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Impact of Big Four Audit Firms on Environmental Disclosure in China: Critical Role of Governance and Ownership Structure

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Abstract

As the corporate world has recently been increasingly held accountable for its non-green behaviour, corporate environmental disclosures (CED) are crucial in informing the relevant stakeholders. Among the factors influencing CED, firm auditors play a pivotal role. Our research investigates the impact of Big Four audit firms on corporate environmental disclosure in China. With unique institutional factors and the most significant carbon emissions globally, China provides an exciting and compelling ground for studying this relationship. For this purpose, we use annual firm-level data of A-listed shares on the Shenzhen and Shanghai stock exchanges and employ the Poisson and negative binomial regression models for empirical analyses. Contrary to the common belief that Big Four audit firms lead to improved disclosure quality, we find that they negatively affect environmental disclosure in China. We also investigate the moderating role of corporate governance and ownership structure in this relationship. A high ratio of state ownership, male directors

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on the board and institutional investor holding worsen the disclosure quality. However, a high ratio of independent directors mitigates this issue. These findings open new avenues for further research and can guide future policy decisions regarding environmental disclosure in Chinese firms. The Big Four audit firms should be more stringent in their operations and supervise public firms regarding environmental disclosures.

Keywords: Big Four audit firms, corporate environmental disclosure, China, corporate governance.

JEL Classification: M48, O16, G34, Q51, Q56

1. Introduction

The significance of corporate environmental disclosure (CED) is growing in tandem with the increasing global emphasis on sustainable development and environmental stewardship. Companies are under mounting pressure from stakeholders, including investors, regulators and the public to be transparent about their environmental practices and performance. In this context, the role of auditors, particularly the Big Four audit firms – Deloitte, PwC, EY and KPMG – has become crucial in ensuring the accuracy and reliability of environmental disclosures.

The Big Four audit firms, renowned for their extensive expertise and global reach, are pivotal in shaping the quality of corporate reporting. Their involvement is often perceived as a hallmark of credibility and rigour. This perception is particularly significant in emerging markets such as China, where the corporate governance landscape is evolving and the demand for high-quality environmental information is rising. The rapid increase in ESG reporting among Chinese firms can be attributed to market and regulatory demands. However, challenges still need to be overcome in acquiring reliable ESG data, as some companies may disclose information selectively, leading to potential misrepresentation. The presence of Big Four auditors can mitigate these challenges by ensuring more rigorous and reliable reporting practices (Cormier and Magnan, 2015). Chinese publicly listed firms, facing domestic and international scrutiny, are increasingly adopting environmental disclosure practices. Integrating environmental, social and governance (ESG) criteria into business strategies is becoming a vital pursuit. However, the extent to which Big Four auditors influence the disclosure of environmental liabilities remains a critical area of investigation in China.

The influence of Big Four audit firms on CED should be significant due to their reputation for high audit quality. Firms audited by the Big Four are often perceived as more credible and transparent, which can enhance the reliability of their environmental disclosures. Studies suggest that the presence of a Big Four auditor is associated with higher levels of environmental reporting due to the stringent audit standards and the emphasis on comprehensive disclosure

practices. The Big Four audit firms play a crucial role in ensuring the accuracy and completeness of environmental disclosures. This is because these firms possess greater resources and expertise in environmental and sustainability reporting compared with other audit firms. Consequently, firms audited by the Big Four are more likely to provide detailed and reliable environmental information, essential for stakeholders assessing the firm's environmental performance (Haniffa and Cooke, 2005). Their stringent audit standards and expertise in sustainability reporting lead to more accurate, comprehensive and extensive environmental reports. However, challenges such as selective disclosure practices still need to be addressed to ensure the reliability of CED. Overall, the involvement of Big Four auditors is crucial for improving the transparency and accountability of environmental disclosures in China.

Contrarily, the Big Four auditing may not always be good for CED. For instance, Simnett *et al*. (2009) stated that Big Four auditors often prioritize financial disclosures over non-financial ones. Since environmental disclosures may not be immediately financially material, they might be undervalued by these auditors. Big Four audit firms, known for their high reputation and stringent audit standards, may be more risk-averse. They may discourage extensive environmental disclosure due to the potential for litigation risk and reputational damage if the disclosures are later found to be inaccurate or misleading (DeFond and Zhang, 2014). Tang and Xu (2021) contended that Big Four audit firms, with their stringent standards, might enforce compliance with minimum regulatory requirements but not necessarily promote extensive voluntary disclosures due to the perceived risks and costs associated with over-disclosure.

Since the question about the definite impact of the Big Four on environmental disclosure is yet to be resolved, the Chinese perspective is interesting and valuable to explore due to its unique institutional, management and governance characteristics. Therefore, we explore the impact of Big Four audit firms on the environmental disclosure practices of Chinese publicly listed companies. By examining the association between the presence of Big Four auditors and environmental reporting, we seek to contribute to the broader understanding of how external audits can influence corporate transparency and accountability in the realm of environmental sustainability. Furthermore, corporate governance plays a crucial role in shaping the effectiveness of external audits. Thus, we also examine how various corporate governance factors moderate this relationship. Specifically, we check the moderating effects of independent directors, female directors, the presence of institutional investors and state ownership, broadly representing corporate governance and ownership structure.

The innovativeness of our study lies in two points. Firstly, there needs to be more consensus in the literature about the impact of Big Four audit firms on environmental disclosures. We can find both positive and negative associations in previous works. Hence, there is a gap in the liter-

ature concerning different scenarios and frameworks surrounding auditors' jobs, the role of governance and corporate features. Secondly, the Chinese context has not been studied in this regard. The country with the most significant emissions globally is highly worthy of investigation. Additionally, the institutional framework surrounding Chinese firms is unique, and Western findings cannot be generalized in the case of China. Thus, our study unearths the relationship between employing internationally established corporate auditors and corporate environmental disclosures within the Chinese governance framework. The findings will help all stakeholders understand the factors surrounding corporate environmental disclosures in China.

We use annual data from 2012 to 2022 for A-listed shares in China and employ panel count models, such as Poisson and negative binomial regression, for our analyses. By investigating the impact of Big Four and the moderating factors, we attempt to provide a comprehensive understanding of the dynamics between audit quality, corporate governance and environmental disclosure. We offer insights into how different governance and ownership structures can enhance or impede the influence of Big Four auditors on CED in the realm of environmental sustainability.

2. Literature Review

2.1 Big Four and CED

The presence of a Big Four auditor is associated with higher levels of environmental reporting due to the stringent audit standards and the emphasis on comprehensive disclosure practices (Haniffa and Cooke, 2005). The high-quality audits performed by these firms ensure that all relevant environmental aspects are disclosed, providing a more balanced and transparent view of the company's environmental performance (Cormier and Magnan, 2015).

The Chinese firms audited by Big Four exhibit higher environmental disclosure levels than those audited by other audit firms. According to Zahid *et al*. (2023), firms audited by Big Four are more likely to provide detailed and reliable environmental information due to their extensive resources and expertise in environmental reporting. Firms audited by Big Four are more likely to engage in extensive environmental reporting. This is partly due to the pressure from Big Four auditors for comprehensive disclosure practices that cover all material environmental aspects (Ho and Wong, 2001). The extensive reporting requirements made by Big Four firms encourage companies to disclose more environmental information, thus increasing the overall quantity of CED (Sun *et al*., 2010). Additionally, Zahid *et al*. (2023) highlighted that the growing emphasis on ESG (environmental, social and governance) reporting in China has been significantly influenced by the involvement of Big Four audit firms. The increased focus on ESG reporting is partly driven by the need to attract global investment and comply with international standards, where Big Four auditors play a crucial role in ensuring adherence to these standards.

Despite the positive influence of Big Four audit firms, challenges still need to be addressed to ensure reliable and consistent environmental disclosure. Companies may still use selective disclosure practices, providing only favourable information while omitting negative aspects. This can lead to misleading and unreliable environmental reports, even when audited by Big Four firms. Big Four audit firms, known for their high reputation and stringent audit standards, may be more risk-averse. They may discourage extensive environmental disclosure due to the potential for litigation risk and reputational damage if the disclosures are later found to be inaccurate or misleading (DeFond and Zhang, 2014). Big Four firms traditionally emphasize financial materiality over non-financial disclosures. Since environmental disclosures may not always have immediate financial implications, Big Four auditors might prioritize financial disclosures over environmental ones (Simnett *et al*., 2009). In the Chinese context, where regulatory environments and market mechanisms are unique, firms may face exceptional institutional pressures that affect their disclosure practices. Big Four audit firms, with their stringent standards, might enforce compliance with minimum regulatory requirements but not necessarily promote extensive voluntary disclosures due to the perceived risks and costs associated with over-disclosure (Tang and Xu, 2021).

According to the agency theory, managers may use environmental disclosure strategically to manage earnings and create a favourable corporate image. When audited by Big Four firms, firms may be constrained in engaging in extensive environmental disclosure that could be perceived as manipulative or opportunistic. Research indicates that Big Four auditors help restrain earnings management through environmental disclosures, leading to more conservative and less voluminous reporting (Shang and Chi, 2023). Given the potential legal liabilities and reputational risks associated with environmental misreporting, Big Four firms might advise their clients to adopt a cautious approach in their disclosures. This conservative stance can result in firms providing only the necessary information to comply with regulations while avoiding the risks associated with extensive voluntary disclosures (Shang and Chi, 2023).

2.2 Corporate governance, Big Four and CED

Corporate governance mechanisms can significantly influence the relationship between Big Four and CED. Zahid *et al*. (2023) indicated that governance factors such as board independence and the presence of institutional investors play a crucial role in enhancing the quality of environmental disclosures. A high ratio of independent directors and the presence of female directors on the board are particularly relevant governance factors in this regard.

According to the stakeholder theory (Freeman, 1984), independent directors may be more attuned to the interests of various stakeholders, including environmental groups and the public. They can advocate for broader disclosures that address stakeholder concerns about the firm's environ-

mental impact. Prado-Lorenzo and Garcia-Sanchez (2010) highlighted the influence of board composition on environmental disclosures, particularly the positive impact of independent directors. Michelon and Parbonetti (2012) examined the impact of corporate governance on sustainability disclosures, providing evidence that independent directors play a significant role. Independent directors can mitigate managerial opportunism and ensure that the firm's environmental disclosures are accurate and comprehensive (Ho and Wong, 2001; Sun *et al*., 2010). Independent directors often prioritize their reputation and the firm's legitimacy, leading to greater transparency and comprehensive environmental reporting (Srinidhi *et al*., 2011). This increased focus on reputation can counteract the tendency of Big Four firms to limit disclosure due to their conservative nature.

According to the resource dependence theory (RDT), independent directors bring valuable resources and networks that can improve environmental disclosure practices. Their connections and expertise can provide the necessary support and guidance for implementing effective environmental policies and reporting mechanisms (Cucari *et al*., 2018; García-Sánchez and Martínez-Ferrero, 2017). According to the agency theory, independent directors help align the interests of shareholders and management by reducing agency costs associated with poor disclosure practices. They ensure that management is accountable for their environmental impact, thus improving the quantity and quality of environmental disclosures. This alignment of interests can positively influence corporate transparency (Chintrakarn *et al*., 2020; Ben-Amar and McIlkenny, 2015).

Due to their oversight capabilities and commitment to social responsibilities, independent directors are crucial in promoting environmentally friendly practices in China. Additionally, firms with more independent directors are more likely to disclose comprehensive environmental information (García-Sánchez and Martínez-Ferrero, 2017). Based on the above insights, independent directors on the board can positively influence CED by enhancing oversight, leveraging their reputational concerns and bringing valuable resources and networks to the firm.

Gender diversity on boards, particularly the presence of female directors, has been linked to more comprehensive and transparent environmental disclosures. Female directors often bring different perspectives and are more likely to advocate for corporate social responsibility, including environmental issues (Harrison *et al*., 2015). Female directors are often associated with higher ethical standards and greater sensitivity to stakeholder concerns, which can translate into more assertive advocacy for environmental transparency (Adams and Ferreira, 2009).

According to the RDT, female directors bring unique perspectives and resources to the board, which can enhance the board's overall effectiveness in overseeing environmental disclosure. The diversity helps address stakeholder concerns more effectively and ensures that environmental disclosures are more transparent and thorough (Khidmat *et al*., 2022). The stakeholder theory suggests that female directors are often more attuned to stakeholder concerns related to corporate

social responsibility (CSR) and environmental sustainability. This aligns with the idea that boards with gender diversity are more likely to engage in activities that benefit a more comprehensive range of stakeholders (Galbreath, 2011; Du, 2016). Female directors may be more stakeholder-oriented, understanding the importance of addressing environmental issues to meet the expectations of various stakeholders, including customers, investors and the community (Bear *et al*., 2010).

Gender-diverse boards in China are positively associated with improved CSR practices, and female directors play a crucial role in promoting transparency and accountability in environmental reporting (Cumming *et al*., 2015; Ge and Zhao, 2017). Increasing presence of female directors can challenge traditional norms and lead to more progressive practices in corporate governance. This cultural shift can further enhance the commitment to environmental sustainability and transparency, thus positively influencing CED (Du, 2016; Gosselt *et al*., 2019). Female directors often bring a different approach to governance and oversight, which can enhance monitoring quality and reduce information asymmetry. This improved governance can mitigate the potential adverse effects of Big Four audit firms on environmental disclosure by ensuring that the disclosures are more accurate and comprehensive (Gul *et al*., 2011; Harjoto and Jo, 2011).

2.3 Ownership structure, Big Four and CED

Institutional investors and state ownership are the two critical factors affecting CED. Their presence can moderate the relationship between Big Four and environmental reporting (Kieschnick and Moussawi, 2018). Institutional investors' short-termism can lead to less emphasis on comprehensive environmental disclosures, as such disclosures often require substantial investment and long-term commitment, which may not immediately enhance financial performance. Li *et al*. (2023) noted that institutional investors might prioritize immediate financial gains over long-term sustainability investments. Institutional investors can pressure management to meet short-term performance targets, potentially at the expense of long-term environmental initiatives. Studies have shown that institutional investors might discourage firms from engaging in extensive environmental disclosures due to the associated costs and resource allocation that do not provide immediate financial benefits (Wang *et al*., 2023).

When institutional investors hold significant ownership, they may push for policies that enhance short-term profitability, thus potentially reducing the focus on environmental disclosure, which is seen as a long-term commitment. The presence of institutional investors might also influence the firm's strategic decisions, including the extent of environmental disclosures. Firms with substantial institutional ownership may have reduced incentives to disclose environmental information extensively, particularly if such disclosures are perceived as not directly contributing to the financial performance metrics that institutional investors closely monitor.

State ownership can have a dual effect on corporate governance and environmental disclosure. On the one hand, state-owned enterprises (SOEs) may face political pressure to demonstrate their commitment to environmental responsibility. On the other hand, the bureaucratic nature of SOEs might impede transparency. However, when Big Four firms audit SOEs, the quality of environmental disclosure tends to improve due to the rigorous audit processes (Jiraporn and Gleason, 2007).

The institutional theory suggests that SOEs face different pressures than private firms. The regulatory environment in China may require SOEs to comply with minimum disclosure standards but not necessarily to engage in extensive voluntary disclosures, thus weakening the impact of the Big Four. As a result, Big Four audit firms, which typically promote transparency, may have a diminished effect on CED in these firms (Zeng *et al*., 2012; Marquis and Qian, 2014). SOEs often have strong political connections that can reduce the pressure to engage in extensive environmental reporting (Li and Zhang, 2010).

State ownership often leads to bureaucratic inefficiencies and slower decision-making processes. This can hinder the implementation of comprehensive environmental disclosure practices. SOEs prioritize compliance with state directives and policies over voluntary practices such as environmental disclosures (Marquis and Qian, 2014). SOEs are typically driven by economic and political goals set by the government, which may not align with the transparency objectives promoted by Big Four audit firms. This misalignment can result in SOEs focusing on meeting regulatory requirements rather than adopting more extensive voluntary disclosure practices.

Based on the studies mentioned earlier that provide conflicting evidence, we formulate the following hypotheses:

- H_1: *The presence of Big Four audit firms in Chinese public firms significantly affects CED positively/negatively.*
- H_2: *A high ratio of independent directors on the board can positively moderate the association between Big Four and CED in China.*
- H_3: *A higher ratio of male directors on the board can negatively moderate the association between Big Four and CED in China.*
- H_4: *Institutional holdings negatively moderate the association between Big Four and CED in China.*
- H_5: *A high ratio of state ownership negatively moderates the association between Big Four and CED in China.*

3. Data and Methodology

3.1 Data sources and variables

Total environmental liabilities are calculated by summing up the firm-level scores on CO_2 emission, SO_2 emission, soot dust emission, wastewater emission, CO emission and industrial solid waste emission. The data on the individual scores on the six dimensions of environmental liabilities are collected from the China Securities Market Accounting Research (CSMAR) database and then the scores are added by the authors to form the primary dependent variable, "Corporate Environmental Disclosure" (CED). "Big Four" is our primary independent variable. It is a binary variable, taking the value of 2 if any of the Big Four audit firms audit the given firm; otherwise, it is 1.

Moderating variables include the ownership proportion of institutional investors, the ratio of state ownership, the ratio of independent directors to the total number of directors on the board and the ratio of male directors to the total number of directors on the board (inverse of the ratio of female directors on the board). All the data on moderating variables are collected from the CSMAR database.

We control for the firms disclosing environmental liabilities in separate reports (other than annual reports) through a binary variable *Source_n*, taking the value of 1 if the firm discloses its environmental liabilities separately, and 0 otherwise. The other control variables are return on assets, the ratio of market value to book value, the proportion of shares held by the state, the rate of growth in operating income, the ratio of intangible to total assets, the ratio of profit earned from financial activities (degree of financialization), the financial leverage (Iqbal *et al*., 2022) and the natural logarithm of total assets (firm size). All the control variables are collected from firm-level data series from the CSMAR database. The frequency of variables is annual and gathered from 31 Dec 2012 to 31 Dec 2022. Only A-listed shares are considered and financial and special treatment (ST) stocks are excluded due to their unique features following the literature. We exclude all those observations for which the total score on environmental disclosure cannot be calculated due to missing values on the six individual dimensions of environmental liabilities.

Table 1 shows the summary statistics of all the variables included in the study. As the standard deviation of the dependent variable (2.38) is slightly higher than the mean (1.55), we also estimate the negative binomial regressions for robustness. The number of observations column shows that we have an unbalanced panel. The CED value ranges between 0 and 12, with a mean of 1.55, which shows that many firms do not provide proper environmental disclosures regarding their environmental liabilities.

Table 1: Summary statistics

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Envlibtotal (CED)	36,281	1.555	2.385	0	12
Big4_n	36,238	1.941	0.235	1	2
Source_n	36,238	0.272	0.445	0	1
ROAB	36,279	0.040	0.169	–14.586	12.211
ValueBookRatioA	35,084	0.621	0.253	0.001	1.601
Proportionofshares	36,281	0.033	0.117	0	0.922
Growthrateofopprofit	29,249	–1.255	120.040	–11,745.835	8,072.186
Ratioofintangibles	35,352	0.047	0.063	0	0.938
Ratioofprofitfromf	35,352	0.104	12.309	-1,742.634	152.122
Finleverage	31,177	1.512	13.911	-81.344	2,402.774
Lntotalassets	35,341	22.157	1.354	14.942	28.636
InsInvestorProp	35,585	43.236	25.043	0	101.140
IndDirectorRatio	35,658	37.693	5.589	14.290	80
MaleRatio	35,662	80.091	11.576	20	100

Notes: *Envlibtotal* is total environmental liabilities (corporate environmental disclosure) and is calculated by summing up the firm-level scores on CO_2 emission, SO_2 emission, soot dust emission, wastewater emission, CO emission and industrial solid waste emission. *Big4_n* is a binary variable taking the value of 2 if the firm is audited by any of the Big Four audit firms; otherwise, it is 1. *Source_n* is a binary variable taking the value of 1 if the firm discloses its environmental liabilities separately from the regular annual reports; otherwise, it is 0. *ROAB* denotes return on assets, *ValueBookRatioA* is the ratio of market value to book value, *Proportionofshares* shows the proportion of shares held by the state, *Growthrateofopprofit* shows the rate of growth in operating income, *Ratioofintangibles* is the ratio of intangible to total assets, *Ratioofprofitfromf* is the ratio of profit earned from financial activities (degree of financialization), *Finleverage* is the financial leverage, *Lntotalassets* is the natural logarithm of total assets (firm size), *InsInvestorProp* represents the ownership proportion of institutional investors, *IndDirectorRatio* shows the ratio of independent directors to the total number of directors on board, *MaleRatio* shows the ratio male directors to the total number of directors on board (inverse of the ratio of female directors on board).

Source: Authors' own calculations

3.2 Methodology

Our study employs Poisson and negative binomial regression models to analyse count data. These models are particularly suitable for count data, which often exhibit unique characteristics that traditional linear regression models cannot adequately address.

The Poisson regression model is a generalized linear model (GLM) used for modelling count data. The primary assumption of the Poisson model is that the mean of the distribution is equal to the variance. This model is specified as follows:

$$\log(\lambda_i) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} \tag{1}$$

where λ_i is the expected count for the i-th observation and X_{ij} is the predictor variable. In our case, CED is the primary dependent variable.

The Poisson regression model is a good choice for count data due to its simplicity and interpretability. However, real-world data often exhibit overdispersion, where the variance exceeds the mean. In such cases, the Poisson model may not provide an adequate fit, leading to underestimated standard errors and overstated significance levels. The mean is lower than the standard deviation in our case, but the difference is not huge. Thus, we estimate both kinds of models for the whole analysis.

We also employ the negative binomial regression model to address the issue of overdispersion. This model extends the Poisson regression by introducing an additional parameter to model the overdispersion. The negative binomial model can be seen as a Poisson-gamma mixture, allowing the variance to exceed the mean:

$$Y_i \sim NB(\lambda_i, \theta) \tag{2}$$

where λ_i is the mean of the distribution and θ is the dispersion parameter.

The negative binomial model is particularly useful when the data show evidence of overdispersion. By fitting this model, we can obtain more reliable estimates and inferences than from the Poisson model under over-dispersed conditions. Studies have demonstrated the efficacy of negative binomial regression in various fields, including ecology and biodiversity research, where overdispersion is expected due to biological aggregation processes (Fiona, 2007; Stoklosa *et al*., 2022). It has recently been used extensively in finance and economics research, especially for modelling corporate innovation output.

Table 2 shows the pairwise correlations for all the variables included in our study. *Big4* is negatively correlated with CED. Most values show low correlations, with few representing moderate associations. Thus, there is no threat of multicollinearity in our sample. The highest correlations are observed between total assets, value-to-book ratio and total assets and source, showing that bigger firms are more likely to disclose their environmental liabilities separately.

Table 2: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) *envlibtotal*	1.000	–	–	–	–	–	–	–	–	–	–	–	–	–
(2) *Big4_n*	−0.160	1.000	–	–	–	–	–	–	–	–	–	–	–	–
(3) *Source_n*	0.354	−0.219	1.000	–	–	–	–	–	–	–	–	–	–	–
(4) *ROAB*	0.029	−0.011	0.018	1.000	–	–	–	–	–	–	–	–	–	–
(5) *ValueBookRatioA*	0.153	−0.134	0.175	−0.056	1.000	–	–	–	–	–	–	–	–	–
(6) *Proportionofshares*	0.020	−0.034	0.054	0.005	0.162	1.000	–	–	–	–	–	–	–	–
(7) *Growthrateofopprofit*	−0.003	−0.004	−0.010	0.044	0.006	0.004	1.000	–	–	–	–	–	–	–
(8) *Ratioofintangibles*	0.051	−0.047	0.035	−0.046	0.049	0.037	0.003	1.000	–	–	–	–	–	–
(9) *Ratioofprofitfromf*	0.001	−0.003	0.008	0.002	−0.007	0.001	−0.001	0.000	1.000	–	–	–	–	–
(10) *Finleverage*	0.003	0.002	0.010	−0.016	0.020	0.009	−0.019	0.002	−0.296	1.000	–	–	–	–
(11) *Lntotalassets*	0.318	−0.335	0.481	0.006	0.538	0.144	0.003	0.050	0.000	0.016	1.000	–	–	–
(12) InsInvestorProp	0.178	−0.247	0.262	0.043	0.150	0.289	0.005	0.066	0.001	−0.003	0.426	1.000	–	–
(13) IndDirectorRatio	−0.015	−0.031	0.009	−0.013	−0.031	−0.057	−0.001	−0.017	0.001	0.002	0.008	−0.059	1.000	–
(14) MaleRatio	0.094	−0.054	0.112	−0.010	0.122	0.106	0.007	0.045	0.004	0.010	0.198	0.149	−0.058	1.000

Note: Please refer to Table 1 for abbreviations.
Source: Authors' own calculations

4. Empirical Results

4.1 Big Four and corporate environmental disclosure

Table 3 shows the primary results from the Poisson fixed-effects regression on how the presence of Big Four auditors affects CED in China. The coefficient of Big Four is negative (−0.20) and significant at the 1% level. Therefore, the Big Four are negatively influencing the CED in China. Keeping other variables constant, the presence of Big Four auditors in a Chinese firm is likely to reduce their CED by up to 20%. The interaction term between *Source_n* and *Big4_n* is significantly positive, stating that if the firms audited by Big Four choose to disclose environmental liabilities separately from the regular annual reports, the combined effect becomes positive. Thus, the Big Four auditors must encourage public firms to disclose environmental liabilities distinctively under a unique framework. Further, the other significantly negative coefficients show that firms with a high ratio of state shares and a high return on assets ratio are also less likely

to disclose more under CED. On the other hand, firms with a high market-to-book value and a higher degree of profit from financial activities are more likely to disclose CED. The probability of chi-square is zero and the value of AIC is high, indicating a good model fit.

Table 3: Baseline model: Conditional FE Poisson

***Envlibtotal* (CED)**	**Coef.**	**St. err.**	***t*-value**	***p*-value**	**[95% conf.**	**interval]**	**Sig.**
Big4_n	−0.201	0.074	−2.72	0.007	−0.346	−0.056	***
Source_n	0.588	0.074	7.96	0	0.443	0.733	***
Big4_n#Source_n	0.205	0.075	2.73	0.006	0.058	0.352	***
ROAB	−0.544	0.137	−3.96	0	−0.812	−0.275	***
ValueBookRatioA	0.214	0.039	5.52	0	0.138	0.29	***
Proportionofshare	−0.497	0.064	−7.76	0	−0.623	−0.372	***
Growthrateofoppr	0	0	0.91	0.361	0	0	
Ratioofintangibles	−0.165	0.209	−0.79	0.43	−0.576	0.245	
Ratioofprofitfrom	0.01	0.005	2.13	0.033	0.001	0.019	**
Finleverage	−0.005	0.003	−1.50	0.133	−0.012	0.002	
Lntotalassets	0.705	0.014	52.09	0	0.678	0.731	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi-square**	5,712.941
Prob > chi²	0	**Akaike crit. (AIC)**	49,491.548

Notes: *** and ** indicate statistical significance at 1% and 5%, respectively. For abbreviations, please refer to Table 1.

Source: Authors' own calculations

As the standard deviation of our dependent variable (CED) is a little larger than the mean, we also compute negative binomial models in each case. Table 4 shows the estimations from the negative binomial approach. We can see that the coefficient (−0.17) of Big Four is still significantly negative, although the value is slightly lower than the Poisson estimate. Moreover, the coefficient is now significant at the 5% level instead of 1%, as in the Poisson approach. Nonetheless,

the main sign and strength of the coefficient remain similar, corroborating the robustness of our primary results. The signs for all other coefficients also remain identical, with slight variations in the absolute values. The only difference is observed in the case of profit from financial activities, which becomes insignificant in this model. However, that is unimportant as it is just a control variable. The high value of the AIC and chi-square test (4,811) shows that the model is a good fit for the data.

Table 4: Baseline model: Conditional FE negative binomial

Envlibtotal	**Coef.**	**St. err.**	***t*-value**	***p*-value**	**[95% conf.**	**interval]**	**Sig.**
Big4_n	−0.171	0.084	−2.03	0.042	−0.336	−0.006	**
Source_n	0.690	0.083	8.320	0	0.528	0.853	***
Big4_n#Source_n	0.193	0.084	2.300	0.021	0.029	0.358	**
ROAB	−0.405	0.158	−2.570	0.010	−0.714	−0.096	**
ValueBookRatioA	0.218	0.044	4.980	0	0.132	0.304	***
Proportionofshare	−0.478	0.070	−6.840	0	−0.615	−0.341	***
Growthrateofoppr	0	0	0.860	0.388	0	0	
Ratioofintangibles	−0.349	0.230	−1.520	0.129	−0.800	0.102	
Ratioofprofitfrom	0.008	0.005	1.560	0.119	−0.002	0.018	
Finleverage	−0.004	0.004	−1.200	0.229	−0.012	0.003	
Lntotalassets	0.648	0.015	42.450	0	0.618	0.678	***
Constant	−12.444	0.365	−34.070	0	−13.160	−11.728	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi-square**	4,811.400
Prob > chi²	0	**Akaike crit. (AIC)**	48,948.678

Notes: *** and ** indicate statistical significance at 1% and 5%, respectively. For abbreviations, please refer to Table 1.

Source: Authors' own calculations

4.2 Moderating role of corporate governance

Table 5 presents the moderating role of a high ratio of independent directors on the relationship between Big Four and CED using the Poisson conditional fixed-effects model. The coefficient of the interaction term is positive (0.005) and significant at the 1% level. Therefore, the presence of a higher number of independent directors can cause the Big Four to have a positive impact on the CED in China. Independent directors prioritize their reputation and the firm's legitimacy, leading to better transparency and comprehensive environmental reporting (Srinidhi *et al*., 2011). They bridge the company and its external environment, promoting activities that enhance the firm's image and legitimacy (Harjoto and Jo, 2011; Al-Shaer and Zaman, 2016). This increased focus on reputation can counteract the tendency of Big Four firms to limit disclosure due to their conservative nature.

Table 5: Independent directors: Conditional FE Poisson

Envlibtotal	**Coef.**	**St. err.**	***t*-value**	***p*-value**	**[95% conf.**	**interval]**	**Sig.**
Big4_n	−0.167	0.143	−1.16	0.244	−0.447	0.114	
Source_n	0.778	0.023	33.32	0	0.733	0.824	***
Big4_n#c.inddir	0.005	0.002	2.61	0.009	0.001	0.008	***
ROAB	−0.538	0.137	−3.92	0	−0.807	−0.269	***
ValueBookRatioA	0.217	0.039	5.60	0	0.141	0.293	***
Proportionofshare	−0.489	0.064	−7.63	0	−0.614	−0.363	***
Growthrateofoppr	0	0	0.89	0.374	0	0	
Ratioofintangibles	−0.17	0.209	−0.81	0.418	−0.58	0.241	
Ratioofprofitfromf	0.01	0.005	2.19	0.029	0.001	0.02	**
Finleverage	−0.005	0.003	−1.47	0.143	−0.011	0.002	
Lntotalassets	0.704	0.014	52.01	0	0.677	0.731	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi-square**	5,710.757
Prob > chi²	0	**Akaike crit. (AIC)**	49,493.961

Notes: *** and ** indicate statistical significance at 1% and 5%, respectively. For abbreviations, please refer to Table 1.

Source: Authors' own calculations

Table 6 shows, using a Poisson specification, how the presence of a high ratio of male directors influences CED in China. The coefficient for the interaction term is negative (−0.006) and significant at the 1% level. Therefore, the higher the ratio of male directors, the more negative the impact of the Big Four on CED. The presence of female directors on the board brings diverse opinions and experiences to the table, which can enhance green practices, transparency and disclosure. Female directors' diverse experiences and viewpoints can lead to more comprehensive discussions and decisions regarding environmental issues. This diversity helps address stakeholder concerns more effectively and ensures that environmental disclosures are more transparent and thorough (Khidmat *et al*., 2022). Studies have shown that gender-diverse boards in China are positively associated with improved CSR practices. For instance, firms with female directors are more likely to engage in socially responsible activities, including environmental disclosures. This suggests that female directors play a crucial role in promoting transparency and accountability in environmental reporting (Cumming *et al*., 2015; Ge and Zhao, 2017). Our results also align with those of Fernandez-Feijoo *et al*. (2014) and Rao and Tilt (2016), who have reported that board diversity, including female directors, positively influences CSR practices and reporting.

Table 6: Male director ratio: Conditional FE Poisson

Envlibtotal	**Coef.**	**St. err.**	***t*-value**	***p*-value**	**[95% conf.**	**interval]**	**Sig.**
Big4_n	−0.131	0.244	−0.540	0.589	−0.609	0.346	
Source_n	0.777	0.023	33.24	0	0.731	0.822	***
Big4_n#c.malerati	−0.006	0.001	−5.750	0	−0.008	−0.004	***
ROAB	−0.556	0.137	−4.06	0	−0.825	−0.287	***
ValueBookRatioA	0.214	0.039	5.540	0	0.138	0.290	***
Proportionofshare	−0.477	0.064	−7.440	0	−0.602	−0.351	***
Growthrateofoppr	0	0	0.800	0.425	0	0	
Ratioofintangibles	−0.147	0.209	−0.700	0.483	−0.557	0.263	
Ratioofprofitfromf	0.010	0.005	2.150	0.032	0.001	0.019	**
Finleverage	−0.005	0.003	−1.360	0.172	−0.011	0.002	
Lntotalassets	0.690	0.014	50.260	0	0.663	0.717	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi-square**	5,753.734
Prob > chi²	0	**Akaike crit. (AIC)**	49,464.312

Notes: *** and ** indicate statistical significance at 1% and 5%, respectively. For abbreviations, please refer to Table 1.

Source: Authors' own calculations

4.3 Moderating role of ownership structure

Table 7 shows how a high proportion of institutional shares holding affects the relationship between Big Four and CED in China. The coefficient of the interaction term is negative (−0.008) and significant at the 1% level, suggesting that institutional investor holding may exacerbate the issue of lower CED in Chinese firms audited by the Big Four. Institutional investors may prefer short-term returns over long-term sustainability goals. This approach leads to less emphasis on CED, as such disclosures often require substantial investment and long-term commitment, which may take time to enhance financial performance. Our findings are consistent with the reporting of Li *et al*. (2021), who said that institutional investors prioritize immediate financial gains over long-term sustainability (Li *et al*., 2023).

Table 7: Institutional investors: Conditional FE Poisson

Envlibtotal	**Coef.**	**St. err.**	***t*-value**	***p*-value**	**[95% conf.**	**interval]**	**Sig.**
Big4_n	0.245	0.138	1.770	0.076	−0.026	0.515	*
Source_n	0.783	0.023	33.450	0	0.738	0.829	***
Big4_n#c.insinv	−0.008	0.001	−10.640	0	−0.010	−0.007	***
ROAB	−0.465	0.137	−3.400	0.001	−0.733	−0.197	***
ValueBookRatioA	0.153	0.039	3.900	0	0.076	0.230	***
Proportionofshare	−0.364	0.065	−5.590	0	−0.491	−0.236	***
Growthrateofoppr	0	0	0.820	0.410	0	0	
Ratioofintangibles	−0.122	0.210	−0.580	0.560	−0.533	0.289	
Ratioofprofitfromf	0.011	0.005	2.350	0.019	0.002	0.021	**
Finleverage	−0.005	0.003	−1.350	0.178	−0.011	0.002	
Lntotalassets	0.720	0.014	52.950	0	0.694	0.747	***

Mean dependent var.	2.089	**SD dependent var.**	2.596	
Number of obs.	21,358	**Chi-square**	5,822.184	
Prob > chi²	0	**Akaike crit. (AIC)**	49,315.514	

Notes: ***, ** and * indicate statistical significance at 1% and 5% and 10%, respectively. For abbreviations, please refer to Table 1.

Source: Authors' own calculations

Table 8 shows how a high ratio of state ownership moderates the negative association between Big Four and CED in China. The coefficient of the interaction term is negative (−0.693) and significant at the 1% level. The high value suggests that while keeping other things constant, a firm audited by the Big Four is more likely to provide less environmental disclosure if it is a state-owned firm. SOEs are often under government influence, which shapes their priorities. The Chinese government may prioritize economic stability and growth over environmental transparency, resulting in less emphasis on voluntary CED. Thus, the presence of Big Four, which typically promotes transparency, may have a diminished effect on CED in these firms (Zeng *et al*., 2012; Marquis and Qian, 2014). These firms prioritize compliance with state directives and policies over voluntary practices, which reduces the quantity and quality of disclosures despite the presence of Big Four (Marquis and Qian, 2014).

Table 8: State shares: Conditional FE Poisson

Envlibtotal	**Coef.**	**St. err.**	***t*-value**	***p*-value**	**[95% conf.**	**interval]**	**Sig.**
Big4_n	−0.019	0.052	−0.360	0.722	−0.121	0.084	
Source_n	0.780	0.023	33.370	0	0.734	0.825	***
Big4_n#proportio	−0.693	0.166	−4.160	0	−1.019	−0.367	***
ROAB	−0.539	0.137	−3.930	0	−0.808	−0.270	***
ValueBookRatioA	0.220	0.039	5.680	0	0.144	0.296	***
Proportionofshare	0.089	0.153	0.580	0.559	−0.211	0.389	
Growthrateofoppr	0	0	0.890	0.374	0	0	
Ratioofintangibles	−0.152	0.209	−0.730	0.466	−0.563	0.258	
Ratioofprofitfromf	0.010	0.005	2.160	0.031	0.001	0.020	**
Finleverage	−0.005	0.003	−1.500	0.135	−0.012	0.002	
Lntotalassets	0.707	0.014	52.200	0	0.680	0.733	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi-square**	5,717.668
Prob > chi²	0	**Akaike crit. (AIC)**	49,481.958

Notes: *** and ** indicate statistical significance at 1% and 5%, respectively. For abbreviations, please refer to Table 1.

Source: Authors' own calculations

4.4 Robustness tests with negative binomial specification

Tables A2, A3, A4 and A5 (in Appendix A) estimate the moderating models with negative binomial fixed-effects specifications. The principal coefficients of the interaction term produce the same signs as in the Poisson specifications, although they have slightly different magnitudes. All the models display high chi-square and AIC values, showing that they fit with the data well. Therefore, our primary estimates from the Poisson specifications are robust.

5. Discussion

The presence of Big Four audit firms has a significant negative impact on CED in Chinese publicly listed firms. One possible explanation for the negative relationship in China is rooted in institutional theory. In the context of China, where regulatory environments and market mechanisms differ markedly from Western contexts, firms may face unique institutional pressures that affect their disclosure practices. Big Four audit firms, with their stringent standards, might enforce compliance with minimum regulatory requirements but not necessarily promote extensive voluntary disclosures due to the perceived risks and costs associated with over-disclosure (Tang and Xu, 2021). State-owned firms should be encouraged to disclose more about their environmental footprints to set examples for the entire corporate sector. From a cost-benefit perspective, the high costs associated with comprehensive environmental reporting might deter firms audited by Big Four from extensive disclosure. Big Four auditors often require robust verification processes for the information disclosed, increasing the reporting costs. Firms may limit the quantity of their disclosures to balance these costs against the perceived benefits. This conservative approach ensures compliance with mandatory requirements without incurring unnecessary expenses. Lastly, the focus on aligning with international standards and attracting foreign investment can also affect the quantity of environmental disclosure. While Big Four firms help enhance the credibility and quality of disclosures, their emphasis on meeting international standards might lead firms to prioritize quality over quantity. Consequently, firms may limit the scope of their environmental disclosures to essential information that meets international benchmarks, thereby reducing the overall quantity (Zahid *et al*., 2023).

Our findings align with the agency theory (Fama and Jensen, 1983), stating that independent directors acting as shareholders' agents are expected to mitigate agency problems by overseeing management actions and ensuring that disclosures are comprehensive and transparent. Their independence allows them to advocate for more extensive environmental disclosures, countering the conservative stance of Big Four auditors. The empirical results also support the resource dependence theory (Hillman and Dalziel, 2003), advocating that independent directors bring valuable resources, such as expertise, legitimacy and networks, which can enhance a firm's environmental disclosure practices (Zhang and Qu, 2021). Their presence can lead to greater accountability and pressure on the firm to disclose more environmental information.

The positive moderating effect of female directors on the relationship between Big Four and CED in China can be explained by their unique contributions to board diversity, stakeholder engagement, improved governance and cultural shifts towards more inclusive and transparent practices. On the other hand, the negative moderation effect of institutional ownership on the relationship between Big Four and CED in China can be attributed to institutional investors' short-term focus, pressure on management for immediate financial returns and misalignment of environmental disclosure incentives with institutional investors' interests. These dynamics highlight the complex interplay between ownership structure and corporate transparency in environmental matters.

6. Conclusion

Corporate environmental disclosure (CED) is critical for stakeholders, including investors, regulators and the public, to assess a company's environmental performance and sustainability efforts. The interplay between Big Four audit firms, ownership structure and corporate governance mechanisms is crucial in understanding the quality of CED in Chinese publicly listed firms. Contrary to the expectation that Big Four auditors enhance the credibility and comprehensiveness of environmental reporting, we found that their presence can lead to limited environmental disclosure in Chinese public firms. Governance factors such as independent and female directors can mitigate the limited disclosure issue. However, ownership structures, such as institutional investors and state ownership, further exacerbate the problem by negatively moderating the relationship between Big Four and CED. Based on the findings, we provide the following policy implications:

Firstly, the government should create an independent environmental auditing body to oversee and audit environmental disclosures, particularly those audited by Big Four firms and state-owned enterprises (SOEs). This body should not be affiliated with existing audit firms to avoid conflicts of interest. A tiered reporting requirement system should be developed based on the company's size, industry and environmental impact.

Secondly, it is essential to consider the composition of corporate boards to enhance CED in China. For example, increasing female and independent directors' presence can play a significant role in achieving this goal. Mandatory gender quotas should be introduced for public firm boards. Incentives, such as tax breaks or preferential treatment in government contracts, should be given to firms that comply with or exceed gender quotas. Training and leadership programmes designed specifically for women to prepare them for board positions should be developed and promoted. Such programmes can be designed in partnership with universities, business schools and professional organizations.

Thirdly, key board committees, such as audit and risk committees, must be composed entirely or predominantly of independent directors. Independent directors should be empowered with greater authority to influence board decisions, particularly in areas related to environmental, social and governance (ESG) issues.

We did not account for the firms' carbon footprints, and different levels of carbon emissions may lead firms to behave differently with respect to CED. We also excluded industry-level dummies, and CED may vary depending on sectors. Therefore, future research may be conducted to analyse the industry and regional heterogeneity and spatial characteristics of CED in China. Further, text mining and machine learning approaches can process online content regarding environmental disclosures and public sentiment analysis in China.

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Appendixes

Appendix A

Table A1: Variable details

Number	Variable name	Variable description and formation
1	*Envlibtotal* – total environmental liabilities – corporate environmental disclosure (CED)	Summation of the scores on six dimensions of corporate environmental liabilities as described below: 1. WasteWaterEmission [waste water discharge] – 0 = no description; 1 = qualitative description; 2 = quantitative description (currency/numerical description) 2. CODEmission [COD emission] – 0 = no description; 1 = qualitative description; 2 = quantitative description (currency/numerical description) (COD) 3. SO2Emission [SO_2 emission] – 0 = no description; 1 = qualitative description; 2 = quantitative description (currency/numerical description) 4. CO2Emission [CO_2 emission] – 0 = no description; 1 = qualitative description; 2 = quantitative description (currency/numerical description) (main components of greenhouse gas) 5. SootDustEmission [soot and dust emission] – 0 = no description; 1 = qualitative description; 2 = quantitative description (currency/numerical description) 6. IndSolidWasteEmission [industrial solid waste production] – 0 = no description; 1 = qualitative description; 2 = quantitative description (currency/numerical description) Note: The six scores are sourced from the CSMAR.
2	*Big4*	Whether the auditor is from a Big Four (Deloitte, PwC, EY and KPMG) accounting firm – 1 means no; 2 means yes
3	*Source*	Whether the company files environmental disclosure as a separate document – 1 means yes; 0 means no
4	*ROAB* – net profit on total assets B	Calculated as: net profit / average total assets, average total assets = total closing balance of assets + total opening balance of assets) / 2
5	*ValueBookRatioA*	Calculated as: total assets / market value A; when the denominator is unannounced or is zero or less than zero, it is denoted by Null
6	*Proportionofshare* – proportions of shares held by the state	Constructed by dividing state–owned shares and state–owned legal person shares by the total number of shares
7	*Growthrateofopprofit* – growth rate of operating profit	Calculated as: (operating profit in current quarter – operating profit in previous quarter) / (operating profit in previous quarter). It is denoted by Null if the denominator is not disclosed or equal to or below zero
8	*Ratioofintangibles* – ratio of intangible assets	Calculated as: net intangible assets / total assets. It is by Null if the denominator is not disclosed or zero
9	*Ratioofprofitfromfin* – ratio of profit from financial activities (degree of financialization)	Calculated as: (investment gains + income from changes in fair value + foreign exchange gains) / total profit. It is denoted by Null if the denominator is not disclosed or zero
10	*Finleverage* – financial leverage	Calculated as: (net profit + income tax expenses + financial expenses) / (net profit + income tax expenses). It is denoted by Null if the denominator is not disclosed or equal to zero, or financial expenses are below zero
11	*Lntotalassets* – firm size	The natural logarithm of the total assets
12	*MaleRatio* – proportion of male executives	The proportion of male directors, supervisors and senior executives to the total. Those whose gender cannot be determined are excluded from the calculation
13	*IndDirectorRatio* – proportion of independent directors	Number of independent directors to the scale of board of directors
14	*InsInvestorProp* – shareholding ratio of institutional investor	The proportion of shares of the list company held by institutional investors

Table A2: Independent directors

Conditional FE negative binomial

envlibtotal	Coef.	St. err.	*t*–value	*p*–value	[95% conf	interval]	Sig
Big4_n	−0.139	0.151	−0.92	0.357	−0.436	0.157	
Source_n	0.870	0.027	32.690	0	0.818	0.922	***
Big4_n#c.inddir	0.005	0.002	2.620	0.009	0.001	0.009	***
ROAB	−0.402	0.158	−2.55	0.011	−0.711	−0.093	**
ValueBookRatioA	0.221	0.044	5.050	0	0.135	0.307	***
Proportionofshare	−0.470	0.070	−6.710	0	−0.607	−0.333	***
Growthrateofoppr	0	0	0.840	0.398	0	0	
Ratioofintangibles	−0.352	0.230	−1.530	0.125	−0.803	0.098	
Ratioofprofitfromf	0.008	0.005	1.620	0.104	−0.002	0.019	
Finleverage	−0.004	0.004	−1.170	0.244	−0.011	0.003	
Lntotalassets	0.647	0.015	42.360	0	0.617	0.677	***
Constant	−12.674	0.423	−29.98	0	−13.503	−11.846	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi–square**	4810.495
Prob > chi²	0	**Akaike crit. (AIC)**	48,948.777

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. For abbreviations, please refer to Table 1.

Table A3: Male director ratio

Conditional FE negative binomial

envlibtotal	Coef.	St. err.	*t*–value	*p*–value	[95% conf	interval]	Sig
Big4_n	−0.157	0.258	−0.61	0.544	−0.663	0.349	
Source_n	0.87	0.027	32.55	0	0.818	0.922	***
Big4_n#c.malerati	−0.008	0.001	−7.15	0	−0.011	−0.006	***
ROAB	−0.438	0.158	−2.77	0.006	−0.749	−0.128	***
ValueBookRatioA	0.217	0.044	4.92	0	0.13	0.303	***
Proportionofshare	−0.45	0.07	−6.41	0	−0.588	−0.313	***
Growthrateofoppr	0	0	0.75	0.456	0	0	
Ratioofintangibles	−0.327	0.23	−1.42	0.155	−0.779	0.124	
Ratioofprofitfromf	0.008	0.005	1.55	0.121	−0.002	0.018	
Finleverage	−0.004	0.004	−1.03	0.301	−0.011	0.003	
Lntotalassets	0.626	0.016	40.33	0	0.596	0.657	***
Constant	−11.354	0.617	−18.40	0	−12.563	−10.144	***

Mean dependent var.	2.089	**SD dependent var.**	2.596
Number of obs.	21,381	**Chi–square**	4879.903
Prob > chi²	0	**Akaike crit. (AIC)**	48,897.563

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. For abbreviations, please refer to Table 1.

Table A4: Institutional investors

Conditional FE negative binomial

envlibtotal	Coef.	St. err.	*t*–value	*p*–value	[95% conf	interval]	Sig
Big4_n	0.267	0.15	1.78	0.076	−0.028	0.561	*
Source_n	0.874	0.027	32.700	0	0.822	0.926	***
Big4_n#c.insinv	−0.008	0.001	−9.300	0	−0.009	−0.006	***
ROAB	−0.355	0.157	−2.270	0.023	−0.663	−0.048	**
ValueBookRatioA	0.163	0.044	3.680	0	0.076	0.251	***
Proportionofshare	−0.353	0.072	−4.930	0	−0.493	−0.213	***
Growthrateofoppr	0	0	0.790	0.429	0	0	
Ratioofintangibles	−0.308	0.230	−1.340	0.181	−0.760	0.144	
Ratioofprofitfromf	0.009	0.005	1.720	0.086	−0.001	0.019	*
Finleverage	−0.004	0.004	−1.030	0.305	−0.011	0.003	
Lntotalassets	0.668	0.015	43.480	0	0.638	0.698	***
Constant	−13.370	0.449	−29.760	0	−14.250	−12.489	***

Mean dependent var.	2.089	**SD dependent var.**	2.596	
Number of obs.	21,358	**Chi–square**	4,910.235	
Prob > chi²	0	**Akaike crit. (AIC)**	48,798.471	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. For abbreviations, please refer to Table 1.

Table A5: State shares

Conditional FE negative binomial

envlibtotal	Coef.	St. err.	t–value	p–value	[95% conf	interval]	Sig
Big4_n	0.011	0.057	0.200	0.841	−0.100	0.123	
Source_n	0.870	0.027	32.720	0	0.818	0.922	***
Big4_n#Proportionofshare	−0.670	0.176	−3.800	0	−1.016	−0.324	***
ROAB	−0.404	0.158	−2.560	0.011	−0.713	−0.094	**
ValueBookRatioA	0.224	0.044	5.110	0	0.138	0.310	***
Proportionofshare	0.084	0.161	0.520	0.605	−0.233	0.400	
Growthrateofoppr	0	0	0.850	0.398	0	0	
Ratioofintangibles	−0.336	0.230	−1.460	0.145	−0.787	0.116	
Ratioofprofitfromf	0.008	0.005	1.590	0.112	−0.002	0.019	
Finleverage	−0.004	0.004	−1.200	0.230	−0.012	0.003	
Lntotalassets	0.650	0.015	42.550	0	0.620	0.680	***
Constant	−12.849	0.346	−37.140	0	−13.527	−12.171	***

Mean dependent var.	2.089	**SD dependent var.**	2.596	
Number of obs.	21,381	**Chi–square**	4,814.907	
Prob > chi²	0	**Akaike crit. (AIC)**	48,939.886	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. For abbreviations, please refer to Table 1.

Source Table A1–A5: Authors' own calculations