Do Academic Independent Directors Affect the Carbon Disclosure Decisions?—Evidence from Listed Companies

Abstract

This study investigates how academic independent directors influence corporate carbon emission disclosure in China. Using upper echelons theory and panel data from A-share listed industrial firms between 2013 and 2023, we find that firms with academic independent directors are more likely to voluntarily disclose carbon emission information. The effect is stronger for firms located in carbon trading pilot regions, suggesting an interaction between internal governance and external regulatory environments. Additionally, firm size, profitability, ownership type, and listing age are significant determinants of disclosure behavior. These findings highlight the governance value of academic directors in promoting environmental transparency and support the integration of board-level expertise with institutional incentives to drive low-carbon transformation in the corporate sector.

Keywords：Academic Independent Directors, Carbon Emissions, Information Disclosure

1. Introduction

Global warming is a defining challenge of contemporary climate change, prompting countries worldwide to actively seek effective responses. Against this backdrop, promoting corporate carbon disclosure has become a central issue in the field of environmental economics. In China, industrial sectors account for over 70% of national carbon emissions (Chen, 2010), making the role of industrial enterprises in energy conservation, emissions reduction, and environmental protection critical to achieving sustainable, healthy, and high-quality development. To this end, the Chinese government has introduced a series of initiatives to regulate carbon disclosure practices.

However, the overall level of carbon emission information disclosure among Chinese firms remains low and uneven. For example, during the 2022–2023 disclosure cycle of the Carbon Disclosure Project (CDP), only around 20% of invited Chinese companies responded to the survey, compared to a response rate of over 90% in Europe.

Independent directors play an essential role in corporate governance. Valued for their professional expertise and external networks, they are expected to exercise objective oversight and contribute strategic advice. In China, listed firms often appoint scholars from universities and research institutions as independent directors to provide intellectual guidance. Previous research suggests that approximately 70% of listed companies employ scholar-type independent directors, who represent about 40% of all independent board members (Ma and Tang, 2023).

Scholar-type independent directors are generally perceived as diligent, ethical, and highly professional. Their long-term academic training fosters analytical thinking, domain expertise, and a strong sense of social responsibility. Moreover, their reputational capital motivates them to

uphold ethical standards and advocate for good governance (Su and Feng, 2018). Boards often value their input due to their expertise and perceived independence (Zhang et al., 2019). In the context of climate change, these directors may prioritize environmental and social issues, and actively support carbon disclosure as part of broader corporate sustainability goals.

Despite this, most existing studies focus on the influence of independent directors on financial outcomes such as firm performance and earnings management (e.g., Ferris et al., 2010; Wei et al., 2007; Tang and Hu, 2008), while their role in non-financial disclosures, such as environmental information, remains underexplored. This study fills that gap by applying Upper Echelons Theory to examine how scholar-type independent directors influence corporate decisions on carbon disclosure. Furthermore, we explore how this relationship is moderated by China's evolving institutional environment, particularly the establishment of carbon emissions trading pilot regions.

The remainder of this paper is structured as follows: Section 2 reviews relevant literature and develops the hypotheses. Section 3 presents the empirical model and variables. Section 4 introduces the data and sample construction. Section 5 reports the empirical results, followed by robustness checks in Section 6. Section 7 concludes with key implications and policy recommendations.

2. Literature review and theoretical hypotheses

Corporate carbon emission disclosure is a key aspect of environmental information disclosure and represents a discretionary decision made by firm managers based on assessments of information value, private contracts, and cost-benefit considerations. According to Principal-Agent Theory, a higher proportion of independent directors on the board is

generally associated with enhanced oversight and greater voluntary disclosure. Empirical studies such as Yang and Zhang (2008), Bi et al. (2015), and Zhao et al. (2022) support this view. However, other studies, including Ho and Wong (2001) and Cui et al. (2016), find no significant correlation between board independence and environmental or carbon disclosure, suggesting inconsistency in existing research.

Most prior work has focused on the overall proportion of independent directors, with little attention to their individual characteristics, which can be critical in strategic decisions. According to Upper Echelons Theory (Hambrick and Mason, 1984), managerial backgrounds—shaped by knowledge, values, and cognitive frameworks—lead to differentiated decision-making. Subsequent research has demonstrated that traits such as academic qualifications, tenure, and expertise affect a firm's disclosure and CSR practices (Thomas and Simerly, 1995; Wang and Yang, 2010; Zhang and Geely, 2020).

This paper argues that individual heterogeneity among independent directors, particularly scholar-type directors, must be considered when analyzing their influence on corporate carbon disclosure. In China, listed firms frequently appoint academics from universities or research institutes as independent directors due to their domain expertise, decision-making capability, and social capital. Prior studies (e.g., Tang et al., 2010; Ma and Tang,2023; Zhang et al., 2019) have shown that scholar-directors enhance firm value, performance, and RandD investment. However, most of these studies focus on financial outcomes rather than non-financial disclosures.

In the context of climate change and growing environmental regulation, it is increasingly important to understand how internal governance can promote environmental responsibility. This study therefore explores the governance role of scholar-type independent directors in

corporate carbon disclosure decisions and investigates the underlying mechanisms driving their influence.

3. Theoretical hypotheses and model specification

3.1 Theoretical hypotheses

According to Upper Echelons Theory, in the face of complex and dynamic external environments, corporate executives tend to make decisions based on their own cognitive models and value systems, which ultimately shape organizational strategies and outcomes (Hambrick and Mason, 1984).

Scholar-type independent directors refer to individuals who concurrently hold academic positions in universities or research institutions. These directors are often characterized by their independence, impartiality, academic integrity, and high levels of education and social reputation, distinguishing them from other types of independent directors (Wang and Yuan, 2019). Given their expertise and credibility, scholar-type independent directors may enhance the effectiveness of board-level decision-making, particularly in strategic areas such as carbon emission disclosure. Their influence can be explained through three primary mechanisms:

First, scholar-type directors provide critical expertise to the board. Based on Resource Dependence Theory, directors with specialized knowledge can support managers in decision-making, especially in emerging areas like environmental governance (Kor and Misangyi, 2008). With long-term academic training, scholar-directors possess deep subject knowledge and broad interdisciplinary perspectives. In the context of increasing attention to climate change, they are more likely to understand the value of carbon disclosure in building corporate legitimacy and

stakeholder trust. Their analytical input may guide boards toward more informed and forward-looking environmental strategies.

Second, scholar-type independent directors tend to have stronger innovation awareness and moral sensitivity. Their rigorous academic background equips them with analytical thinking and openness to new ideas, making them more receptive to non-financial disclosures such as carbon emissions. These disclosures are closely tied to corporate social responsibility (CSR). Unlike managers who may adopt a wait-and-see approach, scholar-directors are more likely to align with stakeholder, legitimacy, and CSR theories and emphasize the firm's broader societal obligations. Their academic roles also instill a sense of professional ethics and social responsibility, reinforcing their commitment to climate-related governance.

Third, scholar-directors often enjoy high public esteem due to their intellectual authority and reputation, which enhances their influence on board decisions. According to the reputation incentive hypothesis, these directors are motivated to maintain their credibility and avoid reputational damage by supporting decisions aligned with environmental responsibility. In the context of climate governance and low-carbon development, carbon disclosure is highly visible and increasingly demanded by stakeholders including governments, investors, and the public. Thus, scholar-type directors may exert stronger oversight over management and advocate for timely and transparent environmental reporting. Moreover, in Chinese culture, deference to academic expertise reinforces their authority and increases the likelihood that their views will shape board decisions (Du et al., 2024).

Based on these considerations, we propose the following hypothesis:

Hypothesis 1: All else being equal, the presence of scholar-type

independent directors significantly increases the likelihood of a firm disclosing its carbon emissions information.

In addition, from the perspective of legitimacy theory, the institutional environment is a critical external factor influencing corporate disclosure behavior. Under regulatory and normative pressure, firms are motivated to disclose environmental information to demonstrate their legitimacy and responsibility. Prior studies have confirmed the impact of environmental regulation on disclosure levels (Shen and Hong, 2015; Knox-Hayes and Levy, 2012; Luo et al., 2015).

In China, the government has strengthened environmental governance through a series of initiatives. In 2012, the National Development and Reform Commission launched pilot carbon emissions trading programs in seven provinces and municipalities, including Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei, and Shenzhen. Although not all firms in these regions are explicitly required to disclose emissions, pilot regions are tasked with setting local emissions caps and mandating reductions in targeted sectors. These areas face stronger institutional pressures, which are expected to encourage higher levels of voluntary disclosure.

Extending from Hypothesis 1, we argue that the institutional setting further enhances the influence of scholar-type directors in promoting disclosure. Specifically, in carbon trading pilot regions, these directors may be more attuned to social responsibility expectations and more motivated to advocate for transparent reporting.

Hypothesis 2: All else being equal, the positive impact of scholar-type independent directors on corporate carbon disclosure is more pronounced in carbon trading pilot regions than in non-pilot region.

3.2 Model specification

This paper investigates the impact of scholar-type independent directors on corporate carbon emission information disclosure. Whether a firm discloses its carbon emissions is treated as a binary choice behavior, represented by a dummy variable equal to 1 if disclosed and 0 otherwise. According to econometric theory, when the dependent variable is binary, using ordinary least squares (OLS) may lead to biased estimates due to heteroscedasticity. Common alternatives include Logit and Probit models, which are more appropriate for discrete outcome variables.

However, given that this study utilizes panel data, the panel Probit model is not suitable for estimating fixed effects due to the incidental parameters problem and the absence of sufficient statistics. Therefore, this paper employs a panel Logit model with fixed effects to conduct the empirical analysis. The following empirical specification is constructed accordingly:

$$Carbon_{i,t} = \alpha_0 + \alpha_1 Aca_{i,t} + \sum_j \alpha_j CV_{i,t} + Year + Ind + \varepsilon_{i,t} \quad (1)$$

In this model, the dependent variable Carbon indicates whether firm i discloses carbon emission information in year t (equal to 1 if disclosed, 0 otherwise). The key explanatory variable Aca is captured by two alternative measures: the number of scholar-type independent directors ($Acanum$) and a dummy variable indicating the presence of such directors $Acadum$). $CV_{i,t}$ represents a vector of control variables, and ε denotes the error term.

The Logit model estimates the log-odds of a firm disclosing carbon emission information. If the estimated coefficient α_1 of Aca in Equation (1) is significantly positive, indicating an odds ratio greater than 1, then Hypothesis 1 is empirically supported. This would suggest that scholar-type independent directors significantly increase the likelihood that a firm discloses its carbon emissions information.

In addition to the Logit model, the Linear Probability Model (LPM) is also widely used in empirical research when the dependent variable is binary and the sample size is large. The LPM is specified as $P(Y = 1 \mid X) = X\beta$, where $Y = 1$ indicates that the firm has disclosed carbon emission information. In this model, X represents the matrix of explanatory variables, including both continuous and discrete covariates, whose effects on the probability of disclosure are assumed to be linear. The coefficient vector β captures the marginal effects of these variables. Compared with the Logit model, the Linear Probability Model (LPM) offers more intuitive interpretation, as its coefficients directly represent the marginal effects of explanatory variables on the probability of the outcome. In large samples, estimates from the LPM and Logit models tend to converge, making the LPM a useful alternative. Moreover, the LPM helps mitigate issues such as inflated standard errors arising from the incidental parameters problem commonly encountered in nonlinear binary models. Prior studies, including Ma and Gan (2020) and Li (2022), have adopted the LPM to analyze panel data with binary dependent variables. Following this practice, the present study also employs the LPM as a complementary approach for robustness checks.

To further explore the effect of scholar-type independent directors on corporate carbon disclosure under varying regional institutional environments, this study conducts both subgroup regression and interaction effect analysis. Given the need to introduce interaction terms, and considering the limitations of interpreting interaction effects in nonlinear models, it is important to proceed with caution. Specifically, in nonlinear models such as Logit, the statistical significance of the interaction term does not necessarily imply the existence of a true interaction effect.

Therefore, to accurately capture the moderating effect of institutional environment, this paper constructs a Linear Probability Model (LPM) incorporating multiplicative interaction terms. This allows for a more straightforward interpretation of interaction effects and enables clearer estimation of how regional policy environments condition the role of scholar-type independent directors in shaping carbon disclosure decisions.

$$Carbon_{i,t} = \beta_0 + \beta_1 Aca_{i,t} + \beta_2 Aca_{i,t} \times Ins_{i,t} + \beta_3 Ins_{i,t} + \sum_j \beta_j CV_{i,t} + Year + Ind + \varepsilon_{i,t} \quad (2)$$

Herein, it is expected that in the above equations (1) and (2), the coefficient of $Aca_{i,t}$ will be significantly positive, and the coefficient of the interaction term $Aca_{i,t} \times Ins_{i,t}$ will also be significantly positive. In order to ensure the robustness of the regression results, all the regressions in this paper adopt the robust standard error adjusted by company-level cluster.

4. Sample, variables and data

4.1 Sample

In China, the industrial sector contributes approximately 40% of GDP and accounts for over 60% of national energy consumption. Research also indicates that carbon emissions from this sector make up more than 70% of the country's total emissions. Given its dominant role in emissions, this study focuses on industrial enterprises when examining corporate carbon emission information disclosure.

Currently, China has not yet implemented a mandatory carbon disclosure system for corporations. Nevertheless, some firms voluntarily disclose their greenhouse gas emissions or reductions as part of their corporate social responsibility practices. Due to limited formal disclosure channels, such information is typically found in publicly available

documents such as annual reports and corporate social responsibility (CSR) reports. Firms may also disclose environmental data in response to external initiatives, such as the Carbon Disclosure Project (CDP). However, the CDP only surveys the top 100 Chinese firms by market capitalization, limiting the representativeness of its data. Therefore, this study uses carbon disclosure information manually collected from annual reports and CSR reports of listed companies.

For data availability and consistency, this paper selects all A-share industrial firms listed on the Shanghai and Shenzhen stock exchanges between 2020 and2024 as the initial sample, yielding 9,868 firm-year observations. The sample is then refined based on the following criteria:

(1) Excluding firms that were newly listed, delisted, or subject to special treatment (ST), particular transfer (PT), or other abnormal trading statuses during the year;

(2) Excluding firms with missing information on scholar-type independent directors or key financial indicators.

After applying these filters, the final dataset comprises 8,675 firm-year observations. To mitigate the influence of outliers, all continuous variables are Winsorized at the 1st and 99th percentiles.

4.2 Variables

This paper takes a firm's decision to disclose carbon emission information as the dependent variable, labeled Carbon. Carbon is a binary variable, taking the value of 1 if the company discloses carbon emission information in a given year, and 0 otherwise.

The key explanatory variable is the presence of scholar-type independent directors, measured by two indicators: the number of such directors (Acanum) and a dummy variable indicating their presence

(Acadum). Specifically, Acanum reflects the total number of scholar-type independent directors on the board, while Acadum equals 1 if the firm has at least one such director, and 0 otherwise.

To test Hypothesis 2, the paper introduces a dummy variable Ins to capture differences in the institutional environment. Ins equals 1 if the company is located in a carbon emissions trading pilot city, and 0 otherwise.

This study also controls for a set of variables that may influence a firm's carbon disclosure decisions, grouped into three categories:

1. Financial characteristics:

Size: Larger firms generally have broader operational scopes and engage more stakeholder groups, making them more visible and subject to scrutiny from governments, investors, environmental groups, and the media (Kim and Lyon, 2012).

Lev (Leverage): Highly leveraged firms may disclose more environmental information to demonstrate social responsibility and boost investor confidence (Yuan and Wang, 2022).

Roa (Return on Assets): According to signaling theory, firms with better performance are more likely to disclose environmental data to attract investment and enhance their market reputation (Tang et al., 2010).

2. Corporate governance characteristics:

First: The ownership share of the largest shareholder. A higher shareholding may lead to more active participation in governance, limiting managerial opportunism and enhancing disclosure (Jensen and Meckling, 1976; Luo et al., 2010). However, overly concentrated ownership may lead to disclosure suppression for cost-saving purposes (Huang and Zhou, 2015).

Board: Board size. Larger boards tend to be more diverse and knowledgeable, promoting more comprehensive disclosures (Shi, 2010).

Indep: Proportion of independent directors.

Dual: Whether the CEO also serves as board chair. Separation of these roles is generally associated with better governance and increased transparency (Bi et al., 2015).

3. Other firm attributes:

State: Nature of ownership. State-owned or state-controlled firms often prioritize environmental and social goals, partly due to legitimacy considerations and political incentives (Huang and Yu, 2010).

Listage: Number of years since listing. Newly listed companies may disclose more environmental information to build credibility and fulfill listing expectations (Wang et al., 2020).

In addition to the above, the model includes industry fixed effects (Ind) and year fixed effects (Year) to control for unobserved heterogeneity across sectors and time.

A summary of variable definitions is provided in the following table.

Table 1 Variable definition table

Variable types	variable name	Variable symbol	Variable meaning
Explained variable	Whether the company disclosed carbon emission information in the sample year	Carbon	Dummy variable: if the company disclosed carbon emission information, the value is assigned to 1, otherwise, it is 0
Explanatory variables	Number of academic independent directors	Acanum	The number of academic independent directors in a company
	Scholarly independent director dummy variable	Acadum	Dummy variable, the value is 1 when the academic independent director exists in the company, otherwise it is 0
Control variables	The shareholding ratio of the largest shareholder	First	The ratio of shares held by the largest shareholder of the company
	The company size	Size	The log of total ending assets

	Debt levels	Lev	Total ending liabilities/Total ending assets
	Return on assets	Roa	Company net profit/Total ending assets
	Board Size	Board	Total number of directors
	Board independence	Indep	Number of independent directors/Total number of board members
	CEO duality	Dual	Dummy variable is 1 if the chairman is also the general manager of the company, otherwise 0
	Nature of the Actual Controller's Equity	State	The dummy variable is assigned to 1 if the actual controller is state-owned, otherwise, 0
	Company listing time	Listage	Add one to the number of years the company has passed since the IPO and take log
	The institutional environment	Ins	Dummy variable: if the company is located in the pilot city of carbon emission trading, the value is assigned to 1, otherwise, the value is 0

Source: Collation of this article

4.3 Data statistics

The data used in this paper are primarily obtained from the following sources: (1) Annual reports and corporate social responsibility (CSR) reports of listed companies, which are manually collected from the official websites of the Shanghai Stock Exchange and the Shenzhen Stock Exchange. (2) Carbon emission disclosure data are manually extracted by conducting keyword searches within the annual and CSR reports of each firm. (3) Information on the personal attributes of scholar-type independent directors during the sample period is collected from the CSMAR and Wind databases. To address data omissions, additional details are manually supplemented by reviewing board member descriptions in company annual reports. (4) Corporate governance and financial indicators are sourced from

the Guotai'an (CSMAR) database. Descriptive statistics for all variables are presented in Table 2.

Table 2 Variable descriptive statistics

Variable name	Number of samples	Mean	Standard deviation	Minimum value	Median	Maximum value
Carbon	8675	0.106	0.307	0.000	0.000	1.000
Acadum	8675	0.807	0.394	0.000	1.000	1.000
First	8675	0.347	0.146	0.090	0.329	0.743
Size	8675	22.079	1.209	19.885	21.904	25.851
Lev	8675	0.403	0.196	0.054	0.391	0.867
Roa	8675	0.040	0.053	-0.147	0.042	0.206
Board	8675	8.547	1.637	4.000	9.000	15.000
Indep	8675	0.374	0.053	0.300	0.333	0.571
Dual	8675	0.277	0.447	0.000	0.000	1.000
State	8675	0.326	0.469	0.000	0.000	1.000
Listage	8675	2.480	0.550	0.693	2.639	3.367
Ins	8675	0.327	0.469	0.000	0.000	1.000

Note: The Size of enterprises is treated by natural logarithm, which is the same in the following tables

Source: Computation and collation of this paper

Table 3 presents the annual distribution of listed companies disclosing carbon emission information. The data reveal a year-on-year increase in the number of firms engaging in such disclosure during the sample period. However, from an overall perspective, only a limited number of listed companies actively disclose their carbon emissions information, indicating that voluntary disclosure remains relatively low.

Table 3 The sample distribution of carbon information disclosure by year

Year	The total number of samples	Disclosure of Sample Number (Percentage)	Undisclosed sample size (percentage)

2023	1576	136（8.6%）	1440（91.4%）
2022	1586	149（9.5%）	1437（90.5%）
2021	1687	173（10.3%）	1514（89.7%）
2020	1835	219（11.9%）	1616（88.1%）
2019	1991	240（12.1%）	1751（87.9）
Total	8675	917（10.6%）	7758（89.4%）

Source: Computation and collation of this paper

5. Empirical results

5.1 Baseline regressions

Based on the regression model specified in Equation (1), this paper empirically tests the impact of scholar-type independent directors on corporate carbon emission information disclosure. The number of scholar-type independent directors (Acanum) and the presence of such directors (Acadum) are used as key explanatory variables. In addition to controlling for firm financial and governance characteristics, the regressions also account for year (Year) and industry (Ind) fixed effects. The results are presented in Table 4.

Column (1) of Table 4 shows that, after controlling for relevant influencing factors, the coefficient of Acanum is significantly positive at the 5% level, consistent with theoretical expectations. This result suggests that an increase in the number of scholar-type independent directors significantly enhances the likelihood of carbon emission information disclosure. Similarly, column (2) demonstrates that the coefficient on Acadum is also significantly positive at the 5% level, indicating that the presence of scholar-type independent directors improves the probability of carbon disclosure.

Columns (3) and (4) report results using the Linear Probability Model (LPM). The estimation results from the LPM and Logit models are broadly

consistent in terms of statistical significance and coefficient signs. In particular, the LPM coefficient in column (3) implies that each additional scholar-type independent director increases the probability of disclosure by approximately 0.9%. According to column (4), firms with at least one scholar-type independent director are 2.5% more likely to disclose carbon emissions information. These findings collectively support Hypothesis 1, confirming that scholar-type independent directors significantly promote firms' decisions to disclose carbon emission data.

Regarding the control variables, Carbon is significantly positively associated with Size, Roa, and State, indicating that larger firms, those with higher profitability, and state-owned or state-controlled enterprises are more likely to disclose carbon-related information. These results are largely in line with previous literature. Interestingly, Listage is also positively and significantly correlated with carbon disclosure, which contrasts with the findings of Wang et al. (2020), who argue that recently listed firms are more proactive in environmental disclosure. A possible explanation is that long-established firms may possess more mature internal governance and accumulated resources, leading them to place greater emphasis on building a strong social image and environmental responsibility. As a form of non-financial disclosure, carbon emission reporting reflects a company's environmental management and awareness in the context of climate change and sustainability. Therefore, firms with longer listing histories may be more inclined to engage in carbon information disclosure.

Table 4 Results from baseline regressions

Variable	The dependent variable：*Carbon*	
	Logit model	LPM model

	（1）	（2）	（3）	（4）
Acanum	0.093** （1.999）		0.009** （2.059）	
Acadum		0.377** （2.492）		0.024** （2.271）
First	0.176 （0.622）	0.156 （0.553）	0.013 （0.548）	0.012 （0.510）
Size	0.586*** （9.596）	0.592*** （9.688）	0.064*** （9.321）	0.064*** （9.373）
Lev	-0.328 （-0.874）	-0.333 （-0.889）	-0.047 （-1.477）	-0.047 （-1.492）
Roa	1.829* （1.727）	1.842* （1.748）	0.125* （1.679）	0.128* （1.702）
Board	0.020 （0.492）	0.031 （0.786）	0.003 （0.692）	0.004 （0.931）
Indep	-0.721 （-0.619）	-0.486 （-0.417）	0.025 （0.228）	0.047 （0.428）
Dual	-0.036 （-0.256）	-0.035 （-0.250）	-0.002 （-0.168）	-0.002 （-0.166）
State	0.445*** （2.921）	0.441*** （2.896）	0.048*** （3.186）	0.048*** （3.204）
Listage	0.841*** （5.846）	0.855*** （5.913）	0.058*** （6.454）	0.059*** （6.476）
Constants	-18.350*** （-13.099）	-18.836*** （-13.470）	-1.563*** （-9.918）	-1.593*** （-10.138）
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	8675	8675	8675	8675
R^2			0.107	0.107
Pseudo R^2	0.149	0.150		

Note: Values in brackets under Logit model and LPM model are z value and t value respectively, which are calculated by standard error after clustering adjustment at company level.

Source: Computation and collation of this paper

5.2 Grouping regressions

To test Hypothesis 2, this paper conducts a group regression based on whether a company is located in a carbon emissions trading pilot city (i.e., Ins = 1). The results are reported in Table 5.

The coefficient difference tests between the two groups show that when the explanatory variables are Acanum and Acadum, the chi-square test p-values are 0.035 and 0.001, respectively. These results reject the null hypothesis, indicating significant differences in the regression coefficients between pilot and non-pilot cities.

After controlling for relevant covariates, the regression coefficient of Acanum in pilot cities (column 1) is significantly positive at the 5% level and larger than that observed in the full-sample regression. In contrast, the coefficient in non-pilot cities (column 2) is statistically insignificant. Similarly, for Acadum, column (3) shows a significantly positive coefficient at the 1% level in pilot cities, while column (4) presents an insignificant result for non-pilot cities. These findings suggest that scholar-type independent directors have a more pronounced effect on promoting carbon disclosure in pilot regions compared to non-pilot ones.

Regarding the control variables, firm size (Size), state ownership (State), and listing age (Listage) are all significantly positively associated with carbon disclosure, consistent with the baseline regression. Notably, Leverage (Lev) shows a stronger and more significant positive impact in pilot regions. This may reflect the greater institutional pressure in these regions, where highly leveraged firms are more inclined to disclose carbon emissions to demonstrate social responsibility, convey positive signals to governments and creditors, and enhance access to financial support and investor confidence.

Additionally, these firms may invest more in emission monitoring and

green technologies, thus increasing their motivation to disclose such information as evidence of environmental engagement. On the other hand, in non-pilot regions, the return on assets (Roa) exerts a stronger influence on disclosure behavior. With fewer institutional constraints, firms in non-pilot areas may base disclosure decisions more on financial capacity and cost considerations. Firms with stronger financial performance may be more capable of managing emissions and affording related disclosure costs.

Table 5 Grouping Regression Results

Variable	The dependent variable：*Carbon*			
	（1）	（2）	（3）	（4）
	Ins=1	*Ins*=0	*Ins*=1	*Ins*=0
Acanum	0.018** （2.727）	0.005 （0.915）		
Acadum			0.060*** （3.555）	0.008 （0.598）
First	0.035 （0.762）	0.014 （0.525）	0.036 （0.775）	0.014 （0.503）
Size	0.095*** （8.206）	0.043*** （5.581）	0.096*** （8.242）	0.043*** （5.620）
Lev	-0.099* （-1.740）	-0.001 （0.036）	-0.098* （-1.730）	-0.001 （-0.024）
Roa	-0.071 （-0.454）	0.222** （2.157）	-0.072 （-0.460）	0.225** （2.177）
Board	0.002 （0.213）	0.002 （0.407）	0.003 （0.462）	0.003 （0.525）
Indep	-0.064 （-0.374）	0.023 （0.157）	-0.033 （-0.780）	0.035 （0.253）
Dual	-0.003 （-0.176）	-0.002 （-0.148）	-0.003 （-0.180）	-0.002 （-0.155）
State	0.061** （2.064）	0.036** （2.106）	0.061** （2.074）	0.036** （2.128）
Listage	0.060*** （3.477）	0.055*** （5.322）	0.062*** （3.554）	0.055*** （5.278）
Constants	-2.193*** （-8.447）	-1.079*** （-6.024）	-2.256*** （-8.686）	-1.093*** （-6.132）

Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	2836	5839	2836	5839
Pseudo R^2	0.194	0.073	0.196	0.072
chi2(1)	4.46		12.04	
Prob＞chi2	0.035		0.001	

Note:①The value in the bracket is t value, which is calculated by the standard error after the clustering adjustment at the company level; ②The last line of this table reports the test result of coefficient difference between groups (suest).

Source: Computation and collation of this paper

5.3 Reciprocal effect regressions

To further clarify the influence of the institutional environment, this paper incorporates the institutional variable (Ins) and its interaction with the explanatory variables into regression model (2). The results are presented in Table 6.

The coefficients of the interaction terms Ins × Acanum and Ins × Acadum are 0.024 and 0.022, respectively, both of which are statistically significant at the 5% level. These findings indicate that scholar-type independent directors in firms located within carbon trading pilot regions exert a significantly stronger influence on carbon emission disclosure compared to those in non-pilot regions.

Together, the regression results from Tables 5 and 6 provide robust support for Hypothesis 2: the positive effect of scholar-type independent directors on the likelihood of carbon disclosure is more pronounced in areas subject to carbon emissions trading schemes.

Table 6 Regression results of interaction effect

Variable	The dependent variable：*Carbon*

	（1）	（2）	（3）	（4）
Acanum	0.009**	0.002		
	（2.146）	（0.320）		
Acanum × Ins		0.024**		
		（2.492）		
Acadum			0.025**	0.011
			（2.377）	（0.921）
Acadum × Ins				0.022**
				（2.494）
Ins	0.046***	0.010	0.046***	0.012
	（3.885）	（0.609）	（3.893）	（0.723）
First	0.018	0.018	0.017	0.018
	（0.761）	（0.773）	（0.722）	（0.758）
Size	0.063***	0.063***	0.063***	0.064***
	（9.332）	（9.340）	（9.386）	（9.373）
Lev	-0.039	-0.040	-0.040	-0.040
	（-1.249）	（-1.276）	（-1.264）	（-1.280）
Roa	0.117	0.118	0.119	0.117
	（1.451）	（1.449）	（1.477）	（1.458）
Board	0.003	0.003	0.004	0.003
	（0.610）	（0.574）	（0.857）	（0.610）
Indep	0.002	0.030	0.027	0.040
	（0.228）	（0.257）	（0.227）	（0.368）
Dual	-0.002	-0.002	-0.002	-0.002
	（-0.224）	（-0.156）	（-0.237）	（-0.163）
State	0.048***	0.047***	0.048***	0.047***
	（3.188）	（3.184）	（3.205）	（3.161）
Listage	0.056***	0.056***	0.057***	0.056***
	（6.277）	（6.252）	（6.311）	（6.255）
Constants	-1.539***	-1.525***	-1.569***	-1.532***
	（-9.935）	（-9.890）	（-10.171）	（-9.976）
Year effect	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES
Observations	8675	8675	8675	8675
R^2	0.112	0.113	0.112	0.114

Note: The value in the bracket is t value, which is calculated by the standard error after the adjustment of company-level clustering
Source: Computation and collation of this paper

6. Robustness test

6.1 Mean difference test

Based on the presence or absence of scholar-type independent

directors on the board, this paper divides the full sample into two subgroups: one with scholar-type independent directors (Acadum = 1) and the other without (Acadum = 0). We then conduct mean difference tests for the dependent variable (Carbon), the institutional environment variable (Ins), and other control variables. The results are presented in Table 7.

As shown in the table, the mean value of Carbon in the subgroup with scholar-type independent directors is 0.114, while that in the subgroup without scholar-type independent directors is 0.073. The two-sample t-test indicates that the former is significantly higher at the 1% level, which is consistent with Hypothesis 1. Furthermore, the mean difference tests for the control variables are also statistically significant, confirming the appropriateness of the selected control variables in this study.

Table 7 Test of mean difference

Variable	Academic independent directors（*Acadum*=1） N=7004		Non-academic independent director（*Acadum*=0） N=1671		T-value
	Mean	Standard deviation	Mean	Standard deviation	
Carbon	0.114	0.230	0.073	0.260	4.844***
Ins	0.321	0.467	0.351	0.476	-2.364**
First	0.348	0.147	0.344	0.142	0.895
Size	22.127	1.203	21.884	1.216	7.380***
Lev	0.406	0.196	0.390	0.198	3.125***
Roa	0.041	0.058	0.037	0.059	2.842**
Board	8.626	1.636	8.215	1.599	9.250***
Indep	0.374	0.052	0.378	0.055	-3.289***
Dual	0.271	0.445	0.300	0.459	-2.417**
State	0.347	0.476	0.241	0.428	8.306***
Listage	2.468	0.554	2.528	0.533	-3.971***

Note: ***, ** and * mean significant at the significant level of 1%, 5% and 10% respectively, the same as in the following table

Source: Computation and collation of this paper

6.2 Correlation Test

This paper conducts a Pearson correlation analysis to examine whether there are statistically significant relationships between the key variables. The results indicate that both Acanum and Acadum, which measure the presence and number of scholar-type independent directors, are positively correlated with Carbon, suggesting that such directors may influence corporate carbon emission disclosure. Similarly, Ins is also significantly and positively correlated with Carbon, implying that external institutional regulatory factors may affect firms' carbon disclosure behavior.

Moreover, the correlation coefficient between Acanum and Acadum is 0.678, indicating a strong positive relationship between these two variables. As such, both are included in the regression analysis.

Among the control variables, except for a slightly higher correlation coefficient between Size and Lev (greater than 0.5), the correlation coefficients between other variables are all below 0.5, suggesting that multicollinearity is unlikely to materially affect the regression results. Furthermore, in accordance with the specification of Model (2), we test for multicollinearity using the Variance Inflation Factor (VIF). All VIF values are below 2, confirming that the model does not suffer from serious multicollinearity issues.

6.3 Endogenous Test

According to the benchmark model of this paper, in order to obtain the real causal identification effect of independent scholar directors on corporate carbon emissions information disclosure, we need to solve the possible endogenous problem. One is the bias of missing variables in the

model. Although this article has controlled a series of factors that may affect the company carbon emissions information disclosure, there are still some missing variables possibly, making the estimation bias. The second is reverse causality. Specifically, the company itself is endogenous in the selection of independent directors, and different types of companies have different preferences for the type of independent directors. For example, companies concerning about environmental issues and voluntary carbon disclosure may prefer independent directors with academic background, and this possible endogenous problem caused by reverse causality will lead to bias in the results of model estimation.

For the endogeneity problem of the model, this paper mainly adopts the identification strategy of panel instrumental variable estimation. In the panel instrumental variable regression, referring to the methods of Ma and Tang (2016), Xiang and Song(2019), this paper uses the number of colleges and universities in city where the company is located (*School*) as the instrumental variable of scholar-type independent directors (*Aca*). The core logic of choosing this instrumental variable is that universities are important places for local listed companies to provide scholar-type independent directors. Firstly, if there are more colleges and universities in the company's location, the colleges and universities will be able to provide more potential independent scholar directors for local listed companies, and the probability they choose suitable independent directors will be higher. Secondly, compared with serving in different places, local appointment of independent directors is conducive to reducing transportation, time and communication costs, so it has become a common preference between the company and independent directors. In addition, there is no direct relationship between the number of universities and the company's carbon disclosure decision, and it will only affect the dependent

variable by affecting the explanatory variable of scholar-type independent director. Therefore, this variable meets the requirements of correlation and exogeneity in the principle of instrumental variables selection.

Because the dependent variable is a binary variable, according to the method of Wooldrige (2002), firstly, this section take the endogenous explanatory variable *Aca* as the dependent variable, the other control variables and the instrumental variable *School* as the independent variables, and carry out Logit model regression. Thus the fitted value of the endogenous variable $\widehat{Aca}$ is obtained. Next, we conduct 2SLS regression. In the first stage, the $\widehat{Aca}$ fitted by Logit regression in the previous step is used as an instrumental variable, and other exogenous variables in Logit regression are used as control variables. In the second stage, *Carbon* is used as the dependent variable, $\widehat{Aca}$ as the independent variable, and other control variables are added. In addition, because the interaction terms between endogenous variables and other variables are involved in the model, a new interaction term is formed by multiplying the fitted value $\widehat{Aca}$ and *Ins* as the exogenous instrumental variable of the original interaction term (Balli and Sorensen, 2010[①]).

Table 8 reports the results of the endogenous tests of the models separately. According to the regression results of the first stage, the estimated coefficients of fitting values obtained by Logit model regression are significant at the level of 1% and 5%, respectively, and the F statistics are greater than 10 and significant at the level of 1%, indicating that the possibility of weak instrumental variables is small. The regression results of the second stage show that the estimated coefficient of the explanatory

[①] Source: No 7929, Discussion Papers from Centre for Economic Policy Research(CEPR). https://econpapers.repec.org/paper/cprceprdp/7929.htm.

variable *Acanum* in column (1) is 0.320, and it is significantly positively correlated with *Carbon* at the 5% level, which is consistent with the basic regression results before this paper, indicating that the increase of the number of scholar-type independent directors can significantly improve the probability of corporate disclosure of carbon emissions information. The interaction term *Acanum* × *Ins* is added in column (2), and its coefficient is 0.344, which is significantly positively correlated with *Carbon* at the level of 1%, indicating that in the companies in the pilot area of carbon emissions trading, scholar-type independent directors can more significantly enhance the possibility of carbon disclosure. Similarly, from that result in columns (3) and (4), both *Acadum* and the cross term *Acadum* × *Ins* are also significantly positively correlated with *Carbon*.

In order to test whether the model endogeneity problem exists, this paper uses Hausman-Wu endogeneity test method, and the results show that the null hypothesis is rejected at the level of 1% and 5% respectively, indicating that the model has endogeneity problem, and it is necessary to use instrumental variables to estimate. In order to test the existence of weak instrumental variables, the Cragg-Donald WaldF test is carried out, and the results significantly reject the null hypothesis, indicating that the model does not have weak instrumental variable. Because the number of instrumental variables in the model is the same as the number of core explanatory variables, it is a moderate identification situation. Endogenous test results show that after controlling endogenous problems, scholar-type independent directors can still significantly promote the disclosure of carbon emissions information, and in the pilot area scholar-type independent directors can play a more significant positive role.

Table 8 Endogenous Test

Regression results of the first stage				
Variable	The dependent variable: *Acanum*		The dependent variable: *Acadum*	
	Coefficient	T-value	Coefficient	T-value
Aĉa	3.064***	5.050	2.293***	4.897
First	-0.109	-1.403	-0.039	-1.363
Size	0.029**	2.328	0.018***	2.265
Lev	-0.046	-0.665	-0.011	-0.446
Roa	0.148***	2.970	0.276***	2.962
Board	0.111***	6.831	0.049***	4.547
Indep	2.358***	8.514	0.688***	6.003
Dual	-0.017	-0.266	-0.007	-0.071
State	0.219***	7.383	0.103***	4.806
Listage	0.115**	2.400	0.089***	2.894
Ins	0.022	0.827	0.031***	3.409
Constants	-3.471***	-7.483	-0.772***	-4.140
Year effect	YES		YES	
Industry effect	YES		YES	
Observations	8675		8675	
Adj R^2	0.087		0.064	
F statistic	15.08***		11.85***	

Regression results of the second stage				
Variable	The dependent variable: *Carbon*			
	（1）	（2）	（3）	（4）
Acanum	0.320**	0.122**		
	（2.365）	（1.993）		
Acanum × *Ins*		0.344***		
		（3.831）		
Acadum			0.241**	0.205**
			（2.318）	（2.086）
Acadum × *Ins*				0.450***
				（3.404）
Ins	0.044***	0.232***	0.041***	0.252***
	（4.915）	（3.123）	（4.457）	（3.348）
First	0.017	0.125	0.024	0.024
	（0.757）	（0.527）	（1.046）	（1.014）
Size	0.065***	0.068***	0.065***	0.063***
	（7.984）	（5.748）	（7.230）	（5.631）
Lev	-0.041**	-0.044**	-0.039*	-0.038*
	（-2.074）	（-2.033）	（-1.893）	（-1.809）

Roa	0.156*	0.203**	0.179**	0.166**
	（1.867）	（2.303）	（2.507）	（2.277）
Board	0.011	0.023	0.009	0.008
	（0.975）	（0.662）	（1.312）	（0.939）
Indep	-0.124	-0.313	-0.038	-0.210
	（0.686）	（0.369）	（-0.484）	（-0.259）
Dual	-0.002	-0.001	-0.002	-0.001
	（-0.064）	（-0.034）	（-0.047）	（-0.032）.
State	0.059***	0.067***	0.069***	0.063***
	（3.448）	（3.915）	（5.474）	（4.913）
Listage	0.052***	0.052***	0.039***	0.044***
	（5.967）	（5.578）	（4.910）	（4.295）
Year effect	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES
Observations	8675	8675	8675	8675
Test Statistic				
Hausman-Wu F test	13.609***	17.210***	10.698***	14.961***
Cragg-Donald Wald F Statistic	28.444***	31.595***	23.999***	25.068***

Note: ① The value in the bracket is the Z value, which is calculated by the standard error after the clustering adjustment at the company level; (2) $\hat{Aca}$ is the fitting value obtained by Logit model regression with instrumental variable School, representing $\hat{Acanum}$ and $\hat{Acadum}$, respectively.

Source: Computation and collation of this paper

6.4 Rare event bias

n binary choice models, when the probability of the outcome variable equaling 1 is very low, the phenomenon is referred to as a rare event. In such cases, standard Logit regression may produce biased estimates due to the imbalanced distribution of the dependent variable. In this study, descriptive statistics show that only 10.6% of listed company observations from 2020 to2024 disclosed carbon emissions information, suggesting that carbon disclosure is indeed a rare event—an observation that aligns with reality. Yan and Chen (2017) similarly reported that only 4.9% of listed companies disclosed such information between 2013 and 2023.

The low disclosure rate may be attributed to the uncertain impact of carbon disclosure on corporate performance, investor behavior, and public

perception, prompting many firms to withhold such information. To address potential bias resulting from rare events, this paper employs the complementary log-log model as a robustness test. This model assumes an asymmetric extreme value distribution, which is left-skewed and better suited for modeling rare events, as it accelerates the probability toward 1 more rapidly than toward 0.

Table 9 reports the regression results using this specification. After correcting for potential estimation bias caused by sample imbalance, the results remain robust. This finding confirms that the positive influence of scholar-type independent directors on corporate carbon disclosure is not driven by rare event bias.

Table 9 An examination of the effects of controlling for rare event bias

Variable	The dependent variable：*Carbon*	
	clog-log model	
	（1）	（2）
Acanum	0.079**	
	（1.988）	
Acadum		0.356***
		（2.560）
Ins	0.434***	0.439***
	（3.894）	（3.932）
First	0.213	0.200
	（0.843）	（0.788）
Size	0.511***	0.516***
	（9.968）	（10.081）
Lev	-0.192	-0.196
	（-0.575）	（-0.589）
Roa	1.428*	1.464*
	（1.704）	（1.711）
Board	0.014	0.024
	（0.417）	（0.752）
Indep	-0.967	-0.769
	（-0.959）	（-0.760）
Dual	-0.062	-0.059
	（-0.468）	（-0.446）

State	0.393***	0.388***
	（2.726）	（2.703）
Listage	0.752***	0.764***
	（5.702）	（5.768）
Constants	-16.400***	-16.862***
	（-13.952）	（-14.405）
Year effect	YES	YES
Industry effect	YES	YES
Observations	8675	8675
Wald chi2	505.71	504.45
Prob＞chi2	0.000	0.000

Note: Values in parentheses are z values, which are calculated based on the standard error adjusted by company-level clustering.
Source: Computation and collation of this paper.

6.5 Other robustness issues

To ensure the robustness of the findings, this paper conducts additional regression analyses using alternative explanatory variable specifications. In addition to the number of scholar-type independent directors (Acanum) and the dummy variable indicating their presence (Acadum), we introduce the proportion of scholar-type independent directors (Acapro) as a substitute variable. Table 10 presents the corresponding regression results. As shown, the significance and direction of the coefficients remain consistent, confirming the stability of the original findings after variable substitution.

Furthermore, to eliminate potential bias from differences in firm characteristics, we exclude observations from companies listed on the SME Board and the ChiNext Market and re-estimate the models. The results remain qualitatively unchanged, providing further support that the core conclusions of this study are robust to alternative specifications and sample selections.

Table 10 Robustness test of independent variable

Variable	The dependent variable：*Carbon*		
	（1）	（2）	（3）
Acapro	0.031**	0.032**	0.008
	（2.203）	（2.286）	（0.499）
Acapro × *Ins*			0.023**
			（2.424）
Ins		0.046***	0.011
		（3.885）	（0.673）
First	0.013	0.018	0.018
	（0.543）	（0.756）	（0.772）
Size	0.064***	0.063***	0.063***
	（9.326）	（9.3438）	（9.341）
Lev	-0.047	-0.040	-0.040
	（-1.478）	（-1.250）	（-1.274）
Roa	0.125*	0.117*	0.118
	（1.846）	（1.748）	（1.563）
Board	0.005	0.005	0.003
	（1.057）	（0.990）	（0.656）
Indep	0.058	0.037	0.010
	（0.537）	（0.341）	（0.095）
Dual	-0.002	-0.002	-0.002
	（-0.169）	（-0.224）	（-0.157）
State	0.047***	0.047***	0.047***
	（3.177）	（3.178）	（3.173）
Listage	0.058***	0.056***	0.056***
	（6.469）	（6.293）	（6.254）
Constants	-1.591***	-1.568***	-1.529***
	（-10.154）	（-10.187）	（-9.998）
Year effect	Control	Control	Control
Industry effect	Control	Control	Control
Observations	8675	8675	8675
R^2	0.107	0.112	0.113

Note: The value in the bracket is t value, which is calculated by the standard error after the adjustment of company-level clustering

Source: Computation and collation of this paper

7. Conclusion and implications

In recent years, carbon emission disclosure has garnered increasing attention from both academic researchers and the public, as it represents a crucial avenue through which firms can demonstrate concern for climate

change and fulfill their social responsibilities. Against this backdrop, this study investigates the role of scholar-type independent directors in shaping corporate carbon disclosure behavior, using a sample of industrial firms listed on the Shanghai and Shenzhen A-share markets from 2020 to2024. Furthermore, it examines how the institutional environment—specifically the carbon emissions trading pilot policy—modifies this relationship.

The main findings are as follows:

Scholar-type independent directors significantly promote carbon emission information disclosure. Drawing on theoretical foundations, this positive influence may stem from their professional expertise, stronger ethical orientation, heightened awareness of social responsibility, and reputation concerns. Regression analyses consistently show that both the number and presence of scholar-type independent directors are positively associated with the likelihood of carbon disclosure.

The positive effect is more pronounced in carbon trading pilot regions. Companies located in pilot cities, subject to more stringent regulatory expectations, are more likely to disclose carbon information when scholar-type independent directors are present. This highlights the amplifying role of institutional environments in fostering corporate transparency on environmental issues.

Other firm-level characteristics also matter. Larger firms, more profitable firms, state-owned enterprises, and companies with longer post-IPO histories are significantly more likely to disclose carbon emission information, consistent with existing literature.

Based on these findings, this paper advocates for recognizing the governance value of scholar-type independent directors. Policymakers and regulatory bodies should consider reforms to strengthen the appointment mechanisms for independent directors and increase the representation of

academic professionals on corporate boards. Listed firms should leverage the expertise of scholar-type directors in strategic decision-making rather than treating them as symbolic appointments. Regulatory institutions may also guide firms to optimize board composition and improve internal governance to support broader climate goals and enhance corporate accountability.

Additionally, as the demand for carbon-related information continues to grow, the government should accelerate the development of the carbon market, incorporate carbon disclosure into corporate governance frameworks, and establish robust regulatory standards. These steps will encourage firms to actively engage in emission control, fulfill their social obligations, and respond to stakeholder concerns.

Limitations and future directions: First, the optimal number or proportion of scholar-type independent directors for promoting disclosure merits further investigation. Second, it is worth exploring how the academic background and discipline of such directors influence environmental decisions. Lastly, future research may extend the analysis to the economic consequences of carbon disclosure, such as its effects on market valuation or financing costs.

References

[1] Balli H , Sorensen B . Interaction Effects in Econometrics . Discussion Paper. Centre for Economic Policy Research(CEPR), 2010.

[2] Bi Qian, Peng Jue, Zuo Yongyan. Environmental Information Disclosure System, Corporate Governance and Environmental Information Disclosure. Accounting Research, 2015 (07): 39-47.

[3] Brammer S, Pavelin S. Voluntary Environmental Disclosures by Large UK Companies[J]. Journal of Business Finance and Accounting, 2010,33(7):1168-1188.

[4] Chen Shiyi. Energy Saving and Emission Reduction and Win-win Development of China's Industry: 2009-2049 [J]. Economic Research, 2010 (03): 129-143.

[5] Cui Yeguang, Li Bo, Sun Yuqing. Can Corporate Governance and Financial Status Affect the Quality of Carbon Disclosure? Based on the data of listed companies in China's power industry [J]. Economics and Management Research,2023, 37 (08): 125-133.

[6] Du X , Jian W , Lai S . Do Foreign Directors Mitigate Earnings Management? Evidence From China[J]. The International Journal of Accounting,2024, 52(02): 142-177.

[7] Fama E F, Jensen M C. Separation of Ownership and Control[J]. The Journal of Law and Economics, 1983,26(02):301-325.

[8] Ferris S P, Jagannathan M, Pritchard A C. Too Busy to Mind the Business? Monitoring by Directors with Multiple Board Appointments[J]. Journal of Finance, 2010,58(03):1087-1111.

[9] Francis B , Hasan I, Wu Q. Professors in the Boardroom and Their Impact on Corporate Governance and Firm Performance[J]. Financial Management, 2022(09):547-581.

[10] Hambrick D C, Mason P A. Upper Echelons: The Organization as a Reflection of Its Top Managers[J]. Academy of Management Review, 1984, 9(02):193-206.

[11] Huang su-chien, Yu Ching. The Nature, Objective and Social Responsibility of State-owned Enterprises. China Industrial Economy, 2010 (02): 68-76.

[12] Huang Jun, Zhou Chunna. An Empirical Study on the Impact of Ownership Structure and Management Behavior on Environmental Information Disclosure: Evidence from Heavily Polluting Industries in Shanghai Stock Exchange. China Soft

Science, 2015 (01): 133-143.
[13] Ho S S, Wong K S. A Study of the Relationship Between Corporate Governance Structures and the Extent of Voluntary Disclosure[J]. Journal of International Accounting, Auditing and Taxation, 2001,10(02):139-156.
[14] Kim E H, Lyon T P. Strategic Environmental Disclosure: Evidence from the DOE's Voluntary Greenhouse Gas Registry[J]. Journal of Environmental Economics and Management, 2012,61(03).
[15] Kor Y Y, Misangyi V F. Research Notes and Commentaries Outside Directors' Industry-Specific Experience and Firms' Liability of Newness. Strategic Management Journal, 2008,29(12):1345-1355.
[16] Knox-Hayes J, Levy D L. The Politics of Carbon Disclosure as Climate Governance[J]. SSRN Electronic Journal, 2012, 9(01):91-99.
[17] Li Li, Lu Chen, Yu Jiayi. Independent Directors of Colleges and Universities and the Performance of Private Listed Companies. Management Review, 2018,30 (01): 98-117.
[18] Li Xuelian, Ma Shuang, Deng Xiang. Family, Entrepreneurship and Rent-seeking Motivation of Civil Servants. Economic Research, 2022, 50 (05): 89-103.
[19] Liu Hao, Tang Song, Lou Jun. Independent Directors: Supervision or Consultation? — — Research on the Influence of Independent Directors with Bank Background on Enterprise Credit Financing. Managing the World, 2015 (01): 141-156.
[20] Luo L, Lan Y C, Tang Q. Corporate Incentives to Disclose Carbon Information: Evidence from the CDP Global 500 Report[J]. Journal of International Financial Management and Accounting, 2015,23(02): 93-120.
[21] Luo S, Courtenay S M, Hossain M. The Effect of Voluntary Disclosure, Ownership Structure and Proprietary Cost on the Return–Future Earnings Relation[J]. Pacific-Basin Finance Journal, 2010,14(05).
[22] Ma Rujing, Tang Xuesong. Academic Background, Independent Directors, Corporate Performance and CEO Turnover. Financial Science,2023 (09): 77-87.
[23] Ma Shuang, Gan Li. An Analysis of the Impact of Minimum Wage on On-the-job Training in Enterprises. Economics (Quarterly), 2021, 13 (01): 1-26.
[24] Rivera J, Leon P D. Chief Executive Officers and Voluntary Environmental Performance: Costa Rica's Certification for Sustainable Tourism[J]. Policy Sciences, 2010,38(2):107-127.
[25] Shen Hongtao, Feng Jie. Supervision of Public Opinion, Government Regulation

and Corporate Environmental Information Disclosure. Accounting Research, 2015 (02): 72-78.
[26] Shi Jianliang. Research on the Relationship between Board Characteristics and Voluntary Disclosure. Economic Issues, 2010 (05): 57-60.
[27] Su Ran, Feng Ke. Research on the Development Status and Governance Effect of Scholar-type Independent Director. Finance and Accounting Communications, 2018,785 (21): 5-10.
[28] Tang Qingquan. The Motivation and Function of Independent Directors under the Influence of Listed Companies: An Empirical Study Based on Shanghai Stock Exchange. Management Science, 2010 (04): 8-13.
[29] Tang Songlian, Hu Yiming. Independent Directors and Earnings Information Quality of Listed Companies. Managing the World, 2008 (09): 149-160.
[30] Tang Yali, Chen Zili, Liu Xing, Li Wenhong. An Empirical Study on Environmental Information Disclosure of Listed Companies in China and Its Influencing Factors. Managing the World, 2010 (01): 158-159.
[31] Thomas A S, Simerly R L. Internal Determinants of Corporate Social Performance: The Role of Top Managers[J]. Academy of Management Proceedings, 1995:411-415.
[32] Wang Fen Mian, Yuan Xin. Research on the Selection Mechanism of Scholars' Independent Directors — — From the Perspective of Human Capital and Social Capital. Economic Management, 2019, 41 (02): 90-106.
[33] Wang Xia, Xu Xiaodong, Wang Chen. Public Pressure, Social Reputation, Internal Governance and Corporate Environmental Disclosure: Evidence from Chinese Listed Manufacturing Companies. Nankai Management Review, 2020, 16 (02): 82-91.
[34] Wang Zhen, Yang Xin. The Relationship between the Characteristics of Independent Directors and the Quality of Information Disclosure of Listed Companies--a Case Study of Shenzhen A-share Listed Companies. Shanghai Economic Research, 2010 (05): 54-63.
[35] Wei Gang, Xiao Zezhong, Nick Travlos, Zou Hong. Background of Independent Directors and Corporate Performance. Economic Research, 2007 (03): 92-105.
[36] Wooldridge J. Econometric Analysis of Cross Section and Panel Data[M]. MIT Press, 2002.
[37] Xiang Rui, Song Congmin. Scholar-type Independent Directors and Earnings Quality--Based on the Empirical Data of Chinese Listed Companies. Accounting

Research, 2019 (07): 27-34.
[38] Yan Haizhou and Chen Baizhu. Climate Change, Environmental Regulation and the Value of Corporate Carbon Disclosure [J]. Financial Research,2024 (06): 142-158.
[39] Yang Jing, Zhang Yan. An Empirical Study on the Influencing Factors of Environmental Information Disclosure of Listed Companies. Friends of Accounting, 2008 (32): 89-90.
[40] Yuan Zeming, Wang Jinyue. Carbon Emission System, Industry Difference and Carbon Information Disclosure--Empirical Data from Shanghai A-share Industrial Enterprises [J]. Finance and Trade Research, 2022,26 (04): 150-156.
[41] Zhang Zhengyong, Ji Li. Entrepreneur Demographic Background Characteristics and Social Responsibility Information Disclosure — — Empirical Evidence from Social Responsibility Reports of Listed Companies in China. China Population, Resources and Environment, 2020, 23 (04): 131-138.
[42] Zhao Changwen, Tang Yingkai, Zhou Jing, Zou Hui. Independent Directors and Firm Value in Family Business: a Test of the Rationality of Independent Director System in China's Listed Companies. Managing the World, 2008 (08): 119-126.
[43] Zhao Xuan, Zhang Lieke, Zheng Kaifang. An Empirical Study on the Performance of Corporate Environmental Responsibility Information Disclosure System and Its Influencing Factors. Journal of Southwest University (Social Science Edition), 2022,41 (03): 64-74.