Received: 24 May 2022 | Revised: 6 October 2022 | Accepted: 19 October 2022

DOI: 10.1002/bse.3294

RESEARCH ARTICLE

Business Strategy and the Environment

WILEY

Director's network location and corporate environmental investment in the carbon neutrality age

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Funding information
Humanity and Social Science Foundation of Ministry of Education of China, Grant/Award Number: 20YJA630024; National Natural Science Foundation of China, Grant/Award Numbers: 71729001, 72025101; Fundamental Research Funds for the Central Universities, Grant/Award Number: FRF-DF-20-11; China Postdoctoral Science Foundation, Grant/Award Number: 2021M700380

Abstract

Although carbon neutrality is a global aim, the potential drivers and influence mechanisms of corporate governance communities are unclear. This study examines the impact of director's network location on corporate environmental investment (CEI) and explores potential channels for CEI performance changes. Using a sample of 495 listed firms in China from 2015 to 2019, we construct a director-based network using contacts of independent company directors. Results indicate that director's network location has positive economic impacts on CEI performance and that financing constraints are an important mechanism of director's networks affecting CEI. Director's networks positively affect corporate performance by improving CEI. Results are robust to endogeneity concerns and contribute to the CEI literature by showing a positive effect between director's network and CEI, as well as between director's network and enterprise value. This paves the way for policymakers, managers, and investors to understand the influence of director's network on CEI performance.

KEYWORDS
agency theory, corporate environmental investment, director's network, enterprise value

1 | INTRODUCTION

Achieving carbon neutrality, or zero emission, is a global aim (Jiang et al., 2021). Joint global efforts are needed to address this emerging issue. China's fast-growing economy has made it one of the world's highest emitters of carbon (Wang & Yang, 2020). To realize national strategic needs and consider the overall international and domestic situations, China put forward the goals of a carbon emission peak in 2030 and carbon neutrality in 2060. Emission peak refers to China's commitment to stopping the increase of carbon dioxide emissions by 2030 and, at the same time, to reducing carbon dioxide emissions gradually after a peak has been reached. Carbon neutrality refers to offsetting carbon dioxide emissions by greening the environment and saving energy (Tang et al., 2018). The carbon emissions generated by enterprises accounted for more than 90% of the total energy carbon emissions (Busch & Hoffmann, 2011). Therefore, it is urgent that enterprises in China are encouraged to participate in carbon peak and carbon neutrality schemes.

Environmental investment is a special type of investment allowing enterprises to practice social responsibility activities, which is an important way for enterprises to participate in achieving the goal of carbon neutrality and emission peak (Yang et al., 2020). Corporate environmental investment (CEI) is the financial disclosure in the reporting of corporate social responsibility (CSR), which is not only a manifestation of capital investment but also a decision of corporate governance (Bhandari & Javakhadze, 2017). In essence, companies can obtain many benefits by improving CEI, which include excellent prestige (Aguilera-Caracuel & Guerrero-Villegas, 2018), market value

(Kong et al., 2014), and investment efficiency (Benlemlih & Bitar, 2018).

However, as a special investment of enterprise, CEI involves multiple interests, including social, economic, and environmental, with some basic characteristics being a long investment cycle, low economic benefits, high opportunity cost, and insufficient incentive mechanisms, which make CEI a sort of "passive" behavior of enterprises (Kearins et al., 2010). Based on a basic understanding of CEI, the potential factors of CEI performance have been documented, including both external and internal factors, with the external factors mainly being environmental regulation (Han, 2020), market competition (Ducassy & Montandrau, 2015; Luken et al., 2008), and external pressure (Testa et al., 2018), and the internal corporate factors mainly being internal control (Yang et al., 2020), corporate culture (Sugita & Takahashi, 2015), and board structure (Post et al., 2011). Although the aforementioned literature has explored the heterogeneous performance of CEI in corporate governance, an important branch of the characteristics of the board has been ignored, especially from the perspective of the director's network.

Director's network is a social network formed by the relationship between directors (Larcker et al., 2013). The existing literature has shown that directors can improve the corporate network through their own relationships (Rossi et al., 2018). An effective director's network has the following functions: to increase access to resources and information, to facilitate the flow of information and transfer of knowledge (Hillman, 2005), to give directors more influence and power, to improve director's governance ability and motivation, and to improve board members' regulators and executors (Adler & Seok-Woo, 2002). Previous research on director's network and corporate governance looks at corporate performance (Larcker et al., 2013), merger and acquisition transaction (Cai & Sevilir, 2012), social responsibility (Nandy et al., 2020), compensation of directors (Ferris et al., 2020), and financial report quality (Intintoli et al., 2018).

Previous literature also shows that board characteristics are related to corporate environmental decisions. In terms of environmental disclosure, Roberts (1992) finds a positive correlation between the proportion of external independent directors and the information disclosure of corporate environmental protection behavior. Haniffa and Cooke (2005) believe that the environmental behavior of enterprises is promoted when the sources of directors are diversified and the number of directors is reasonable. Regarding CEI, Nada et al. (2001) point out that the CEO, as chairman of the board, is negatively related to environmental investment. Sheng et al. (2011) find a negative correlation between executive political relationships and corporate investment efficiency. Atif et al. (2020) confirm the influence of female directors on the scale of environmental investment in enterprises. The director's network formed by the relationship between directors is one of the characteristics of the board that affects the governance ability and motivation of directors and affects the formulation of CSR strategy (Cullinan et al., 2017; Mason & Simmons, 2014). Therefore, CEI, as an important part of CSR, may be affected by the network characteristics of company corporate directors. However, the impact of board characteristics on environmental investment from the perspective of a director's network is a research gap. Therefore, the above-mentioned reasons inspired us to investigate CEI performance from a broad perspective of the director's network location of the board of directors.

Based on the aforementioned analysis, we assume that a firm's environmental investment may be closely related to its director's network location. Thus, we aim to address the following questions in this research:

Q1: *Does the director's network location of a firm affect its CEI performance?*

We further explore the influence mechanism of the director's network on CEI. Inspired by agency theory and resource dependence theory, we find that the director's network can affect the financing constraints of enterprises, and financing constraints are an important factor affecting CEI (Bernanke & Gertler, 1989; Chang & Wu, 2021; Engelberg et al., 2012). Accordingly, we ask the following questions:

Q2: *How does the director's network location of a firm affect its CEI performance?*
Q3: *Can the director's network affect CEI by alleviating the financing constraints of enterprises?*

The enterprise value is influenced by the characteristics of the board, and the director's network is one of those characteristics. Previous research on director's networks and enterprise value has not yet reached a final conclusion (Fich & Shivdasani, 2006; Hillman & Dalziel, 2003; Kim, 2005). Many researchers, such as Lee et al. (2015), have also studied the impact of CEI on enterprise value. We are interested in the relationship between the director's network location, CEI, and enterprise value. Therefore, we formulate the following research questions:

Q4: *How does the director's network location of a firm affect its enterprise value?*
Q5: *Does CEI moderate the relationship between the director's network location of a firm and enterprise value?*

To answer these questions, we collect the unbalanced panel data of 495 listed companies' A shares in Shenzhen and Shanghai from 2015 to 2019 to test the relationship between director's networks and CEI based on agency theory and resource dependence theory. Following the research of Larcker et al. (2013) and Amin et al. (2020), we measure the director's network connection by using network centrality of directors. We calculate three indicators of degree centrality, closeness centrality, and betweenness centrality. Degree centrality refers to the number of direct connections between an independent director and other directors, focusing on the activity of communication in the network (Amin et al., 2020; Larcker et al., 2013). Closeness centrality is

the reciprocal of the sum of the shortest connection distances between an independent director and other directors, which mainly measures the effectiveness of communication in the network (Amin et al., 2020; Larcker et al., 2013). Betweenness centrality means that intermediary centrality measures the control degree of different connections in the director network, that is, the ability of independent directors as mediators (Amin et al., 2020; Larcker et al., 2013). According to the three centralities, we calculate the centrality index of integrated enterprise network as an index to measure the network of independent directors. In further analysis, we examine the mechanism by which the director's network affects CEI, and we explore whether financing constraints play an intermediary role in the director's network relationship to environmental investment. Furthermore, we also measure enterprise value in terms of economic value added (EVA), through a stepwise regression coefficient test, to confirm whether the impact of the director's network on CEI leads to changes in enterprise value.

Our main results show a significant positive correlation between director's networks location and environmental investment. This result is valid in the regression test between the comprehensive index of director's network centrality, degree centrality, closeness centrality, betweenness centrality, and environmental investment. The results from further analysis show that one of the ways in which the director's network location affects environmental investment is through financing constraints, and the director's network increases the environmental investment of the enterprise by reducing the financing constraints of the enterprise. The centrality of a director's network has a positive impact on enterprise value. We indicate that environmental investment plays an intermediary role in the relationship between a director's network and enterprise value. Our results are robust for both the test of variable substitution and the control of endogenous problems.

The contributions of our research are as follows. This is the first comprehensive study to explore the relationship between a director's network location and CEI. Previous studies on the impact of corporate governance on CEI only focused on controlling shareholders, management shareholding ratio, and so on (Li et al., 2020). Although previous studies have confirmed the correlation between director's networks and CSR, we further explore the relationship between environmental investment, which is affected by CSR decision-making and the director's network. It enriches the relevant literature on director's networks and corporate governance, as well as encouraging enterprises to pay more attention to the role of independent directors in environmental investment decisions. We further study the path of the director network's impact on CEI and the impact of the director's network on enterprise value, which has reference significance for enterprises' environmental investment decisions.

The remainder of this paper proceeds as follows. In Section 2, we propose the hypotheses and theoretical basis. In Section 3, we describe the data and variable measurements. In Section 4, we present the empirical results and further analysis. Finally, we summarize our research in Section 5.

2 | LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 | Literature review

Previous studies show that directors with strong networks have better connections and have more advantages than those with weaker networks (Egginton & McCumber, 2019; Faleye et al., 2014; Miranda-Lopez et al., 2019). In research on director's networks, centrality is the most commonly used method for measuring location among directors (Burt, 1997). If a director is well connected, his location advantage will enable him to have more resources and information communication channels than other people who are not well connected (measured by degree centrality). At the same time, if there are fewer degrees of separation between a director and other directors, which means he or she is more closely related to other directors, he or she can obtain a faster speed of resource exchange because of the advantage of location (measured by closeness centrality). Moreover, if a director can act as the key to the exchange of resources and information between other directors, that is, between pairs of other directors, he or she has more lines of communication, then their network centrality is better (measured by betweenness centrality). Generally speaking, the better the director's network location, the higher the network centrality and the stronger his ability to obtain resources and information in the network (Godigbe et al., 2018); this will affect the corporate governance ability of independent directors. The existence of director's network strengthens the reputation effect of independent directors (Chuluun et al., 2014). For independent directors, the reputation incentive of director's network will also affect their corporate governance motivation and decisions. Therefore, the difference in director's network characteristics represents the difference in governance motivation and governance ability of independent directors in corporate governance decision-making. The higher is the director's network centrality, the more obvious their governance effect.

Previous studies have analyzed the influencing factors and roles of corporate environmental investment. On the influencing factors of Environmental Protection Investment in Enterprises, Han (2020) believes that environmental regulations will affect enterprises' environmental investment. Kong et al. (2020) find that the business strategy of enterprises has a significant impact on environmental protection behavior. Atif et al. (2020) find that the proportion of female directors on the board of directors was positively correlated with the environmental protection investment of enterprises. As for the role of environmental investment in enterprises, Orsato (2006) finds that some companies gained core competitiveness through environmental investment. De Miguel and Pazo (2017) find that environmental investment is positively related to the innovative behavior of Spanish manufacturing companies. Ambec and Lanoie (2008) believe that environmental investment can improve the environmental performance and financial performance of enterprises and achieve a win–win situation.

Corporate environmental investment is not only the behavior of the management in pursuit of the economic interests of the enterprise but also their behavior in fulfilling social responsibility (Hambrick & Mason, 1984). According to the previous literature, it can be found that environmental investment decisions are not only directly subject to the government's environmental policies but also affected by the internal corporate governance mechanism. Corporate environmental investment is a high investment, but it is difficult for it to bring direct economic benefits, and it crowds out production funds (Gray & Shadbegian, 2003). Therefore, in the case of information asymmetry and the conflict between environmental protection and economic development, agents may undertake short-sighted behavior to reduce environmental investment in the process of realizing enterprise economic benefits, in order to bring higher incentive benefits for themselves and maximize their own interests (Yang et al., 2021). The environmental investment decision of the enterprise can be seen to be affected by the agency problem and restricted by company resources. Referring to the previous literature, this study believes that the theoretical explanation for the relationship between a director's network and CEI is rooted in two perspectives, namely, agency theory and resource dependence theory.

2.2 | Hypotheses development

According to agency theory, the board of directors can make the interests of managers consistent with the interests of shareholders through the implementation, supervision, and governance mechanisms (Hart, 1995) or the use of incentive schemes (Meckling, 1976). Independent directors can coordinate the interests of stakeholders, managers, and shareholders; they can perform fiduciary obligations more faithfully, maintain the company by reducing management opportunism, and protect the results of the social responsibility and financial performance of the company (Fama, 1980). Reputation is an important motivation for independent directors in playing a role (Fama & Jensen, 1983). In recent years, stakeholders have paid increasing attention to CSR (Zhang et al., 2020), and independent directors must consider the potential reputation damage cost of insufficient social responsibility (Liu et al., 2016). As independent directors with higher director's network centrality can obtain higher reputation incentives embedded in the director's network, they have more motivation for supervising the management's decision-making regarding social responsibility activities and restraining opportunistic behavior. In addition, as the network of directors can bring potential positions in the board market to independent directors (Cashman, 2010), in this case, because it is less subject to management and major shareholders, and its "bargaining" power is also relatively stronger, it is more likely to take into account the long-term interests of stakeholders and the company in the company's environmental investment decisions and express objective independent opinions. Generally speaking, independent directors with a high director's network centrality will supervise the management's opportunistic behavior more actively from governance motivation, in order to reduce the company's agency cost and increase the enterprise's environmental investment.

According to the theory of resource dependence, the board of director's most important responsibility is to provide resources. These resources mainly include four types: information exchange channels (Hillman et al., 1999), consulting functions (Westphal, 1999), reputation, and external resource acquisition (Zald, 1969). According to this theory, the professional knowledge of the board of directors and the network relationship of the board of directors can help enterprises achieve social and economic performance. The network of directors enables independent directors with external connections to provide managers with key resources that are useful for the operation and strategic development of the company, such as professional knowledge, influence, information, skills, and advice, which are of strategic significance to the performance of CSR.

The better is the network connection of independent directors, the higher the efficiency of information and knowledge transmission (Hillman, 2005). Larcker et al. (2013) propose that a director's network can bring information advantages for enterprises to cope with market changes and predict the future development of the market. Schoorman et al. (1981) put forward a similar point of view, believing that for competitors, suppliers, and customer information access and grasp, more network-centric enterprises have an advantage. The higher is the centrality of the independent director's network of the company, the better the director's network location of the company director. Therefore, the higher the director's network centrality, the better the governance ability of independent directors, which is reflected in the acquisition of more resources, information, and knowledge for the company, while affecting CSR activities. Independent directors with higher director's network centrality are likely to become better consultants and supervisors, helping managers adopt practices that can improve the value of CSR and increase corporate investment in environmental protection.

In summary, the theoretical argument shows that the director's network can alleviate the agency problem of enterprises and provide enterprises with more access to information, knowledge, and resources, which influences the environmental investment of enterprises. The higher the centrality of the director's network, the more advantages can be gained in the network. Based on the above analysis, we propose the following hypotheses:

Hypothesis 1. The centrality of a director's network is positively related to the environmental investment of enterprises.

Hypothesis 2. The degree centrality of a director's network is positively related to the environmental investment of enterprises.

Hypothesis 3. The closeness centrality of a director's network is positively related to the environmental investment of enterprises.

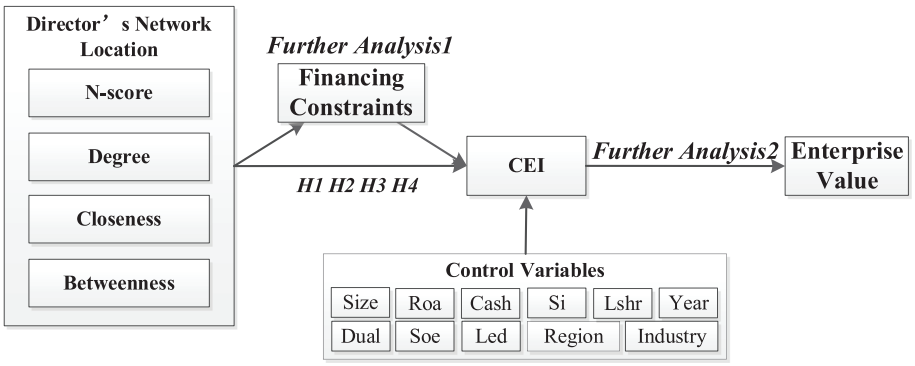

FIGURE 1 The research framework of this study

Hypothesis 4. The betweenness centrality of a director's network is positively related to the environmental investment of enterprises.

The research framework of this study is presented in Figure 1.

3 | DATA AND VARIABLE MEASUREMENT

3.1 | Data and sample selection

The data in this study are from three main sources: First, corporate financial performance and board data are from the China Securities Market and Accounting Research (CSMAR) database; second, CEI data are from the CSMAR database, with partly missing data from the official website of the China Securities Regulatory Commission; third, raw data on regional economic development level and regional environmental regulation intensity are from the official website of the China Statistical Yearbooks.

Sample selection criteria in this paper have four main aspects: (1) All quoted firms must be listed on Shenzhen and Shanghai Stock Exchanges between 2015 and 2019, because the newly revised Environmental Protection Law was issued on January 1, 2015; (2) due to the peculiar operating characteristics and industry property, we first exclude insurance, financial, and securities listed companies; (3) we also exclude empirical samples with special treatment firms, such as ST (the company has suffered losses for two consecutive years), SST (the company has suffered losses for two consecutive years and has not completed the share reform), and *ST (the company has suffered losses for three consecutive years); (4) some firms without disclosed CEI data, or those missing the board data and financial data, are also excluded. We should notice that the new Environmental Protection Law, the strictest environmental protection law in Chinese history, was revised on January 1, 2015, providing an unprecedented environmental protection guideline for CEI decisions. As such, we select this as the starting point. Finally, we merge all raw data according to stock code and obtain 895 firm-year observations in our sample set.

3.2 | Variable descriptions

3.2.1 | Dependent variable

We choose environmental investment as the main dependent variable, and we specify CEI as the measure, following previous research (Li & Lu, 2016; Patten, 2005). In this study, we take the natural logarithm of environmental investment to measure CEI.

3.2.2 | Independent variables

The connection of the director's network is defined as the same independent director of the same year serving on two boards of directors at the same time. In our director's network, this kind of independent director who serves on two boards of directors at the same time is a link, and the board of directors of each company is a node. Our study does not take into account the contacts of directors within the company, and repeated links to multiple common independent directors are also excluded. We consider the network between the boards of directors of different companies.

The first object worth studying is the independent director, to study the influence of director's networks on director governance behavior. Independent directors play a prominent role as a "bridge" in the director's network, occupying the advantage of information and control, while the position of internal directors in the entire network of directors of listed companies is often illiquid and belongs to relatively isolated individuals. In the position of "passive acceptance," the network characteristics are not obvious. At the same time, the weak connection advantage theory holds that independent directors master most of the weak connections in the director's network, which not only plays the role of information communication (Granovetter, 1973) but also grasps the exchange, borrowing, and grabbing of resources, so independent directors play a key role in the network of directors. Therefore, we choose independent directors to study the impact of director's networks on director governance behavior.

To measure the director's network location, we use the index of the director's network centrality. Based on the existing literature (El-

Khatib et al., 2015), we choose three indicators: degree, closeness, and betweenness.

$$\text{Degree}_i = \frac{\sum_j X_{ji}}{g-1}$$

In this formula, i and j, respectively, represent different directors in the network, if i and j at least serving on the same board is 1, otherwise it is 0. G is the total number of directors of listed companies in that year; $(g-1)$ is used to eliminate differences in size.

$$\text{Betweenness}_i = \frac{\sum_{j<k} g_{jk(n_i)}/g_{jk}}{(g-1)(g-2)/2.}$$

In this formula, g_{jk} is the number of necessary shortest paths for the connection between director j and k, $\sum_{j<k} g_{jk(n_i)}/g_{jk}$ is the degree of director i in the shortest path of all other director–director connections in the entire director network. g is the number of directors in the network of listed companies in the current year, and $(g-1)(g-2)/2$ is the elimination of the difference in the scale of the director network of listed companies in different years.

$$\text{Closeness}_i = \frac{g-1}{\sum_{j=1}^{g} d(i,j)}$$

In this formula, $d(i,j)$ is the distance between directors i and j. $\sum_{j=1}^{g} d(i,j)$ is the sum of the shortest distances between director i and other directors.

The larger is the degree of an independent director, the more directly the other directors are connected to that director. Closeness is a measure of the number of steps connected between two independent directors, which reflects the intimacy of the relationship between independent directors and the highest-ranking directors in the network. Independent directors with high betweenness have a greater advantage in obtaining information in the whole network because betweenness measures the shortest path between two independent directors in the network (Nandy et al., 2020).

To comprehensively measure the director's network, this study considers three indicators (Larcker et al., 2013). We end up with four independent variables. The construction steps of the director's network are presented in Figure 2. A detailed description of the metric construction is as follows:

Step 1: We first collect the personal data of all directors of the entire A-share listed company, sort them into a matrix form, and calculate the network centrality of each director (degree centrality, closeness centrality, and betweenness centrality). The network centrality index is calculated using the large-scale social network analysis software PAJEK.

Step 2: We next select companies with data on environmental investment available from 2015 to 2019 as sample companies.

Step 3: We screen out data of degree centrality, closeness centrality, and betweenness centrality of the independent directors of each sample company.

Step 4: The maximum values of degree centrality, closeness centrality, and betweenness centrality among all independent directors of each company are, respectively, selected to calculate degree centrality, closeness centrality, and betweenness centrality at the company level, which is used to measure the location of the director's network of the company.

Step 5: To eliminate the dimensional differences of each central index and the influence of outliers, as well as to highlight the

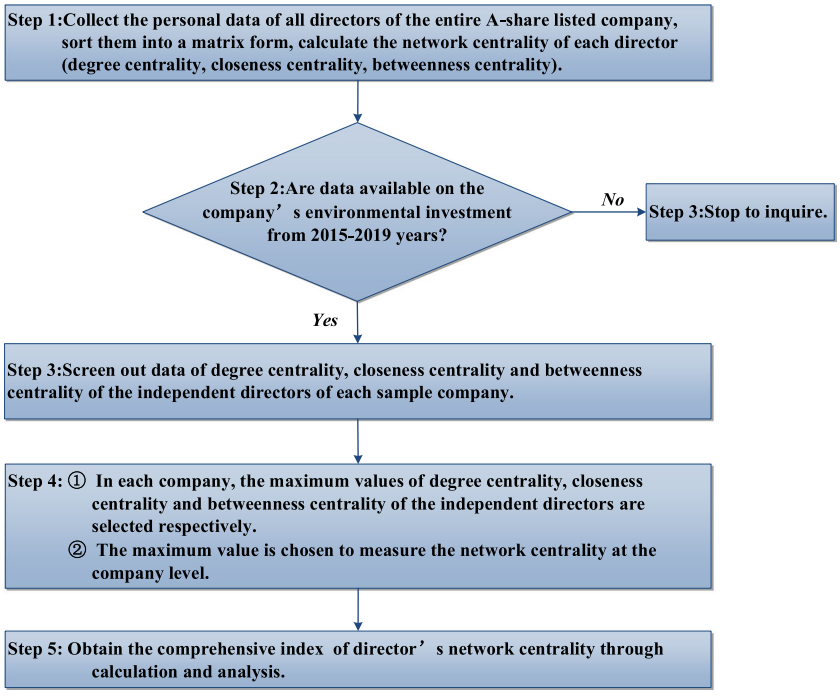

FIGURE 2 The construction steps of the director's network

differences in indicators, we divide the sample into five quintiles in each year based on the degree, closeness, and betweenness centralities. Through this calculation, the comprehensive corporate network centrality index Q (*n* score) is obtained as the main analysis variable. The aggregated board centrality measure Q (*n* score) is defined as follows:

$$Q(\text{nscore}) = \text{Quint}\left[\frac{1}{3}\{\text{Quint}(\text{degree}) + \text{Quint}(\text{closeness}) + \text{Quint}(\text{betweenness})\}\right] \quad (1)$$

3.2.3 | Control variables

We select control variables according to previous research and divide them into three categories: (i) corporate governance variables, (ii) corporate financial performance, and (iii) external factors. First, we follow prior literature on corporate environmental protection and social responsibility (Hollindale et al., 2019; Jo & Harjoto, 2012): The *corporate governance variables* mainly contain the shareholding ratio of the largest shareholder, the proportion of independent directors, and the integration of the two positions; second, inspired by Amin et al. (2020) and Larcker et al. (2013) that *corporate financial performance* has an important influence on director's network connections, we therefore control enterprise size, corporate performance, and cash holding level; and third, following Gan et al. (2021), *external factors*, including the regional economic development level, the level of regional marketization, and the nature of equity, have an important effect on CEI; therefore, we also control for *external factors*. Finally, the fixed effects of industry and year are controlled (Nandy et al., 2020). All independent, dependent, and control variables are shown in Table 1.

3.3 | Descriptive statistics

We present the descriptive statistics of the dependent, independent, and control variables. Table 2 shows the descriptive statistics of CEI. After the implementation of the new Environmental Protection Law in 2015, the average value of CEI has gradually increased year by year, and the maximum and minimum values have also increased year by year, indicating that Chinese enterprises have paid increasing attention to environmental investment in recent years. As for the standard deviation of CEI, we can see it is relatively large, which indicates prominent individual differences of CEI.

TABLE 1 Variable selection and definition

Variable name	Variable symbol	Variable description
Independent variable		
Director's network centrality	Q(*n* score)	Equation (1)
Degree centrality	Q(degree)	Quartile ranking of degree centrality
Closeness centrality	Q(closeness)	Quartile ranking of closeness centrality
Betweenness centrality	Q(betweenness)	Quartile ranking of betweenness centrality
Dependent variable		
Corporate environmental investment	CEI	The natural logarithm of the total investment in environmental protection of enterprises
Control variable		
Enterprise size	Size	Standardized data on total assets at the end of the year
Corporate performance	Roa	Return on total assets
Cash holding level	Cash	Year-end monetary fund amount/average total assets
The proportion of independent directors	Si	The proportion of independent directors to the board of directors
Shareholding ratio of the largest shareholder	Lshr	The shareholding ratio of the largest shareholder
Integration of the two positions	Dual	If CEO is the chairman, the virtual variable equals 1, otherwise it equals 0
Industry	Industry	Industry classification of SFC in 2012
Year	Year	Year
Nature of equity	Soe	When state-owned, the value is 1, otherwise 0
Regional economic development	Led	Natural logarithm of actual per capita GDP in the registered area of the company
The level of regional marketization	Region	The marketization value of provinces, cities and regions constructed by Fan Gang and Wang Xiaolu[1]

Note: CEI, corporate environmental investment; SCF, industry classification standards of China securities regulatory commission.

TABLE 2 Descriptive statistics of CEI

Year	Obs	Mean	SD	p25	Median	p75	Max	Min
2015	88	7.537	2.49	6.413	7.81	9.115	11.83	−0.916
2016	349	6.949	2.367	5.278	7.139	8.485	15.06	−0.223
2017	172	7.949	2.47	6.358	8.116	9.424	18.17	−0.371
2018	159	8.352	2.471	6.715	8.488	9.872	18.74	3.729
2019	127	8.145	1.964	6.72	8.2	9.585	13.89	3.612
Total	895	7.618	2.43	5.991	7.806	9.206	18.74	−0.916

Note: CEI, corporate environmental investment.

TABLE 3 Descriptive statistics of independent and control variables

VARIABLES	Obs	Mean	SD	p25	Median	p75	Max	Min
Degree	895	36.416	15.361	25	37	47	92	4
Closeness	895	0.152	0.04	0.149	0.162	0.173	0.194	0
Betweenness	895	0.003	0.002	0.001	0.002	0.004	0.015	0
N score	895	2.991	1.319	2	3	4	5	1
Size	895	0.018	0.071	0.001	0.004	0.011	1	0
Roa	895	0.052	0.061	0.018	0.044	0.084	0.358	−0.362
Cash	895	0.169	0.129	0.078	0.136	0.22	0.899	0
Bi	895	0.375	0.059	0.333	0.333	0.429	0.8	0.3
Lshr	895	36.4	15.531	25.49	34.98	46.16	89.09	4.08
Dual	895	0.25	0.433	0	0	1	1	0
Soe	895	0.449	0.498	0	0	1	1	0
Led	895	11.193	0.419	10.809	11.221	11.55	12.009	10.172
Region	895	8.493	1.914	7.1	9.15	9.97	11.4	1

Table 3 presents the descriptive statistics of the independent and control variables. The median degree is 37, indicating that the core firm is connected with 36 other corporate directors. At the same time, the betweenness score of most companies is close to zero. Average closeness centrality is 0.152, and the difference between the maximum and minimum is minor. As we can see from the table, *n* score, the total index of the director's network centrality, has an average value of approximately 3, indicating that the overall network connection is good.

The average property right, Soe, is approximately 0.449, indicating that non-state-owned enterprises account for the majority of the samples. The average regional economic development level (Led) is 11.193, and the average of regional marketization level (Region) is 8.493. The difference between the maximum and the minimum is huge, which indicates that there are great differences in the levels of regional marketization in different provinces of China.

4 | EMPIRICAL ANALYSIS

4.1 | Multiple regression and analysis

To investigate the relationship between the director's network characteristics and CEI, the models are set as follows:

$$CEI_{i,t} = \beta_0 + \beta_1 Q(nscore)_{i.t} + \sum Control + \varepsilon \quad (2)$$

$$CEI_{i,t} = \beta_0 + \beta_1 Q(degree)_{i.t} + \sum Control + \varepsilon \quad (3)$$

$$CEI_{i,t} = \beta_0 + \beta_1 Q(closeness)_{i.t} + \sum Control + \varepsilon \quad (4)$$

$$CEI_{i,t} = \beta_0 + \beta_1 Q(betweenness)_{i.t} + \sum Control + \varepsilon \quad (5)$$

where *i* denotes firms and *t* denotes years. The definitions of the dependent, independent, and control variables in Equations (2)–(5) can be found in Section 3.2.

We then conduct the ordinary least squares regression and compare the effects of the total index (*n* score) and the single index (degree, closeness, and betweenness) on CEI. We winsorize the continuous variables in the 1% and 99% quantiles. The empirical results are presented in Table 4. From the first to the fourth columns of Table 4, we study the impact of the quartile centrality index *Q* (*n* score), *Q* (degree), *Q* (closeness), and *Q* (betweenness) on CEI. Correspondingly, the coefficients of *Q*(*n* score), *Q* (degree), *Q* (closeness), and *Q* (betweenness) are 0.161, 0.123, 0.141, and 0.144, respectively, and all of them are positively correlated and significant at the 1% level, which is statistically significant.

According to the empirical results in Table 4, we conclude that the higher the centrality of the director's network, the higher the

TABLE 4 Director's network centrality and CEI regression results

VARIABLES	CEI (2-1)	CEI (3-1)	CEI (4-1)	CEI (5-1)
Q(*n* score)	0.161*** (3.69)			
Q(degree)		0.123*** (2.79)		
Q(closeness)			0.141*** (3.14)	
Q(betweenness)				0.144*** (3.28)
Size	17.231*** (8.47)	17.530*** (8.60)	17.159*** (8.39)	17.323*** (8.50)
Roa	2.540** (2.04)	2.688** (2.15)	2.454* (1.96)	2.582** (2.07)
Cash	−3.125*** (−5.88)	−3.151*** (−5.90)	−3.118*** (−5.85)	−3.150*** (−5.91)
Bi	−0.746 (−0.66)	−0.852 (−0.75)	−0.841 (−0.74)	−0.801 (−0.70)
Lshr	1.161** (2.57)	1.166** (2.58)	1.138** (2.52)	1.179*** (2.61)
Dual	−0.491*** (−3.25)	−0.490*** (−3.23)	−0.467*** (−3.09)	−0.499*** (−3.29)
Soe	0.544*** (3.50)	0.558*** (3.58)	0.556*** (3.58)	0.549*** (3.53)
Led	−0.567* (−1.92)	−0.592** (−2.00)	−0.599** (−2.02)	−0.566* (−1.91)
Region	0.020 (0.30)	0.031 (0.47)	0.018 (0.28)	0.023 (0.35)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	6.674** (1.99)	6.997** (2.08)	7.145** (2.13)	6.689** (1.99)
Observations	895	895	895	895
R-squared	0.465	0.461	0.463	0.463

Notes: This table reports the impact of director's network centrality on environmental investment. We winsorize all variables at the 1% and 99% levels. Robust *t*-statistics are shown in parentheses. CEI, corporate environmental investment.

***$p < .01$.

**$p < .05$.

*$p < .1$.

environmental investment of enterprises. This positive effect is straightforward: First, the higher the director's degree centrality, the more active the director at the company level will be, and the more contact he or she will have with the directors of their own company or other companies. Second, the higher the degree of betweenness centrality, the more important the position of directors in the whole network, and the higher the degree of closeness centrality, the closer the relationship between enterprises and their connected companies, which allows highly centralized directors to be encouraged by their own reputation, have more resource exchange channels and faster exchange speed, and, at a lower cost, more actively obtain valuable information for the company. Therefore, according to agency theory and resource dependence theory, the improvement of the three centrality indices is conducive to the improvement of corporate governance and the reduction of environmental investment caused by agency cost, insufficient resources, and information asymmetry. Therefore, Hypotheses 1–4 are supported, namely, the director's network centrality is positively related to the environmental investment of enterprises.

As for the control variables, the company's performance coefficient of Roa is positive and statistically significant at the 5% level, indicating that when corporate profitability is stronger, more remaining resources are put into environmental investment. The coefficient of Bi is not statistically significant. The coefficient of Lshr is significant at the 5% and 1% levels, and all are positive, which may be because the governance structure cost of several major shareholders is higher and they are more likely to conspire to reduce CEI. The dual coefficient is significantly negative at the 1% level, indicating that the agency cost caused by the director's concurrent role as CEO is not beneficial to the fulfillment of CSR. Soe is the coefficient of property rights, its coefficient is positive, and its significance level is 1%, which means that state-owned enterprises invest more in environmental protection. Although the significance is low, the coefficient of the regional economic development level is significantly negative, which may be because the areas with weak economic development have more serious pollution and need more investment in environmental protection.

4.2 | Robustness test

4.2.1 | Use the median method to measure the director's network location

Variable replacement is one of the ways to robustness test; therefore, we replace the independent variable for the robustness test. In the

TABLE 5 The regression results by using the median method

VARIABLES	CEI (2-2)	CEI (3-2)	CEI (4-2)	CEI (5-2)
Q(*n* score)	0.092** (2.07)			
Q(degree)		0.093** (2.14)		
Q(closeness)			0.116** (2.58)	
Q(betweenness)				0.088** (2.11)
Size	17.699*** (8.67)	17.870*** (8.78)	17.559*** (8.61)	17.717*** (8.69)
Roa	2.694** (2.15)	2.714** (2.16)	2.558** (2.04)	2.670** (2.13)
Cash	−3.156*** (−5.90)	−3.167*** (−5.92)	−3.129*** (−5.86)	−3.162*** (−5.91)
Bi	−0.911 (−0.80)	−0.847 (−0.74)	−0.858 (−0.75)	−0.953 (−0.84)
Lshr	1.198*** (2.63)	1.195*** (2.63)	1.167** (2.58)	1.208*** (2.65)
Dual	−0.476*** (−3.13)	−0.473*** (−3.12)	−0.474*** (−3.13)	−0.479*** (−3.15)
Soe	0.578*** (3.71)	0.572*** (3.67)	0.565*** (3.63)	0.592*** (3.80)
Led	−0.611** (−2.06)	−0.626** (−2.11)	−0.608** (−2.05)	−0.616** (−2.08)
Region	0.026 (0.40)	0.031 (0.46)	0.021 (0.31)	0.029 (0.43)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	7.234** (2.15)	7.245** (2.15)	7.284** (2.17)	7.384** (2.19)
Observations	895	895	895	895
R squared	0.459	0.459	0.461	0.459

Notes: This table reports the robustness test by using the median method. We winsorize all variables at both the 1% and 99% levels. Robust *t*-statistics appear in parentheses. CEI, corporate environmental investment.
***$p < .01$.
**$p < .05$.
*$p < .1$.

previous analysis, since the specific decisions of corporate governance may be most influenced by the independent directors with the highest director's network centrality, we take the average value of the maximum network centrality of the independent directors as the basis of the quintile ranking of the degree centrality, closeness centrality, and betweenness centrality indices, and then take the average value of the quintile of the three centrality indicators as the total index *n*-score of the network centrality of corporate directors.

Following Larcker et al. (2013), in the context of robustness tests, we adopt the median independent director's network centrality as the baseline to construct independent variables for the substitution test. We choose the median because it is not affected by the maximum or minimum value of the distribution series, which improves its representation of the distribution series to a certain extent. As shown in Table 5, the empirical results from the median method are significant at the 5% level. Therefore, the obtained results are positive and support hypothesis H1.

4.2.2 | Use the average method to measure the director's network location

Referring to Amin et al. (2020), we have another way to replace the independent variables. That is, we choose the director's network location index of each company calculated according to the average of the director's network centrality of all independent directors of the company, then we sort and sum the three indicators by quintile, and then took the average to get the composite index of the network location of company's independent directors This practice can reflect the average level of the sample and improve the robustness. As shown in Table 6, the empirical results from the median method are significant at the 1% level. Therefore, the obtained conclusion, that is, the positive relationship between the director's network and CEI, is robust.

4.3 | Endogeneity concerns

Although our research results indicate that there is a positive relationship between director's network centrality and CEI, any research related to directors may have endogeneity problems caused by the omission of variable bias or reverse causality (Hermalin & Weisbach, 1988). Omission variables lead to a false correlation between the director's network centrality and CEI. Our results may also be affected by reverse causality. We use the 1 year lag data method and the independent director constant sample method to investigate the robustness of endogenous problems.

To alleviate the endogeneity problem, we adopt the method of lagging the explanatory variable for 1 year and apply it to all

TABLE 6 The regression results by using the average method

VARIABLES	CEI (2-3)	CEI (3-3)	CEI (4-3)	CEI (5-3)
Q(*n* score)	0.130*** (2.99)			
Q(degree)		0.139*** (3.12)		
Q(closeness)			0.119*** (2.64)	
Q(betweenness)				0.135*** (3.06)
Size	17.504*** (8.60)	17.540*** (8.62)	17.424*** (8.53)	17.365*** (8.51)
Roa	2.589** (2.07)	2.735** (2.19)	2.525** (2.01)	2.570** (2.05)
Cash	−3.117*** (−5.84)	−3.136*** (−5.88)	−3.119*** (−5.84)	−3.159*** (−5.93)
Bi	−0.743 (−0.65)	−0.600 (−0.52)	−0.874 (−0.77)	−0.797 (−0.70)
Lshr	1.204*** (2.66)	1.221*** (2.69)	1.152** (2.54)	1.221*** (2.69)
Dual	−0.481*** (−3.18)	−0.478*** (−3.16)	−0.474*** (−3.12)	−0.491*** (−3.24)
Soe	0.557*** (3.58)	0.550*** (3.53)	0.562*** (3.61)	0.568*** (3.66)
Led	−0.606** (−2.05)	−0.605** (−2.05)	−0.611** (−2.06)	−0.600** (−2.03)
Region	0.024 (0.37)	0.028 (0.42)	0.022 (0.33)	0.025 (0.38)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	7.137** (2.13)	6.863** (2.04)	7.308** (2.18)	7.047** (2.10)
Observations	895	895	895	895
R squared	0.462	0.463	0.461	0.463

Notes: This table reports the robustness test by using the average method. We winsorize all variables at both the 1% and 99% levels. Robust *t*-statistics appear in parentheses. CEI, corporate environmental investment.
***$p < .01$.
**$p < .05$.
*$p < .1$.

regression models (Amin et al., 2020). As shown in Table 7, the four centrality indicators Q(*n* score) $_{t-1}$, Q (degree) $_{t-1}$, Q (closeness) $_{t-1}$, and Q (betweenness) $_{t-1}$ with a lag of 1 year are significant, with significance levels of 1%, 5%, 1%, and 1%, respectively. The results of the regression model test still support the positive correlation between director's network centrality and CEI, and the main results remain unchanged.

Referring to Larcker et al. (2013), we limit the sample to companies whose independent director composition remains unchanged from the previous year to the current year. The advantage of limiting the sample to a company where independent directors remain unchanged is that the change in director's network centrality can be attributed to changes in the company's links with other external boards of directors. Therefore, for a company sample with the same composition of independent directors, the change in the director's network centrality of the company is essentially exogenous and depends on the changes and decisions of other companies. Table 8 shows the regression of independent director's unchanged company samples, and the observed value of independent director's unchanged company samples after screening is 320. The regression results show that the four centrality indices are significant, which proves the previous conclusion. The test results show that our results are robust to endogenous problems, especially reverse causality.

4.4 | Further analysis

4.4.1 | The influence of director's network on CEI: The intermediary role of financing constraints

Many factors affect CEI, including financing constraints, which is one of the most important. Due to the scarcity of corporate financial resources, once environmental protection funds are invested, they crowd out other project resources and increase the opportunity cost of enterprises. Although it is expected to have a long-term impact on enterprises, environmental investment usually has a limited impact on corporate performance in the short term. Financing constraints make managers of enterprises tend to invest for the short term, therefore prioritizing non-environmental investment (Li et al., 2021). Zhang et al. (2019) find that financing constraints seriously hinder the ability of enterprises to invest in environmental protection.

Bernanke and Gertler (1989) point out that agency problems lead to financing constraints for enterprises. The principal-agent relationship between external investors and managers makes managers maximize their own interests and may infringe upon the interests of investors. To compensate for the principal-agent risk of investment, investors can only ask the enterprise for a certain level of premium, resulting in differences in internal and external financing costs. The

TABLE 7 Director's network centrality and CEI regression results: Endogenous test of explanatory variables lagging by 1 year

VARIABLES	CEI (2-4)	CEI (3-4)	CEI (4-4)	CEI (5-4)
Q(*n* score) $_{t-1}$	0.230*** (2.99)			
Q(degree) $_{t-1}$		0.162** (2.08)		
Q(closeness) $_{t-1}$			0.226*** (2.85)	
Q(betweenness) $_{t-1}$				0.245*** (3.15)
Size $_{t-1}$	12.324*** (3.02)	12.987*** (3.15)	12.626*** (3.10)	11.958*** (2.93)
Roa $_{t-1}$	3.776* (1.66)	3.851* (1.68)	3.468 (1.52)	3.701 (1.63)
Cash $_{t-1}$	−4.658*** (−5.14)	−4.677*** (−5.12)	−4.634*** (−5.11)	−4.631*** (−5.12)
Bi $_{t-1}$	−1.936 (−0.98)	−2.218 (−1.11)	−2.086 (−1.06)	−1.874 (−0.95)
Lshr $_{t-1}$	0.662 (0.84)	0.720 (0.91)	0.652 (0.83)	0.704 (0.90)
Dual $_{t-1}$	−0.727*** (−2.66)	−0.707** (−2.56)	−0.708** (−2.59)	−0.746*** (−2.73)
Soe $_{t-1}$	0.731** (2.57)	0.770*** (2.69)	0.704** (2.46)	0.736** (2.59)
Led $_{t-1}$	−0.972* (−1.91)	−1.033** (−2.02)	−1.052** (−2.08)	−0.953* (−1.88)
Region $_{t-1}$	0.183 (1.53)	0.206* (1.72)	0.185 (1.54)	0.178 (1.49)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	17.521*** (3.44)	18.106*** (3.53)	18.458*** (3.64)	17.740*** (3.35)
Observations	336	336	336	336
R-squared	0.459	0.450	0.457	0.460

Notes: This table reports robustness tests using explanatory variables with a lag of 1 year. We winsorize all variables at both the 1% and 99% levels. Robust *t*-statistics appear in parentheses. CEI, corporate environmental investment.
***$p < .01$.
**$p < .05$.
*$p < .1$.

favorable position of the director's network can not only enhance the supervision motivation of chain directors and reduce the cost of external supervision but also help enterprises to obtain more information, improve the ability of directors to advise and consult, and reduce the possibility of managers investing blindly (Larcker et al., 2013). Therefore, the director's network can optimize corporate governance and play a role in alleviating corporate financing constraints.

The resource dependence theory shows that the director's network can bring more resources to the enterprise and alleviate the information asymmetry of the enterprise. Previous literature includes studies on director linkages and corporate financing. Chang and Wu (2021) find that companies with greater demand for external financing benefit more from the links between the boards of directors and bankers. Engelberg et al. (2012) find that lending rates drop significantly when there is alumni or professional association between the bank and the management of the company.

Xia et al. (2019) find that independent directors have a good relationship and can obtain more trade credit for their companies. Based on the information effect, enterprises can obtain effective information with the help of director's networks, spread information conducive to their own image, and alleviate the financing constraints caused by information asymmetry. Based on the resource effect, the network location of chain directors makes use of the business relations between the board of directors to provide business resources for the company, reduce the company's difficulty in obtaining external resources, and ease financing constraints.

Therefore, director's network can be seen to reduce the financing constraints of enterprises, and financing constraints are an important factor affecting the environmental investment of enterprises. Therefore, we propose the following hypothesis: Reducing financing constraints is a possible way for the network of directors to affect the environmental protection investment of enterprises.

We choose the WW index of Whited and Wu (2006) to measure financing constraints. Compared with the SA index by Hadlock and Pierce (2010) and KZ index of Kaplan and Zingales (1997), the WW index contains more comprehensive factors that affect corporate financing, and it takes into account the external industry characteristics of enterprises in addition to their own financial characteristics, which makes it more economically significant. We build Models (6)–(8) to test the above hypotheses. Model (6) is the same as the principal regression, and Model (7) examines the impact of a director's network centrality on corporate financing constraints. Model (8) examines the intermediary effect of financing constraints between a director's network centrality and environmental investment.

TABLE 8 Director's network centrality and CEI regression results: Endogenous test of invariant samples of independent directors

VARIABLES	CEI (2-5)	CEI (3-5)	CEI (4-5)	CEI (5-5)
Q(*n* score)	0.218*** (2.73)			
Q(degree)		0.195** (2.41)		
Q(closeness)			0.152* (1.83)	
Q(betweenness)				0.180** (2.20)
Size	14.260*** (4.00)	14.533*** (4.07)	14.536*** (4.04)	14.514*** (4.05)
Roa	5.699** (2.46)	5.935** (2.56)	5.665** (2.43)	5.691** (2.45)
Cash	−4.344*** (−4.51)	−4.388*** (−4.55)	−4.362*** (−4.50)	−4.296*** (−4.44)
Bi	−1.758 (−0.83)	−1.670 (−0.78)	−2.255 (−1.06)	−1.962 (−0.92)
Lshr	1.278 (1.56)	1.228 (1.50)	1.137 (1.39)	1.256 (1.53)
Dual	−0.513* (−1.86)	−0.514* (−1.85)	−0.462* (−1.67)	−0.524* (−1.88)
Soe	0.887*** (3.09)	0.903*** (3.14)	0.893*** (3.08)	0.902*** (3.13)
Led	−0.345 (−0.63)	−0.368 (−0.67)	−0.364 (−0.66)	−0.389 (−0.71)
Region	0.014 (0.12)	0.034 (0.28)	0.018 (0.15)	0.032 (0.26)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	4.051 (0.72)	4.220 (0.75)	4.736 (0.84)	4.621 (0.82)
Observations	320	320	320	320
R-squared	0.514	0.511	0.507	0.509

Notes: This table reports a robustness test using company sample observations with the same composition as independent directors. We winsorize all variables at the 1% and 99% levels. Robust *t*-statistics are shown in parentheses. CEI, corporate environmental investment.
***$p < .01$.
**$p < .05$.
*$p < .1$.

$$CEIi,t = \alpha 0 + \alpha 1Q(nscore)i,t[Q(degree)i,t/Q(closeness)i, t/Q(betweenness)i,t] + \sum Control + \varepsilon 1 \quad (6)$$

$$WWi,t = \beta 0 + \beta 1Q(nscore)i,t[Q(degree)i,t/Q(closeness)i, t/Q(betweenness)i,t] + \sum Control + \varepsilon 2 \quad (7)$$

$$CEIi,t = \lambda 0 + \lambda 1Q(nscore)i, t[Q(degree)i, t/Q(closeness)i, t/Q(betweenness)it] + \lambda 2WWi, t + \sum Control + \varepsilon 3 \quad (8)$$

The experimental results are listed in Table 9. The results of models (6-1) and (7-1) show that the coefficients of Q (*n* score) are 0.154 and −0.007, respectively, which are significant at the 1% level, indicating that the network center of directors has a negative impact on corporate financing constraints. The results of the model (8-1) show that financing constraints play a complete intermediary role in Q (*n* score) and environmental investment. The regression results of Q (degree), Q (closeness), and Q (betweenness) are shown in the table, and the regression results all prove the existence of a mediating effect. This proves that the level of director's network centrality reduces the financing constraints of enterprises, thereby increasing the environmental investment of enterprises, and the intermediary effect of financing constraints is established.

4.4.2 | The influence of director's network on enterprise value: The intermediary role of CEI

With regard to the impact of director's network on enterprise value, in the existing literature, some scholars found that director's network can have a positive effect on enterprise value. Hillman and Dalziel (2003) point out that directors with social network relationships can perform their duties more effectively and bring better performance to enterprises. Kim (2005) finds that the elite school network of board members is positively related to a company's performance. However, some scholars found that director's networks can produce higher agency costs, thus damaging corporate performance and reducing enterprise value. Fich and Shivdasani (2006) put forward the "busy director hypothesis," believing that if a director is appointed to multiple positions, their efficiency will be reduced, and the busy director will not have enough energy to work, which will reduce the value of the company.

Environmental investment is closely related to enterprise value. Some studies believe that enterprise environmental investment can ensure the effective implementation of sustainable development strategies, promote the formation of environmental management capacity, and increase investment in environmental science and technology and research and development to improve

production efficiency, reduce costs, and enhance enterprise value. Other studies believe that the environmental protection behavior of enterprises is not conducive to the promotion of enterprise value (Lee et al., 2015) because expanding the scale of environmental investment will not only reduce productive investment funds but also increase the normal production costs of enterprises, which is not conducive to production efficiency and competitiveness, which may reduce corporate profits (Sueyoshi & Wang, 2014).

In a previous study, we found that a network of directors can affect the environmental investment of enterprises. The higher the director's network centrality, the stronger the corporate governance ability, the more information, knowledge, and resources can be obtained, the information asymmetry can be reduced, and the corporate social responsibility activities will be affected. Therefore, a director's network centrality is positively related to environmental investment. As can be seen from the existing literature, the director's network centrality and the environmental investment of the enterprise can have an impact on enterprise value. Therefore, what is the impact of a director's network on enterprise value? Does environmental protection investment play a role in it? That is, does the director's network affect enterprise value by affecting the enterprise's environmental protection investment?

We build models (9)–(11) to verify our conjecture. We use EVA (Hahn & Kuhn, 2012) to measure enterprise value. Model (9) examines the influence of a director's network centrality on enterprise value. Model (10) examines the impact of a director's network centrality on environmental investment. Model (11) examines the intermediary role of environmental investment between a director's network centrality and enterprise value.

$$EVAi,t = \alpha 0 + \alpha 1 Q(nscore)i,t[Q(degree)i,t/Q(closeness)i, t/Q(betweenness)i,t] + \sum Control + \varepsilon 1 \quad (9)$$

$$CEIi,t = \beta 0 + \beta 1 Q(nscore)i,t[Q(degree)i,t/Q(closeness)i, t/Q(betweenness)i,t] + \sum Control + \varepsilon 2 \quad (10)$$

$$EVAi,t = \lambda 0 + \lambda 1 Q(nscore)i, t[Q(degree)i,\ t/Q(closeness)i,\ t/Q(betweenness)it] + \lambda 2 CEIi, t + \sum Control + \varepsilon 3 \quad (11)$$

The test results are presented in Table 10. Model (9-1) shows that the director's network centrality Q (*n* score) has a positive effect on EVA, and the regression results are significant at the 1% level. Models (10-1) and (11-1) indicate that CEI plays an intermediary role in Q (*n* score) and EVA, and Q (*n* score) positively affects enterprise value by positively affecting CEI. To Q (degree) and EVA and Q (closeness) and EVA, CEI plays a complete intermediary role, and to Q (betweenness) and EVA, CEI plays a partial intermediary role. The test results show that the director's network centrality can

TABLE 9 Regression analysis results of the models

VARIABLES	CEI (6-1)	WW (7-1)	CEI (8-1)	CEI (6-2)	WW (7-2)	CEI (8-2)
Q(*n* score)	0.154*** (2.85)	−0.007*** (−4.50)	0.050 (1.00)			
Q (degree)				0.133** (2.44)	−0.007*** (−4.30)	0.032 (0.65)
WW			−15.341*** (−11.66)			−15.432*** (−11.74)
Size	13.062*** (6.53)	−0.685*** (−12.30)	2.552 (1.26)	13.228*** (6.62)	−0.691*** (−12.41)	2.561 (1.27)
Roa	3.487** (2.00)	−0.260*** (−5.36)	−0.505 (−0.31)	3.620** (2.07)	−0.267*** (−5.49)	−0.502 (−0.31)
Cash	−2.762*** (−3.89)	0.040** (2.03)	−2.146*** (−3.33)	−2.781*** (−3.91)	0.041** (2.06)	−2.150*** (−3.33)
Bi	−0.124 (−0.09)	−0.011 (−0.29)	−0.295 (−0.24)	−0.200 (−0.15)	−0.009 (−0.25)	−0.345 (−0.28)
Lshr	0.904 (1.61)	−0.016 (−1.03)	0.657 (1.30)	0.911 (1.63)	−0.017 (−1.06)	0.656 (1.29)
Dual	−0.363* (−1.88)	−0.003 (−0.53)	−0.407** (−2.33)	−0.363* (−1.88)	−0.003 (−0.50)	−0.404** (−2.31)
Soe	0.709*** (3.86)	−0.013** (−2.55)	0.510*** (3.05)	0.729*** (3.97)	−0.014*** (−2.66)	0.519*** (3.11)
Led	−0.563 (−1.61)	0.005 (0.47)	−0.493 (−1.56)	−0.578* (−1.65)	0.005 (0.53)	−0.498 (−1.57)
Region	0.063 (0.81)	−0.002 (−0.84)	0.035 (0.50)	0.071 (0.91)	−0.002 (−1.00)	0.038 (0.53)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Constant	6.208 (1.61)	−1.009*** (−9.39)	−9.268** (−2.48)	6.408* (1.66)	−1.015*** (−9.44)	−9.252** (−2.48)
Observations	675	675	675	675	675	675
R-squared	0.496	0.512	0.588	0.495	0.510	0.588

Notes: This table tests the mediating effect of financing constraints on director's network centrality and CEI relationships. We winsorize all variables at the 1% and 99% levels. Robust *t*-statistics are shown in parentheses. CEI, corporate environmental investment.

***$p < .01$.

**$p < .05$.

*$p < .1$.

TABLE 9 **(continued).** Regression analysis results of the models

VARIABLES	CEI (6-3)	WW (7-3)	CEI (8-3)	CEI (6-4)	WW (7-4)	CEI (8-4)
Q(closeness)	0.128** (2.34)	−0.006*** (−3.69)	0.041 (0.82)			
Q(betweenness)				0.131** (2.41)	−0.007*** (−4.76)	0.020 (0.40)
WW			−15.419*** (−11.78)			−15.478*** (−11.73)
Size	12.984*** (6.46)	−0.682*** (−12.14)	2.474 (1.22)	13.119*** (6.55)	−0.684*** (−12.30)	2.534 (1.25)
Roa	3.373* (1.93)	−0.255*** (−5.23)	−0.562 (−0.35)	3.475** (1.99)	−0.260*** (−5.37)	−0.554 (−0.34)
Cash	−2.758*** (−3.87)	0.040** (2.01)	−2.142*** (−3.32)	−2.778*** (−3.90)	0.041** (2.06)	−2.148*** (−3.33)
Bi	−0.240 (−0.18)	−0.006 (−0.16)	−0.333 (−0.27)	−0.183 (−0.13)	−0.012 (−0.32)	−0.372 (−0.30)
Lshr	0.877 (1.56)	−0.015 (−0.95)	0.647 (1.28)	0.926* (1.65)	−0.017 (−1.12)	0.656 (1.29)
Dual	−0.336* (−1.74)	−0.004 (−0.75)	−0.398** (−2.28)	−0.369* (−1.91)	−0.002 (−0.40)	−0.402** (−2.30)
Soe	0.728*** (3.96)	−0.014*** (−2.69)	0.514*** (3.08)	0.724*** (3.94)	−0.013** (−2.55)	0.523*** (3.13)
Led	−0.586* (−1.67)	0.006 (0.57)	−0.500 (−1.58)	−0.561 (−1.60)	0.004 (0.44)	−0.495 (−1.56)
Region	0.059 (0.75)	−0.002 (−0.74)	0.034 (0.47)	0.065 (0.83)	−0.002 (−0.85)	0.037 (0.52)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Constant	6.640* (1.72)	−1.028*** (−9.54)	−9.208** (−2.47)	6.252 (1.62)	−1.003*** (−9.35)	−9.272** (−2.48)
Observations	675	675	675	675	675	675
R-squared	0.494	0.506	0.588	0.495	0.514	0.588

Notes: This table tests the mediating effect of financing constraints on director's network centrality and CEI relationships. We winsorize all variables at the 1% and 99% levels. Robust t-statistics are shown in parentheses. CEI, corporate environmental investment.

***$p < .01$.

**$p < .05$.

*$p < .1$.

TABLE 10 Regression analysis results of the models

VARIABLES	EVA (9-1)	CEI (10-1)	EVA (11-1)	EVA (9-2)	CEI (10-2)	EVA (11-2)
Q(*n* score)	0.001*** (2.74)	0.159*** (3.62)	0.001** (2.10)			
Q(degree)				0.001** (2.05)	0.121*** (2.73)	0.001 (1.56)
CEI			0.002*** (5.30)			0.002*** (5.43)
Size	0.051** (2.34)	17.165*** (8.43)	0.017 (0.78)	0.053** (2.45)	17.462*** (8.56)	0.018 (0.83)
Roa	0.834*** (62.19)	2.914** (2.31)	0.828*** (62.58)	0.835*** (62.21)	3.067** (2.42)	0.829*** (62.60)
Cash	−0.030*** (−5.27)	−3.135*** (−5.87)	−0.024*** (−4.18)	−0.030*** (−5.30)	−3.164*** (−5.90)	−0.024*** (−4.18)
Bi	−0.008 (−0.63)	−0.812 (−0.71)	−0.006 (−0.50)	−0.008 (−0.69)	−0.915 (−0.80)	−0.007 (−0.55)
Lshr	−0.000 (−0.77)	0.013*** (2.77)	−0.000 (−1.29)	−0.000 (−0.76)	0.013*** (2.77)	−0.000 (−1.30)
Dual	−0.001 (−0.53)	−0.458*** (−3.01)	0.000 (0.02)	−0.001 (−0.52)	−0.457*** (−2.99)	0.000 (0.03)
Soe	0.004*** (2.71)	0.539*** (3.46)	0.003** (2.10)	0.005*** (2.77)	0.552*** (3.54)	0.004** (2.13)
Led	0.003 (1.05)	−0.555* (−1.87)	0.004 (1.41)	0.003 (0.98)	−0.579* (−1.95)	0.004 (1.37)
Region	−0.000 (−0.41)	0.017 (0.26)	−0.000 (−0.47)	−0.000 (−0.28)	0.029 (0.43)	−0.000 (−0.37)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Constant	−0.049 (−1.38)	6.465* (1.92)	−0.062* (−1.76)	−0.047 (−1.31)	6.789** (2.01)	−0.060* (−1.71)
Observations	887	887	887	887	887	887
R-squared	0.869	0.465	0.873	0.868	0.462	0.873

(Continues)

TABLE 10 (Continued)

VARIABLES	EVA (9–3)	CEI (10–3)	EVA (11–3)	EVA (9–4)	CEI (10–4)	EVA (11–4)
Q(closeness)	0.001** (1.99)	0.140*** (3.10)	0.001 (1.43)			
Q(betweenness)				0.001*** (2.59)	0.141*** (3.20)	0.001** (2.02)
CEI			0.002*** (5.41)			0.002*** (5.35)
Size	0.051** (2.35)	17.090*** (8.34)	0.017 (0.77)	0.051** (2.36)	17.266*** (8.46)	0.017 (0.78)
Roa	0.833*** (61.95)	2.839** (2.24)	0.828*** (62.40)	0.834*** (62.19)	2.954** (2.34)	0.828*** (62.59)
Cash	−0.030*** (−5.26)	−3.131*** (−5.85)	−0.024*** (−4.16)	−0.030*** (−5.30)	−3.159*** (−5.90)	−0.024*** (−4.20)
Bi	−0.009 (−0.72)	−0.907 (−0.80)	−0.007 (−0.58)	−0.008 (−0.65)	−0.872 (−0.76)	−0.006 (−0.52)
Lshr	−0.000 (−0.81)	0.012*** (2.71)	−0.000 (−1.34)	−0.000 (−0.74)	0.013*** (2.79)	−0.000 (−1.27)
Dual	−0.001 (−0.42)	−0.435*** (−2.85)	0.000 (0.11)	−0.001 (−0.59)	−0.468*** (−3.06)	−0.000 (−0.03)
Soe	0.005*** (2.79)	0.550*** (3.53)	0.004** (2.15)	0.004*** (2.72)	0.543*** (3.48)	0.003** (2.10)
Led	0.003 (0.97)	−0.583** (−1.97)	0.004 (1.35)	0.003 (1.06)	−0.553* (−1.87)	0.004 (1.42)
Region	−0.000 (−0.40)	0.016 (0.23)	−0.000 (−0.45)	−0.000 (−0.39)	0.021 (0.31)	−0.000 (−0.45)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Constant	−0.045 (−1.26)	6.910** (2.05)	−0.059* (−1.67)	−0.050 (−1.39)	6.491* (1.93)	−0.062* (−1.77)
Observations	887	887	887	887	887	887
R-squared	0.868	0.463	0.873	0.868	0.463	0.873

Notes: This table reports the test results of the intermediary role of environmental investment in the relationship between director's network centrality and enterprise value. We winsorize all variables at the 1% and 99% levels. Robust *t*-statistics are shown in parentheses. CEI, corporate environmental investment; EVA, economic value added.

***$p < .01$.

**$p < .05$.

*$p < .1$.

increase the enterprise value, in which environmental investment plays an intermediary role, and environmental investment is an important mechanism for the director's network to affect the enterprise value.

5 | CONCLUSIONS

In recent years, the Chinese government has paid increasing attention to environmental governance and proposed strengthening the protection and restoration of the ecosystem, improving the eco-environmental monitoring and evaluation system, and building an eco-environmental governance system. To protect the environment, enterprises also need to carry out environmental protection activities. Environmental investment, an important part of CSR, can be influenced by directors because they are in charge of corporate decision-making. Although recent studies by Nandy et al. (2020) have shown that the network of directors can positively influence CSR decisions, our research further explores the relationship between director's networks and CEI.

To explore the relationship between director's networks location and CEI, this study collects the data of Chinese Shanghai and Shenzhen A-share listed companies from 2015 to 2019 and establishes a comprehensive empirical robust model to study the relationship between director's networks and environmental investment. According to the analysis of agency theory and resource dependence theory, the higher network centrality of directors brings higher reputation incentives and bargaining power to directors and increases governance motivation. The higher the director's network centrality, the more influence, knowledge, and information they obtain, and the higher the efficiency of obtaining resources and transferring knowledge, which increases governance ability. Our empirical results indicate that the director's network centrality positively affects the environmental investment of the enterprise, and the degree centrality, betweenness centrality, and closeness centrality of the director's network are all positively related to CEI. Further research shows that the director's network increases environmental investment by reducing the financing constraints of enterprises, and the positive influence of the director's network on enterprise environmental investment also promotes enterprise value. All empirical results passed the robustness test.

Based on our research results and the actual situation of Chinese enterprises and environmental investment, we propose the following suggestions: First, enterprises, especially the heavily polluting industries and new energy industries that are currently the focus of the country, should pay attention to the role of director's network when responding to the national carbon neutrality policy and pursuing the carbon neutrality goal. Enterprise that carries on the green development strategy should pay attention to the influence of the independent directors. Enterprises should take the position of the network of

independent directors as an important factor in the assessment and employment of independent directors, and select more directors who are in the core position of the network. Enterprises should make use of the director's network to promote the motivation and ability of independent director enterprise governance, enhance the environmental protection investment of enterprises, so as to better complete the national carbon neutrality requirements. Secondly, enterprises whose social responsibility decisions are restricted by financing constraints should pay attention to the role of the network of independent directors while considering government subsidies and environmental regulations. Enterprises need to optimize the network structure of independent directors to ease the financing constraints of enterprises at a lower cost, increase the investment in environmental protection, promote the sustainable development of enterprises, and promote the promotion of enterprise value.

Therefore, the results obtained between the director's network and CEI, not only complement the research field of board characteristics and CEI but also enrich the literature on director's networks and corporate governance research. First, our research extends the literature of Roberts (1992) and Haniffa and Cooke (2005) and provides incremental evidence on the positive correlation between director's network centrality and environmental investment. This study also further expands the research on director's networks and CSR by Amin et al. (2020) and Nandy et al. (2020). The existing literature is only from the perspective of CSR decision-making and social responsibility performance, while this study is a subdivision of environmental investment as a sub-item of social responsibility, which complements previous studies.

Second, we find the potential mechanism by which the director's network influences CEI, that is, the path reducing financing constraints, which makes our research clearer. The combined analysis of agency theory and resource dependence theory complements previous research on director's networks and financing constraints, which also provides new evidence to indicate a relationship between corporate governance and corporate financing constraints (Chang & Wu, 2021; Engelberg et al., 2012; Xia et al., 2019).

Third, we find that CEI plays an intermediary role in the director's network and enterprise value. The current literature has not yet reached a consistent conclusion on the relationship between director's networks and enterprise value, or the impact of environmental investment on enterprise value (Fich, 2005; Hillman & Dalziel, 2003; Lee et al., 2015). However, the exploration of this impact is important because, under the special background of China, based on government regulations, business needs, and social responsibility pressure, CEI decision-making is very important in corporate strategic decision-making. Our evidence shows that the network of directors has a positive impact on enterprise value in the current year by increasing investment in environmental protection. From this perspective, our research enriches the theoretical understanding of how the network of directors and environmental investment affects the value of the company.

Finally, the findings of our study have practical significance. The results of this study can guide enterprises to pay more attention to the role of independent directors in environmental protection investment decisions and realize that when selecting independent directors, fully considering their social network location can change the decision-making ability of CSR strategy. In addition, enterprises should comprehensively consider the possible impact of environmental investment decisions on enterprise value and make investment decisions that simultaneously adapt to enterprise development and environmental protection.

Our research supplements the study of the relationship between director's networks and CEI. However, because of the small number of companies publishing specific environmental investment data in China, our research data are limited. Second, we are unable to conduct panel data analysis over a long period of time because of the small number of companies that continuously disclose environmental investments. Third, the environmental regulation and market of China are unique; therefore, our research results may have some regional limitations. We encourage future research to discuss the relationship between a director's network and environmental investment across borders. In addition, we only study the impact of director's network centrality on CEI; in future research, we can consider more factors that represent the characteristics of the director's network, such as structural holes, to conduct a more comprehensive investigation.

ACKNOWLEDGMENTS

The authors gratefully acknowledge financial support from the National Natural Science Foundation of China (71729001 and 72025101), the Humanity and Social Science Foundation of Ministry of Education of China (20YJA630024), the China Postdoctoral Science Foundation (No. 2021M700380), and the Fundamental Research Funds for the Central Universities (No. FRF-DF-20-11).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Wang, L., Su, Y., Huang, H., Gong, Y., & Wang, W. (2022). Director's network location and corporate environmental investment in the carbon neutrality age. *Business Strategy and the Environment*, 1–19. https://doi.org/10.1002/bse.3294