imitates the human brain nervous system, learns a set of mutually corresponding input and output signals, excavates the potential law between the two, and then completes the process of the input signal to calculate the output result

according to these laws [32]. Compared with traditional research methods, when dealing with nonlinear complex problems, the artificial intelligence approach overcomes the drawbacks of traditional models which depend on linear function modeling, and improves the accuracy of the model, among which the most widely used is the artificial neural network method, for example, Yang [33], Pendharkar [34], Back [35], Yang [28], Zhang [36] Siroopoulos [37], all used different artificial neural network models to evaluate the financial performance of a company and compare the results with traditional linear models. It is proved that the artificial neural network is superior to the traditional linear method in accuracy.

However, there are many factors in the issues that have not been noticed: how the position of female directors, executive or nonexecutive directors can affect CSR, how many female directors an enterprise needs a minimum to get a real impact on CSR, and whether enterprises which reach a high level of CSR are willing to hire female directors, to achieve a virtuous circle of corporate governance. The answers to these questions are of great theoretical and practical significance for further analyzing and perfecting the causal chain of female directors influencing CSR decision-making.

We pose four research questions to fill up the gaps: (1) are companies with high levels of CSR more willing to hire female directors to achieve gender diversity virtuous circles of corporate governance? (2) Does the involvement of female directors in corporate governance have an impact on CSR? (3) Are there any differences in the impact of different roles of female directors on the boards of directors on CSR? (4) What number of female directors will have a real impact on CSR in the Chinese context?

In this study, we used BP neural network to examine whether the level of CSR exerts influence on the employment of female directors. We investigate whether and under what conditions female directors would influence CSR using the fixed-effect model and panel data to overcome the problem of model bias.

The following paragraph shows the presentation sequence of this paper. The theoretical model and assumptions for empirical testing are described in the second part; how we collected the data and created the variables, as well as the empirical approach we used to test our hypotheses are shown in the third part; the findings of the empirical analysis are presented in the fourth part; the final part sums up the findings and explores some fascinating implications as well as their limits.

2. Theory and Hypotheses

2.1. Female Directors and CSR. Compared with men, women are more inherently risk-averse [38]. Drawing on upper echelon theory, key majority theory, and social role theory, this study investigates the influence of female directors (FDs) on CSR performance. The social role theory of gender differences [39] shows that gender roles specify assumptions and expectations about attributes held by females and males. Females were often regarded for common traits and behaviors [40], such as relationship-oriented, kind, helpful,

caring, and sympathetic to others [41]. This expectation reinforces female values that emphasize voluntary concern for the welfare of others, as well as for the welfare of society and nature [42].

In 1984, Hambrick and Mason [43] defined the upper echelons' perspective. The focus on gender diversity and political background of top management will increase the presence of females in top positions, and a diverse top management layer serves as a key element of CSR performance in Chinese firms [21].

The key majority theory argues that it is only after the number of FDs exceeds a certain level that they will have a meaningful effect on the decision-making of the board of directors and on organizational performance; otherwise, it is still impossible for the voice of FDs to be heard. Furthermore, there is a strong link between the number of FDs and organizational results only when FDs exceed 30% of the total [44]. Whether the same conclusion can be drawn in the Chinese market is also one of the issues studied in this paper.

Social role theory espouses that the style of female leadership is more interpersonal, democratic, and participatory [27]. Meanwhile, Huse and Nielsen [45] proposed that their leadership style can be attributed to the impact of women directors on the board of directors. Boulouta [46] also concluded that women are more likely to conform to gender stereotypes in the operation of the board of directors and to pay more attention to "soft" issues such as CSR. Figure 1 shows the theoretical model of this study.

2.2. The Relationship between Female Directors and CSR. Previous research mostly used artificial neural network models to evaluate the financial performance of a company and compared the results with traditional linear models. It is proved that the artificial neural network is superior to the traditional linear method in accuracy [4–8].

Hypothesis 1. Companies with high levels of CSR tend to be gender-diverse.

In this paper, the influence of FDs on CSR-related issues is discussed based on studies which adopt the upper echelon perspective. Nadeem et al. [25] measured sustainable practices with the Environmental, Social and Governance index (ESG index) and found a strong positive link between the percentage of women on the board of directors and sustainable management practices. Meanwhile, Harjoto and Rossi [23] analyzed the data of 156 Italian listed firms from 2002 to 2014 and found a strong association between the involvement of FDs and CSR. Zhou et al. [19] studied charitable donations as a substitute variable for CSR and showed that listed companies with FDs on the board of directors made more charitable donations than those without FDs. However, the findings of Zhai and Liu [47] show a strong U-shaped association between the proportion of female executives and the level of CSR.

Hypothesis 2. female executives have a positive influence on CSR.

Executive directors and nonexecutive directors are the two types of executives in China, based on their positions, whose roles and functions are significantly different in corporate decision-making. Huang and Zhou [48] found that, in contrast to female executive directors, female nonexecutive directors reduce business diversification. Jiang and Long [49] studied 404 listed companies on the main board of Shenzhen Stock Exchange in 2013 and observed that the percentage of female independent directors was strongly negatively associated with corporate value.

Based on this analysis, the existing corporate governance system in China shows that, due to the existence of asymmetry of nonexecutive directors and information in management and the lack of time to perform their duties, the impact of female executive directors on CSR is comparatively important.

Hypothesis 3. Compared to female nonexecutive directors, female executive directors have a positive influence on CSR.

3. Methodology

3.1. Data and Sample. (I) The CSR Assessment Index of Rankings CSR Ratings was adopted to assess CSR results. In 2009, Rankins CSR Scores, an authoritative credit rating firm for CSR in China, published its index for the first time, and updated its version in 2012. Therefore, this paper takes 2013 as the starting year of the study. The scores were divided into three dimensions: macroscopic strategic (M), fulfilment content (C), and disclosed technology (T). (II) based on research practice, 4,426 samples from 2013 to 2020 were screened according to the following principles: (i) excluding 318 listed companies in the financial and insurance sectors; (ii) excluding 244 listed companies with special trading status such as PT, St, and * St; (iii) excluding 72 companies with less than 2 years of listing (with a one-phase lag); (iv) excluding 69 companies with missing core data. The final remaining samples totaled 3,723. Data on the number of FDs and other control variables were obtained from the CSMAR database. To prevent the potential control of extreme values, all continuous variables were winsorized means at level 1%. This paper mainly used MATLAB and STATA16 for data processing.

3.2. Empirical Analysis CSR to FDs. A BP neural network is a multilayer feed-forward network that has been trained using the error BP algorithm. It is capable of learning and storing a large number of input-output pattern mapping relationships without disclosing the mathematical equations describing the mapping relationships beforehand. In the previous research from the Web of Science index database, there are only two papers applying the BP neural network to the CSR's field [50, 51], the application of BP in the field of economics is still in the initial stage, so this part is an experimental test. The purpose of this experiment is to establish a prediction model to judge the existence of female directors in a company based on four characteristic parameters: RKS rating score, M , C , and T evaluation indexes. The model uses

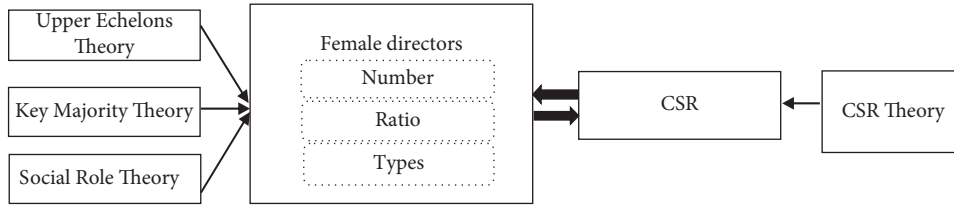


FIGURE 1: A theoretical model of the influence of FDs on CSR.

an input-level, hidden-layer, and output-layer network structure with a BP 3-layer structure. The model uses RKS rating scores, M , C , and T to predict whether there is a female director in a company. As shown in Figure 2, there are four neurons in the input layer, eight neurons are concealed, and two neurons are in the output layer. Among them, the activation function of the neurons in the hidden layer adopts the asymmetric Sigmoid function, and the function expression is $f(x) = 1/(1 + \exp(-x))$. The activation function of the neurons in the output layer adopts the linear function, and the expression is $f(x) = x$. A total of 3723 sets of data were normalized during the input of the network. BP algorithm is used to alter the mass of the overseas layer and the output layer so that the difference between the calculated output and the real sample output is minimized and eventually, the existence of female directors is predicted more accurately.

Based on the characteristics and advantages of neural network, this paper chooses BP neural network to predict the existence of female directors. Four rating indices, RKS rating scores, M , C , and T are chosen based on the specifications of the model establishment in this paper. The sample interval set of the BP neural network should be $[0, 1]$ and $[-1, 1]$, so that the sample set can be standardized.

The normalization formula is $x'_k = (x_k - x_{\min}) / (x_{\max} - x_{\min})$, and single hidden layer of the network design is adopted, which is divided into two network layers: single hidden layer and output layer, as shown in Figure 3.

In this paper, RKS rating scores, M , C , T four evaluation index are a set of inputs, and the existence of female directors of the company is taken as the output target. If there is an existence, the output is 1, and if not, it is 0.

Figure 4 shows the training process of MATLAB for the first model, that is, the four input models. Figure 4 shows the prediction result of the BP neural network. It can be seen from the figures that the experimental model's input layer is 4, the hidden layer is 8, and the output layer is 2. After training, the accuracy of the final prediction result is shown in Figure 5, in which the red circle represents the predicted results, the dot represents the real results, and the coincidence of the two represents the forecast of the existence of a female director is the same as the actual results. A total of 100 companies are randomly selected in the prediction, and the accuracy reaches 74%, which further shows that the RKS rating scores, M , C , T four evaluation indices can effectively represent the existence of female directors, and the model can effectively predict the existence.

3.3. Empirical Analysis FDs to CSR

- (i) Dependent variables. As the data are positively skewed (right-skewed), when the CSR evaluation index of RKS is adopted to measure CSR performance [22, 24, 49], so that the logarithm of RKS social responsibility report evaluation index is used to measure CSR performance with reference to Li [52], and the variable data are normally distributed after taking the logarithm.
- (ii) Independent variables. Three dimensions are used to measure FDs: whether there are FDs, "1" for "yes" and "0" for "no" (FD)[53], the number of FDs (FN) [54], and the proportion of FDs (FR). The women executives are also split into executive directors and nonexecutive directors. The number of female executive directors (FEN) and the percentage of female executive directors (FER) and female nonexecutive directors were determined by the number of female nonexecutive directors (FNEN) and the percentage of female nonexecutive directors (FNER).
- (iii) Controlled variables: First, variables at the level of corporate characteristics, such as years of listing (Age), company size (Csize) [55], corporate return on assets (Roa), asset-liability ratio (Lev) [10, 52, 53]. Second, variables at the level of ownership characteristics, such as the shareholding ratio of the largest shareholder (TOP1), the shareholding ratio of the board of directors (DShare) [56], and whether it is a state-owned enterprise (State)[57, 58]. Third, variables at the level of corporate governance, such as separation of chairman and general manager (Separa), size of the Board (Board), and the proportion of independent directors (Indepe) [7, 60].

3.3.1. Research Models

- (i) To test Hypothesis 1, the following econometric model is developed:

$$CSR_t = \alpha_0 + \beta_1 FDNR_{t-1} + \sum x_i Control_{t-1} + \varepsilon. \quad (1)$$

- (ii) To test Hypothesis 2, the following econometric model is developed:

$$CSR_t = \alpha_0 + \beta_1 FTYPE_{t-1} + \sum x_i Control_{t-1} + \varepsilon. \quad (2)$$

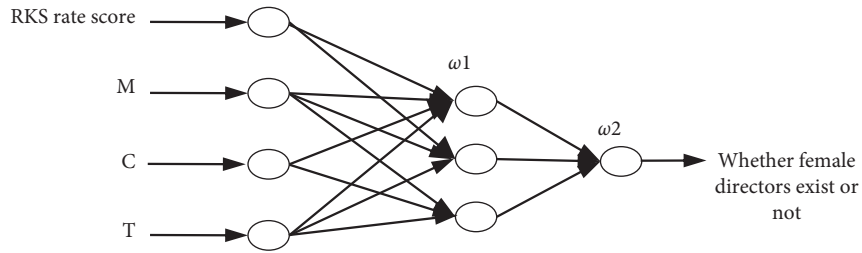
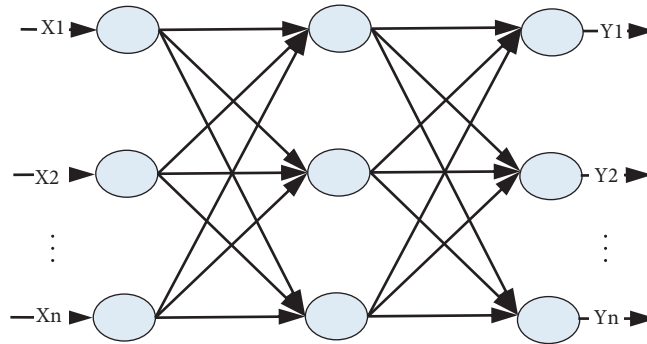


FIGURE 2: The network structure of prediction model.



Input layer; Single hidden layer; Output Layer

FIGURE 3: Structure of neural network.

Neural Network

Algorithms

Data Division: Random (dividerand)
 Training: Levenberg-Marquardt (trainlm)
 Performance: Mean Squared Error (mse)
 Calculations: MEX

Progress

Epoch:	0	9 iterations	2000
Time:		0:00:00	
Performance:	1.01	0.203	1.00e -05
Cradiant:	1.58	0.000539	1.00e -07
Mu:	0.00100	0.000100	1.00e+10
Validation Checks:	0	6	6

Plots

Performance	(Plotperform)
Training State	(Plottrainstate)
Regression	(Plotregression)

√ Validation stop.

FIGURE 4: MATLAB neural network training process.

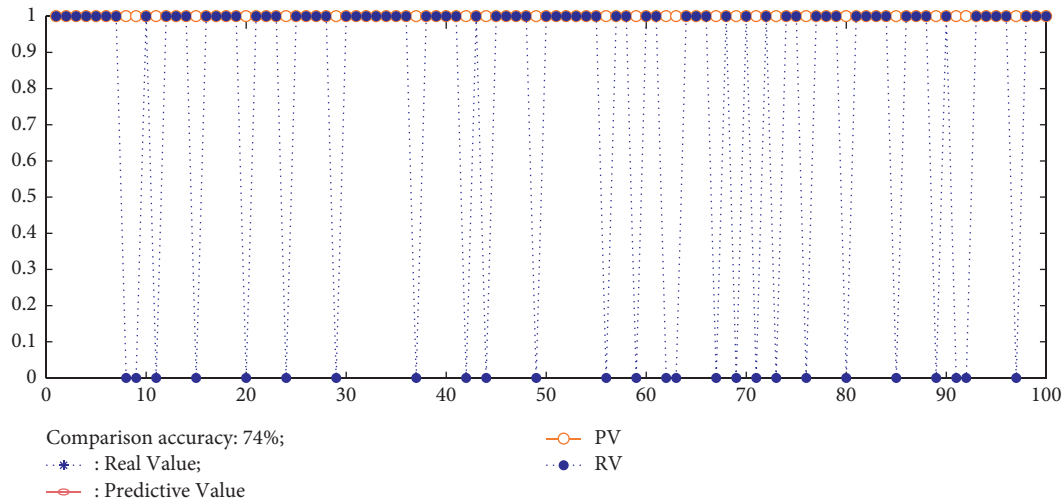


FIGURE 5: BP neural network prediction results.

TABLE 1: Definition of variables.

Type	Variable	Description	Method of calculation
Dependent variable	CSR	Corporate social responsibility	The natural logarithm of Rankins CSR ratings
Independent variables	FD	Whether there are FDs	“1” for “yes” and “0” for “no”
	FN	Number of FDs	The number of female directors on the board of directors
	FR	Proportion of FDs	The proportion of female directors on the board of directors
	FEN	Number of female executive directors	The number of female executive directors on the board of directors
	FER	Proportion of female executive directors	The proportion of female executive directors on the board of directors
	FNEN	Number of female nonexecutive directors	The number of female nonexecutive directors on the board of directors
	FNER	Proportion of female nonexecutive directors	The proportion of female nonexecutive directors on the board of directors
	Age	Years of listing	Logarithm of years of listing
	Csize	Company size	The logarithm of the total assets at the end of the year
Controlled variables	State	Nature of enterprise	Whether it is a state-owned enterprise, “1” for “yes” and “0” for “no”
	Roa	Return on assets	Net profit/average balance of total assets
	Lev	Ratio of assets to liabilities	Average annual total liabilities/average annual total assets
	TOP1	Shareholding ratio of the largest shareholder	Number of shares held by the largest shareholder/total share capital of the enterprise
	Separate	Separation of chairman and general manager	“1” for combination and “0” for separation
	Board	Size of the board	Total number of directors on the board
	DShare	Shareholding ratio of the board of directors	Number of shares held by the board of directors/total share capital of the enterprise
	Indepe	Proportion of independent directors	Number of independent directors/number of directors on the board

The FDNR is determined by the presence or absence of FDs, FN, and FR. As for FTYPE, the FEN and FER are used to quantify female executive directors, whereas FNEN and FNER are used to quantify female nonexecutive directors. Control represented all controlled variables. To avoid possible endogenous problems between the data of FDs, corporate finance, and CSR, the independent variables and controlled variables are all taken from the previous year’s data [61]. Table 1 is the definition of variables. Table 2 shows that the average board size, proportion of FDs, and proportion of independent directors by industry from 2013–2018.

As can be seen from Table 2, the board of directors that are large scale are Mining, Electricity/Heat/Gas/Water Production and Supply, Transportation/Warehousing and Postal Services, Lodging and Catering and Leasing and Business Services. The higher proportion of female directors is in Farming/Forestry/Animal Husbandry and Fishery and Health and Social Work, The higher proportion of independent directors is Realty, Construction and Health and Social Work.

Then, first, an *F*-test (Table 3) is carried out for unbalanced panel data to determine the type of benchmark regression. $\text{Prob} > F = 0.000$, rejecting the original

TABLE 2: 2013–2018 average board size, FR and IDR by industry.

Industry/Year	2013			2014			2015			2016			2017			2018		
	BS	FR	IDR	BS	FR	IDR	BS	FR	IDR	BS	FR	IDR	BS	FR	IDR	BS	FR	IDR
Mining	10.111	0.060	0.378	9.966	0.076	0.369	9.345	0.089	0.388	9.469	0.078	0.376	9.424	0.094	0.386	9.516	0.094	0.390
Electricity, heat, gas, water production and supply	10.546	0.156	0.367	10.543	0.163	0.359	10.286	0.152	0.363	10.824	0.121	0.355	10.541	0.150	0.361	10.539	0.154	0.370
Realty	8.784	0.138	0.401	8.675	0.164	0.389	8.400	0.164	0.402	8.463	0.205	0.392	8.413	0.200	0.389	8.408	0.194	0.394
Construction	8.333	0.065	0.424	8.000	0.075	0.423	8.000	0.075	0.436	8.136	0.083	0.424	8.409	0.064	0.409	8.261	0.062	0.404
Transportation, warehousing and postal services	10.389	0.095	0.369	10.306	0.104	0.364	9.743	0.134	0.375	10.028	0.130	0.362	9.750	0.105	0.372	9.795	0.114	0.375
Scientific research and technology services	Omit	Omit	Omit	Omit	Omit	Omit	Omit	Omit	Omit	8.250	0.158	0.368	7.800	0.244	0.391	8.000	0.246	0.381
Farming, forestry, animal husbandry and fishery	8.429	0.241	0.383	8.429	0.243	0.367	8.125	0.192	0.380	8.500	0.254	0.372	8.667	0.277	0.366	8.500	0.221	0.362
Wholesale and retail	8.700	0.170	0.358	8.645	0.162	0.358	8.971	0.141	0.354	8.722	0.155	0.367	16.564	0.194	0.366	8.732	0.163	0.365
Water conservancy, environment and public facilities management	9.000	0.124	0.365	8.000	0.140	0.381	8.143	0.170	0.374	8.250	0.204	0.369	8.000	0.210	0.380	7.750	0.191	0.393
Health and social work	9.000	0.267	0.375	9.000	0.273	0.396	8.333	0.229	0.407	9.000	0.251	0.384	8.800	0.288	0.392	8.250	0.309	0.406
Culture, sports and entertainment	10.000	0.037	0.333	9.400	0.072	0.387	9.111	0.237	0.382	9.167	0.215	0.381	8.667	0.147	0.365	8.647	0.181	0.375
Information transmission, software and information technology services	9.192	0.110	0.395	9.379	0.105	0.386	8.758	0.145	0.393	8.838	0.141	0.384	8.591	0.181	0.391	8.711	0.166	0.387
Manufacturing	9.262	0.127	0.372	9.092	0.146	0.371	8.985	0.156	0.373	8.974	0.162	0.374	9.033	0.163	0.373	9.014	0.167	0.374
Lodging and catering	10.000	0.100	0.400	9.000	0.222	0.444	10.000	0.100	0.400	10.000	0.100	0.400	10.000	0.100	0.400	9.500	0.161	0.367
Comprehensive	9.500	0.091	0.369	9.000	0.091	0.396	8.333	0.095	0.407	8.400	0.073	0.392	8.800	0.085	0.373	9.400	0.178	0.341
Leasing and business services	10.000	0.118	0.374	9.000	0.187	0.368	8.875	0.188	0.369	9.375	0.218	0.361	9.333	0.167	0.387	9.000	0.210	0.399

TABLE 3: F-test.

	Coef.
F-Test	71.875
P value	0.000
Result	Fixed effect

TABLE 4: Descriptive statistics.

Variable	N	Mean	SD	Minimum	Maximum
CSR	3723	3.681	0.27	2.751	4.489
FD	3723	0.708	0.455	0	1
FN	3723	1.332	1.252	0	7
FR	3723	0.154	0.151	0	0.833
FEN	3723	0.660	0.876	0	5
FER	3723	0.074	0.101	0	0.6
FNEN	3723	0.670	0.79	0	5
FNER	3723	0.076	0.093	0	0.571
Age	3723	2.545	.535	1.099	3.367
Csize	3723	23.26	1.484	18.491	28.509
State	3723	0.608	0.488	0	1
Roa	3723	0.041	0.063	-0.725	0.669
Lev	3723	0.488	0.202	0.008	1.412
TOP1	3723	0.372	0.163	0.03	0.863
Separa	3723	0.175	0.38	0	1
Board	3723	9.104	1.979	4	18
DShare	3723	0.05	0.122	0	0.676

hypothesis “HO: all $\mu_i = 0$ ”, that is, this model is a fixed effect model.

3.3.2. Descriptive Statistics and Correlation Analysis.

Table 4 shows that the average value of the logarithmic CSR data is 3.681, indicating that the CSR level of listed companies in China is still at the initial stage. An average FD of 0.708 indicates that 70.8% of companies have FDs; an average FN of 1.332 indicates that Chinese listed companies have an average of one to two FDs; and an average FR of 0.154 indicates that women hold 15.4% of board seats; that is to say, the average number of women on the board of directors is one in seven. The average FEN is 0.660, meaning that Chinese listed companies have an average of 0.660 female executive directors; and the average FENR is 0.074, suggesting that women executive directors hold only 7.4% of the board seats, that is, there is only one female executive director for every 14 directors.

In this analysis, the Pearson correlation coefficient is used to analyze the correlation between variables. As shown in Table 5, all coefficients that measure the correlation between the substitution variables of FDs are above 0.9, the correlation coefficient between the number and proportion of female executives is 0.930, the correlation coefficient between the number and proportion of female executive directors is 0.969, and the correlation coefficient between the number and proportion of female nonexecutive directors is 0.964, suggesting that there is a high correlation between the substitutive variables of means. There is no significant correlation among FDNR, FTYPE, and CSR, which indicates

that there is interference by other factors on the influence of FDs on CSR [62]. The correlation coefficients between independent variables, controlled variables, and between control variables are all below 0.2 and thus very weak; whereas, generally, a relationship with the coefficient above 0.5 is regarded as strong correlation. Therefore, to prevent multicollinearity between variables, the variance inflation factor test is performed.

3.3.3. Hypothesis Testing. The fixed effect is used to test the principal effect of this paper as the reference regression. The findings of Table 6 show that FDs have a major positive influence on CSR if FD, FN, or FR are regarded as separate variables. The number and percentage of FDs had an important positive effect of 0.01 on CSR and of 0.010 (3.07) and 0.110 on CSR (4.19), respectively, indicating that the number and proportion of FDs participating in board governance have a significant role in promoting CSR. As for the controlled variables, the larger the scale of the enterprise and the board of directors, the higher the shareholding ratio of the largest shareholder and the board of directors, the higher the level of CSR; the higher the ratio of assets and liabilities of the enterprise, the lower the level of CSR; and among enterprises with different property rights systems, state-owned enterprises have a relatively high level of CSR.

Hypothesis 2 is also tested with a fixed effect as the benchmark. The findings of Table 7 indicate that the number and percentage of female executive directors have a significant and positive impact on CSR, with coefficients and T-values of 0.012 (2.32) and 0.145 (3.43), respectively. In comparison, the number and percentage of female nonexecutive directors have a positive but not statistically significant influence on CSR, with coefficients and T-values of 0.006 (0.89) and 0.082 (1.54), respectively. This indicates that the advantageous presence of FDs on CSR is largely due to female executive directors, rather than female nonexecutive directors.

3.3.4. Multicollinearity Test. To prevent multiple regression models from multicollinearity, the test of variance inflation factor (VIF) is performed. The findings of Tables 8 and 9 indicate that the inflation variance factors in Models 1 and 2 are far smaller than the empiric critical value 10 and that the tolerance is between 0 and 1, suggesting that there is no multicollinearity in each model.

3.3.5. Robustness Test. According to the key majority theory, only after the number of FDs exceeds a certain level will they have a meaningful effect on the decision-making and organizational success of the board of directors, Studies [31] have pointed out that “three” is the magic number whereby females have a substantial impact on group dynamics [63]. Given the specificity of the Chinese context, if there is more than one FD (FD1), if there are more than two FDs (FD2), and whether there are more than three FDs (FD3), then they are taken as dummy variables to assess FDs and are replaced in Model 1 for research. OLS regression is performed to

TABLE 5: Correlation analysis of variables.

	CSR	FD	FN	FR	FEN	FER	FNEN	FNER	Age	Csize	State	Roa	Lev	TOPI	Separa	Board	DShare	Indepe
CSR	1																	
FD	0.006	1																
FN	0.007	0.683**	1															
FR	0.017	0.655**	0.930**	1														
FEN	-0.023	0.469**	0.756**	0.691**	1													
FER	-0.033*	0.461**	0.723**	0.716**	0.969	1												
FNEN	-0.062**	0.536**	0.697**	0.625**	0.109**	0.090**	1											
FNER	-0.089**	0.519**	0.666**	0.657**	0.100**	0.109**	0.964**	1										
Age	-0.001	-0.005	0.018	-0.017	0.03	0.024	0.039*	0.018	1									
Csize	0.462**	-0.074**	-0.083**	-0.069**	-0.083**	-0.105**	-0.127**	-0.157**	0.161**	1								
State	0.163**	-0.122**	-0.144**	-0.179**	-0.136**	-0.164**	-0.094**	-0.137**	0.324**	0.288**	1							
Roa	0.035*	0.019	0.046**	0.044**	0.040*	0.039*	0.027	0.029	-0.101**	-0.03	-0.129**	1						
Lev	0.164**	-0.062**	-0.089**	-0.089**	-0.062**	-0.069**	-0.090**	-0.097**	0.212**	0.531**	0.219**	-0.379**	1					
TOPI	0.202**	-0.075**	-0.076**	-0.048**	-0.125**	-0.118**	-0.047**	-0.055**	-0.070**	0.311**	0.345**	0.057**	0.101**	1				
Separa	-0.083**	0.051**	0.059**	0.089**	0.070**	0.098**	0.024	0.051**	-0.148**	-0.105**	-0.289**	0.061**	-0.097**	-0.103**	1			
Board	0.168**	0.065**	0.098**	-0.113**	0.068**	-0.079**	0.074**	-0.095**	0.069**	0.213**	0.232**	-0.012	0.097**	0.036*	-0.150**	1		
DShare	-0.079**	0.033*	0.043**	0.074**	0.060**	0.084**	0.015	0.055**	-0.473**	-0.283**	-0.490**	0.115**	-0.249**	-0.213**	0.192**	-0.180**	1	
Indepe	0.027	-0.059**	-0.069**	0.028	-0.095**	-0.03	-0.029	0.039*	-0.023	0.121**	-0.018	-0.004	0.060**	0.084**	0.096**	-0.386**	0.02	1

** At the level of 0.01 (two-tailed), the correlation is significant.

TABLE 6: The results of the main effect regression.

	With FD as the independent variable		With FN as the independent variable		With FR as the independent variable	
	Coef	t-value	Coef	t-value	Coef	t-value
Fdnr	0.025**	2.85	0.010**	3.07	0.110***	4.19
Age	-0.027**	-3.09	-0.028**	-3.23	-0.028**	-3.21
Csize	0.090***	26.03	0.090***	26.06	0.089***	25.93
State	0.031**	3.07	0.032**	3.18	0.034**	3.33
Roa	0.040	0.58	0.037	0.54	0.039	0.57
Lev	-0.120***	-4.76	-0.119***	-4.70	-0.116***	-4.61
TOP1	0.077**	2.83	0.076**	2.77	0.074**	2.72
Separa	-0.023*	-2.13	-0.023*	-2.15	-0.024*	-2.20
Board	0.009***	3.89	0.008***	3.71	0.010***	4.42
DShare	0.146***	3.62	0.144***	3.58	0.145***	3.60
Indepe	-0.008	-0.11	-0.010	-0.13	-0.010	-0.13
Constant	1.578***	20.38	1.586***	20.57	1.580***	20.52
N		3723		3723		3723
R-squared		0.240		0.240		0.242
F value (P value)		106.446(0.000)		106.607(0.000)		107.576(0.000)

Note. *shows that it is relevant at the 0.1 level, **at the 0.05 level, and ***at the 0.01 level.

TABLE 7: Regression results of different types of FDs on CSR.

	Female executive directors				Female non-executive directors			
	With FN as the independent variable		With FR as the independent variable		With FN as the independent variable		With FR as the independent variable	
	Coef	t-value	Coef	t-value	Coef	t-value	Coef	t-value
Ftype	0.012***	2.32	0.145**	3.43	0.006	0.89	0.082	1.54
Age	-0.038**	-2.92	-0.036**	-2.82	-0.020	-1.66	-0.019	-1.65
Csize	0.093***	16.81	0.092***	16.54	0.088***	20.07	0.088***	20.08
State	0.058***	3.91	0.060***	4.01	0.006	0.45	0.007	0.48
Roa	0.030	0.29	0.039	0.38	0.040	0.43	0.040	0.43
Lev	-0.201***	-5.05	-0.196***	-4.94	-0.055	-1.70	-0.054	-1.65
TOP1	0.064	1.48	0.060	1.39	0.080*	2.24	0.077*	2.18
Separa	-0.039*	-2.56	-0.038*	-2.55	-0.007	-0.47	-0.008	-0.48
Board	0.004	1.07	0.007*	1.99	0.012***	3.89	0.013***	4.07
DShare	0.156**	2.75	0.157**	2.78	0.106	1.82	0.107	1.83
Indepe	-0.056	-0.45	-0.068	-0.55	0.002	0.02	0.001	0.01
Constant	1.618***	12.65	1.613***	12.64	1.543***	15.86	1.540***	15.85
N		1697		1697		2026		2026
R-squared		0.217		0.220		0.269		0.270
F value (P value)		42.506(0.000)		43.242(0.000)		67.467(0.000)		67.663(0.000)

Note. *shows that it is relevant at the 0.1 level, ** at the 0.05 level, and *** at the 0.01 level.

control the industry and annual effects. The results of Table 10 show that FD1 and FD2 have a positive but not significant impact on CSR performance. FD3 has a positive and significant impact on CSR performance. This is consistent with the key majority theory and the findings of foreign studies; that is, in the Chinese context, it takes more than three FDs to break their “minority status” and enhance their self-confidence and courage to speak out on the board.

4. Discussion

Corporate social responsibility (CSR) is a critical component of a company's long-term existence and collaborative sustainable growth with society and the environment [64]. It

meets the realistic expectations of the entire society and can help businesses increase their competitiveness and reputation. The majority of sustainability studies, however, is undertaken in developed market economies, particularly in the United States and Europe. As a result, prosocial behavior and sustainable development in developing economies are still poorly understood.

In the aspect of the development test, BP neural network is used to predict the existence of female directors. The results showed that the RKS rating score, M , C , T four evaluation indices can effectively represent whether there are female directors in the company or not, and the model can effectively predict the existence of female directors. The higher the score of social responsibility, the more female

TABLE 8: Test results of variance inflation factor of main effect regression models.

	With FD as the independent variable		With FN as the independent variable		With FR as the independent variable	
	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance
Fdir	1.03	0.969	1.06	0.948	1.05	0.956
Age	1.42	0.705	1.42	0.702	1.42	0.704
Csize	1.74	0.573	1.75	0.573	1.74	0.574
State	1.64	0.609	1.65	0.606	1.65	0.607
Roa	1.25	0.802	1.25	0.802	1.25	0.802
Lev	1.74	0.574	1.74	0.574	1.74	0.573
TOP1	1.32	0.759	1.32	0.759	1.32	0.759
Separa	1.11	0.899	1.11	0.899	1.11	0.899
Board	1.35	0.741	1.36	0.733	1.35	0.743
DShare	1.62	0.619	1.62	0.619	1.62	0.619
Indepe	1.25	0.802	1.25	0.802	1.25	0.802

TABLE 9: Test results of variance inflation factor of regression models for different types of FDs.

	Female executive directors				Female nonexecutive directors			
	With FN as the independent variable		With FR as the independent variable		With FN as the independent variable		With FR as the independent variable	
	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance
Ftype	1.04	0.963	1.07	0.931	1.02	0.981	1.03	0.969
Age	1.49	0.669	1.49	0.673	1.39	0.717	1.39	0.717
Csize	1.79	0.558	1.8	0.556	1.75	0.571	1.74	0.574
State	1.6	0.626	1.6	0.627	1.67	0.6	1.67	0.6
Roa	1.25	0.797	1.26	0.797	1.25	0.798	1.25	0.798
Lev	1.84	0.542	1.85	0.541	1.68	0.594	1.69	0.593
TOP1	1.31	0.762	1.31	0.762	1.32	0.757	1.32	0.755
Separa	1.07	0.931	1.09	0.92	1.17	0.854	1.17	0.854
Board	1.4	0.716	1.43	0.7	1.34	0.746	1.35	0.742
DShare	1.62	0.616	1.62	0.616	1.64	0.609	1.64	0.609
Indepe	1.18	0.847	1.18	0.847	1.33	0.752	1.33	0.752

TABLE 10: Regression results of FDs' influence on CSR.

	With Fdum1 as the independent variable		With Fdum2 as the independent variable		With Fdum3 as the independent variable	
	Coef	t-value	Coef	t-value	Coef	t-value
Fdir	0.011	1.32	0.013	1.18	0.059***	3.75
Age	-0.038***	-4.37	-0.038***	-4.34	-0.040***	-4.52
Csize	0.086***	24.38	0.086***	24.36	0.086***	24.36
State	0.034**	3.36	0.034**	3.33	0.036***	3.54
Roa	0.050	0.72	0.050	0.72	0.049	0.71
Lev	-0.103***	-4.05	-0.103***	-4.04	-0.100***	-3.93
TOP1	0.091**	3.34	0.092**	3.36	0.088**	3.23
Separa	-0.026*	-2.46	-0.026*	-2.42	-0.026*	-2.40
Board	0.010***	4.47	0.010***	4.48	0.010***	4.24
DShare	0.137**	3.40	0.137**	3.40	0.136**	3.38
Indepe	0.003	0.04	0.002	0.02	0.004	0.05
Ind year		Controlled		Controlled		Controlled
Constant	-27.633***	-5.78	-27.845***	-5.83	-27.666***	-5.80
N		3723		3723		3723
R-squared		0.247		0.247		0.249
F value (P value)		93.481(0.000)		93.445(0.000)		94.741(0.000)

Note. *shows that it is relevant at the 0.1 level, ** at the 0.05 level, and *** at the 0.01 level.

directors may exist, which further verifies that the high social responsibility of enterprises pay more attention to the gender balance in the management and make full use of the advantages of female gender characteristics.

We examined the impact of FDs scale and type on CSR through fixed effect. Our results were as follows: (a) generally speaking, China's listed companies lacked FDs, and they were still at a "starting" stage in the fulfilment of social responsibility; (b) the FD's involvement in corporate management had a major positive impact on the CSR, and three or more FDs had a noticeable positive influence on Chinese social responsibility; (c) compared with the supervisory role of female nonexecutive directors, the advisory and executive role of female executive directors showed a more significant impact on CSR.

4.1. Managerial Implications. China is an emerging developing country, and the problem of social responsibility will exert great influence on the sustainable development of enterprises and overall social welfare. It is one of the effective approaches to promote the fulfilment of CSR through the arrangement of board structure, so this study has provided important enlightenment for the improvement of CSR performance through the arrangement of board structure, especially based on gender composition. Meanwhile, enterprises are more willing to hire female directors after the level of CSR is improved, indicating that enterprises with high CSR performance pay more attention to gender balance. The combination of the two can produce a virtuous circle impact on corporate management.

4.2. Limitations and Directions for Future Research. This research has some limitations. First, our sample comprised only Chinese listed companies disclosing social responsibility reports, which may lead to a sample selectivity problem, and listed company samples not disclosing social responsibility were absent. Second, owing to version updating of the RKS-CSR database, the unbalanced panel only covered 6 years. Because the data were missing, we had to reduce the sample scale. When we discovered that data for a specific year were missing, we removed those companies from the sample set; firms with significant omissions or outliers were also removed from that year. Finally, multiple collinearity and endogenous problems were considered, but the test for sample Selection Bias was not conducted due to space limitations. We suggest that researchers should solve the sample selectivity problem with Heckman two-step method in the future. In addition, the application of BP neural network in the field of economics is still in the initial stage, lacking previous research background.

5. Conclusion

Drawing on the "essential plurality principle" and "social role theory" (1, Ditto), we described research about the relationship between the scale and type of FDs and CSR. Our results provide greater understanding of how FDs influences

CSR. We also found that the situation in the Chinese context was the same as that of overseas studies, and 3 is the magic number for women to produce a material impact on group dynamics. Meanwhile, enterprises are more willing to hire female directors after the level of CSR is improved, indicating that enterprises with higher CSR performance pay more attention to gender balance.

Therefore, we call for a new era of economic and social integration in the world, enterprises should pay more attention to gender equality, which has become a global challenge under today's backdrop. They need to implement from their own prospective to promote the social goal of gender equality, as well as to dig out the social value and economic value which will be brought by gender equality, so that they will become sustainable development enterprises with responsibility. Paying attention to the mainstream trend of gender equality in global society and communities, and regarding social responsibility standards and relevant laws and regulations of the region, this study reveals the impact of this issue on the enterprise. Gender equality has not only attracted the attention of government departments in many countries but also has become an important factor of local culture shock and community economic development in many enterprises during their overseas operations. It is necessary for enterprises to identify the risks and impacts of this issue on their sustainable operation and it should be incorporated into long-term decisions.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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