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Executive Accountability Pressure and Green Innovation: Evidence from China

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Abstract: This study explores the influence of the accountability system on corporate green innovation. Using data on Chinese A-share-listed companies from 2013 to 2022, we found that the accountability system significantly promotes green innovations in state-owned enterprises (SOEs). Furthermore, the promoting effect is stronger in central SOEs as opposed to local SOEs. A mechanism analysis suggested that its positive effect may stem from improving corporate internal controls, curbing managerial myopia, and providing sufficient resources. In addition, heterogeneity tests suggested that the promoting effect of the accountability system on green innovation is more pronounced when the CEO is close to retirement or subject to high accountability pressure, in heavily polluting firms, and in regions with intense environmental regulations. Further analyses suggested that the accountability system also improves green innovation quality, persistence, and environmental performance. Our findings indicate that the accountability system has unexpected real effects on promoting corporate green innovation and sustainable development.

Keywords: the accountability system; green innovation; agency problem; internal controls; managerial myopia

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1. Introduction

Sustainable development and green economic growth have gradually become a worldwide consensus. Green innovation, also referred to as environmental innovation, is one of the most important factors in harmonizing economic growth with environmental sustainability [1]. However, in emerging markets like China, green innovation faces specific challenges and opportunities. On the one hand, emerging markets often face more serious environmental problems and resource constraints. Therefore, there is a greater need for them to deal with environmental challenges through green innovation. On the other hand, emerging markets generally lack green innovation capabilities and may need to rely on advanced green technologies from abroad.

In contrast to private firms, state-owned enterprises (SOEs) are expected to shoulder additional environmental and social responsibilities apart from profitability goals [2]. As the backbone of economic development, Chinese SOEs play an incomparable role in environmental protection and green development. The government encourages SOEs to play an exemplary role in green technology research, development, achievement transformation, and application [3]. However, due to the absence of owners, SOEs have long suffered from the governance defect of natural insider control. Managers with unequal power and responsibilities are more likely to put their own interests above those of shareholders, causing losses to shareholders [4]. Previous studies have shown that in the absence of supervision,

SOEs may suffer from corruption, poor decision-making, reduced social responsibility, and less green innovation [5–8].

In order to strengthen the supervision of SOE managers, the Chinese government issued the "Opinions of the General Office of the State Council on Establishing an Accountability System for Business Operation and Investment in Violation of Regulations by State-Owned Enterprises" (hereafter, the accountability system) in August 2016. The accountability system proposes to implement lifelong accountability for major decisions made by SOE managers. The restraining effect on executives' non-compliance pressure may reduce interest conflict between SOE managers and stakeholders. Thus, an examination of accountability in the Chinese context should have positive implications for corporate governance improvement. A few recent studies have found that the implementation of the accountability system improved corporate internal controls, curbed management misconduct, and reduced risk-taking [9–12]. How does the accountability system influence the green innovation of SOEs? Till now, it has gained little attention in existing research.

To fill this research gap, we tried to answer the following questions: (1) Does the accountability system have an influence on corporate green innovation? (2) Is this effect related to the political status of managers in different types of SOEs? (3) What are the potential mechanisms through which accountability affects green innovation? (4) Is there any heterogeneity in the effect of the accountability system across different CEOs or firms?

The empirical results suggest the following: (1) The accountability system has a positive influence on green innovations, with a significant increase in both green invention and green utility model patents. (2) The accountability system exerts more influence on managers in central SOEs than those in local SOEs. (3) The accountability system affects SOEs' green innovation level by improving corporate internal controls, curbing managerial myopia, and alleviating financing constraints. (4) The positive influence is more pronounced when the CEO is approaching retirement or subject to high accountability pressure, in heavily polluting firms, and in regions with intense environmental regulations. (5) The accountability system further improves green innovation quality, persistence, and environmental performance.

Our research contributes to the existing literature in several respects. First, this study adds to the research on the influence factors of corporate green innovation. Previous studies have mainly focused on environmental regulations, legitimacy pressure from stakeholders, corporate resource constraints, and executive characteristics [13–16]. The scarce literature about corporate governance factors is primarily based on ex ante incentives and control perspectives, such as executive compensation incentives and institutional investor ownership [17,18], and pays little attention to ex post accountability systems. We discuss the drivers of green innovation from the perspective of ex post accountability systems, filling a gap in the existing literature. Second, our study expands the research on the influence of accountability systems from a green innovation perspective. Existing studies on accountability systems mainly focus on the fields of law and politics [19–21]. The relevant literature in the economic field seldom pays attention to the nexus between the accountability system and corporate green innovation. Our study examines the impact of executive accountability pressure on corporate green innovation in SOEs and the potential mechanisms, shedding new light on the economic consequences of the accountability system. Finally, we enrich the studies on the influence of accountability on corporate green innovation from the perspective of corporate governance. We suggest the accountability system as a potential incentive to effectively reduce agency problems through its effects on internal control, managerial myopia, and financial constraint. In addition, our findings may not only contribute to deepening the accountability system of SOEs in China but also

offer valuable implications for other developing countries looking to set up accountability systems and improve corporate green innovation.

2. Literature Review and Hypothesis Development

2.1. Accountability System

Accountability is a relationship in which the performer takes responsibility for their actions, and the supervisor poses questions and makes judgments [22–24]. Previous studies have mainly focused on accountability in public sectors, such as electoral accountability and political accountability [25–27]. Within an organization, properly designed and implemented accountability systems may help to limit the abuse of power and curb managers' self-serving decisions [28]. For instance, Goodman et al. [29] showed that strengthening accountability inside the board can improve board effectiveness. Liew and Cao [30] found that supply chain carbon accountability is an essential component of corporate environmental governance. Therefore, accountability has become a cornerstone of legitimacy and effective organization governance [24,31].

In China, there are a variety of accountability systems, such as intra-party accountability, administrative accountability, and the one discussed in our study [9,11,32]. Among them, the accountability system discussed in our study is particularly aimed at SOE executives. This is the first time that China has established an accountability system for the violation of regulations of SOEs that introduces lifelong accountability. It defines the scope of accountability, the identification of losses, the determination of responsibility, and the corresponding punishment in detail. According to the accountability system, SOE executives should be held accountable if they fail to fulfill their responsibilities. With its expanded implementation across the country, the accountability system plays a significant role in enhancing SOEs' efficiency.

In general, the accountability system discourages irregularities by managers through ex ante prevention as well as ex post punishment. The establishment of the accountability system has reduced corporate violations by enhancing internal control quality and curbing managerial myopia [11]. Accountability has also been proven to improve the audit quality of SOEs by curbing managerial misbehavior, reducing earnings manipulation, and improving the quality of internal controls [9]. By improving corporate governance and mitigating information asymmetry, increased regulation has significantly curbed executives' opportunistic stock-selling behavior [33]. Overall, prior research has mainly concentrated on the influence of the accountability system on audit quality, manager violation, risk-taking, and diversified investment [9–12]. However, the existing literature has not yet examined the economic consequences of accountability from a sustainable development perspective.

2.2. The Determinants of Green Innovation

According to a substantial amount of research, external forces like legitimacy pressure from stakeholders and environmental regulations are important drivers of corporate green innovation [34–36]. For example, prior studies have shown that stricter environmental regulations, major customer demands, pressure from institutional investors, media attention, and societal requirements can significantly promote green innovation [15,37,38]. Furthermore, since corporate green innovation demands long-lasting investments, financial support, such as government subsidies, green finance policy, and tax incentives, also has a boosting effect on it [39–42].

Besides external pressure and support, environmental innovation has also proved to be influenced by internal factors such as executive characteristics, ownership structure, and corporate governance. On the basis of upper echelon theory, prior studies have shown that CEO hubris, marketing experience, academic experience, foreign experience, and women

directors can facilitate corporate green innovation, while individual foreign residency rights have a negative influence on it [16,43–47]. Moreover, green transformational executives also have an encouraging effect on green creativity [48]. In terms of ownership structure, the existing literature finds that state ownership and political connection impede corporate green innovation [7,8]. A possible explanation is that due to insufficient supervision, SOE managers lack the willingness to conduct green innovation, which is extremely uncertain and requires a long period to receive payback.

Corporate governance and executive incentives also have an influence on green innovation. For instance, Amore and Bennedsen [49] found that ineffective corporate governance leads to fewer environmental innovations. Flammer et al. [50] showed that linking executive salary to corporate social responsibility (CSR) performance significantly promotes environmental innovation. As shown by Dwekat et al. [51], environmental innovation can benefit from diverse, long-term, and independent boards. Cheng et al. [52] revealed that collective decision-making systems fostered corporate green innovation through alleviating manager myopia. Moreover, political inspection could encourage green innovation by reducing rent-seeking [53]. However, strict constraints and insufficient incentives may inhibit green creativity. For example, Li et al. [54] found that regulating executive compensation inhibits their motivation to conduct corporate green innovation, while managerial shareholding, social capital, and government subsidies can alleviate its negative impact [55]. On the whole, relatively little is known about the role that the accountability system plays in corporate green innovation. Our study adds to existing studies by investigating the influence of the accountability system on green innovation and its potential mechanisms, providing implications for the role that regulatory systems play in promoting the sustainable development of the economy.

2.3. Hypothesis Development

2.3.1. The Accountability System and Green Innovation

The implementation of the accountability system may promote SOE green innovation through the subsequent means. First, drawing on the agency and stakeholder theory, the accountability system may promote green innovation through the strengthening of internal controls. According to the accountability system, ineffective internal control and risk management systems may lead to ex post accountability. If there are substantial deficiencies in internal control, SOE managers may encounter harsh punishments, including compensation cutting, demotion, and sometimes removal. Under the pressure of the severe punishment of accountability, SOE managers tend to improve internal control quality and standardize the decision-making process as an ex ante response. On the one hand, the improvement of corporate internal control helps to enhance management supervision and reduce agency costs [56,57], thus preventing a lack of green innovation due to the management's risk aversion, laziness, or enjoyment of a quiet life [58]. On the other hand, previous studies have documented that firms seek rents to obtain favors from politicians, thus avoiding strict environmental regulations [59]. With the introduction of accountability, rent-seeking behavior is limited, and SOE managers become more regulation-compliant and inclined to focus on completing government tasks for political promotion. The Chinese government has clearly set the construction of an environmentally friendly society as a national task [60,61]. As government delegates, SOEs have to meet the demands of a broad range of stakeholders, particularly in terms of social and environmental responsibility. Hence, following the implementation of the accountability system, SOE executives might be denoted as meeting the legitimacy requirements of stakeholders and achieving political promotion.

Second, the accountability system may incentivize SOE executives to generate green innovation investments by curbing managerial myopia. As mentioned above, agency problems, compensation restrictions, and short-term tenure lead SOE managers to be shortsighted, pursuing personal interests at the cost of long-term corporate development [62]. The severe ex post penalties for SOE managers' improper business decisions and the deterrent effect can enhance their sense of responsibility and morality, as well as curb their opportunistic and shortsighted tendencies. The accountability system imposes lifelong accountability on SOE managers. Business decisions that have serious negative consequences in the long run may result in severe penalties for decision-makers, even if they have retired. By linking their career development to the long-term growth of the company, the accountability system helps to mitigate management shortsightedness in SOEs. Overall, the accountability system may incentivize SOE executives to increase investments in environmentally friendly innovations that support sustainable development over the long run.

Finally, the accountability system may facilitate corporate green innovation by providing more financial resources. According to the resource-based theory, financial resources are a major obstacle constraining corporate green innovation. Similarly to general innovation, green innovation involves an extensive amount of capital expenditure and is extremely uncertain and risky. Prior studies have documented that corporate profitability significantly promotes green innovation [63], while financing constraints inhibit green innovation [64]. In addition, R&D subsidies by the government and green credits can considerably boost corporate green innovation [65,66]. Preventing state-owned-asset loss is the main goal of the accountability system. Many clear prescriptions have been set for fund management. For example, the system emphasizes punishment for fund expenditures exceeding authority approval, illegal guarantees, and illegal payment in advances to other partners in joint ventures. Thus, the accountability system may lessen fund occupation and improve cash flow. In addition to internal finance, the accountability system may facilitate firms' access to external finance by strengthening corporate supervision and mitigating internal and external information asymmetries. Taken together, the accountability system may alleviate the impediment of financial constraints to environmental innovation.

On the other hand, accountability may reduce SOE managers' willingness to take risks and thus inhibit green innovation. Whether overregulation inhibits managerial risk-taking is a long-standing concern. For example, Bargeron et al. [67] found that the introduction of the Sarbanes–Oxley Act inhibits executive risk-taking by increasing their personal liability for non-compliance. Mao and Zhang [68] show that the implementation of the FAS 123R accounting regulation dampens managerial risk-taking incentive and leads to a considerable decrease in explorative innovation. Faleye et al. [69] documented that intense board monitoring exhibits diminished corporate innovation. In China, the compensation of SOE executives is under mandatory restrictions. Li et al. [55] found that executive compensation regulation inhibits their incentive to conduct corporate green innovation. The accountability system expands the liability of SOE managers through enhanced oversight and ex post accountability. When the accountability system is put into place, investment failure may bring severe penalties to managers, while its success does not allow managers to obtain a lot of benefits. Chen et al. [12] showed that the deterrent effect of the accountability system significantly inhibits managerial risk-taking in SOEs. However, green innovations are usually long-term and risky, which demands an adventurous spirit and risk-taking willingness [70,71]. Therefore, the accountability system may exacerbate the insufficient incentives of SOE managers and lead to a reduction in green innovation.

Taken together, we proposed competitive hypotheses as follows:

H1a. *Ceteris paribus, the accountability system has a positive impact on green innovation.*

H1b. *Ceteris paribus, the accountability system has a negative impact on green innovation.*

2.3.2. Types of SOEs, the Accountability System, and Green Innovation

On the basis of an institution-based view, ownership type has a significant impact on environmental strategy configurations [72]. In China, SOE managers are essentially employees of the government with political positions [55]. SOEs have both political and economic functions, and their managers have two distinct identities, namely, an "economic man" and "political man." The government has its political demands on SOEs and advocates for executives to actively take on corporate social responsibility.

Considering the types of SOEs, the green innovation of central SOEs is likely to have distinct characteristics apart from local SOEs. First, China's SOE managers are employed within an enclosed pyramidal labor market and possess different political ranks [73]. The higher the political rank of SOE managers, the better their career prospects, but also the more responsibility they have to take when SOEs are underperforming. Consequently, central SOE managers with higher political positions may make more cautious decisions than their counterparts in local SOEs.

Second, political incentives shape managerial behavior in SOEs [74]. Normally, the greatest incentive of executives in SOEs is political promotion [75]. Based on the tournament competition hypothesis, executives choose a positive strategy to obtain greater corporate performance since they are more likely to be promoted to an upper-level status [76]. In the context of the double assessment of economic and social benefits, the executives of SOEs are committed to social responsibility and seek to improve their political status.

In conclusion, the accountability system puts more pressure on the executives of central SOEs than those of local SOEs to proceed carefully and maintain their political position, resulting in an increased focus on green innovation. Therefore, we proposed our second hypothesis as follows:

H2. *Ceteris paribus, the effect of the accountability system on green innovation is stronger in central SOEs than in local SOEs.*

On the basis of the preceding analysis, we developed a theoretical framework in Figure 1.

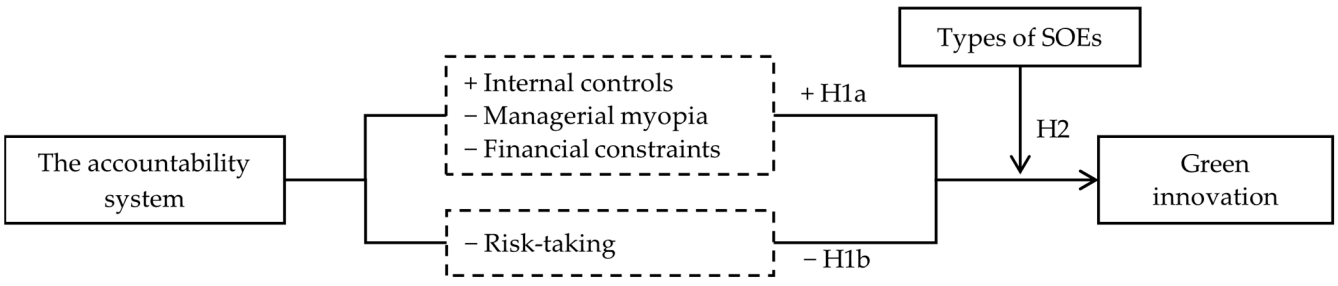


Figure 1. Theoretical framework.

3. Research Design

3.1. Sample and Data

The sample for our analysis comprised A-listed firms on the Shanghai and Shenzhen stock exchanges during 2013–2022. In order to avoid the influence of alterations in the macro-regulatory environment before and after the 18th National Congress of the Chinese

Communist Party, we selected 2013 as the initial year (The 18th National Congress of the Chinese Communist Party marked a brand-new chapter of classified SOE reform). Then, we excluded the following: (1) firms in the financial and cultural industry, since these firms are subject to other accountability systems; (2) special treatment firms flagged with ST or *ST; and (3) samples with missing observations of core variables. Moreover, we winsorized continuous variables at 1% and 99% to alleviate the impact of outliers. As a result, the final sample comprised 24,976 firm-year observations.

The data on green innovation were obtained from the CNRDS database. The firm-level and CEO-level data were mainly from the CSMAR database. The corporate internal control index came from the DIB Database. Data related to environmental regulation at the regional level were collected from the China Environment Yearbook and the National Bureau of Statistics. To identify the equity nature of each listed firm, we merged and cross-checked the relevant data from the CSMAR, CNRDS, and WIND databases (all the databases mentioned above are widely used in studies on China). For companies with an ambiguous nature of equity in the database, we used the equity chain diagram to determine the nature of the equity of the actual controller. And this information was collected manually from the TianYanCha (https://www.tianyancha.com/advance/search/e-pc_searchinfo (accessed on 2 January 2024)) or annual report.

3.2. Variable Measurement

3.2.1. Measure of Green Innovation

Following previous research [77,78], we used the number of green patent applications to measure corporate green innovations. Since investment in environmental innovation is difficult to identify and ignores the efficiency of input–output transformation, the existing literature mainly uses green patent applications as well as green innovation grants to capture green innovation [13,79]. Before being granted, green patent applications usually need to undergo a long period of time. Therefore, we used green patent applications to explore the influence of accountability on green patent innovation in a timely and accurate manner. Specifically, EnvrPat is the natural logarithm of one plus the number of green patent applications. The larger the value of EnvrPat, the higher the level of corporate green innovation. A patent application was regarded as a green patent application if it contained green keywords, such as 'low carbon', 'emissions reduction', 'energy saving', 'environmental protection', and so on. Based on the type of green patent, we also separated green patents into green invention patent applications (EnvrInvPat) and green utility model patent applications (EnvrUtyPat). More green invention patent applications mean a higher quality of green innovation.

3.2.2. Measure of the Accountability System

We recognized the application of the accountability system as an exogenous shock and estimated a staggered difference-in-difference (DID) model. The independent variable is a dummy variable that equals 1 if a firm is affected by the accountability system and 0 otherwise (denoted as DID). This independent variable is equivalent to the interaction term of the policy implementation variable (Post) and the treatment variable (Treat) in a traditional DID model.

First, we manually collected the accountability system issued by all levels of the State-owned Assets Supervision and Administration Commission of the State Council (SASACs). On the basis of "Opinions of the General Office of the State Council on Establishing an Accountability System for Business Operation and Investment in Violation of Regulations by State-Owned Enterprises", SASACs at all levels have successively introduced corresponding systems, further clarifying the scope, standards, responsibility determination,

investigation and treatment, duties, and work procedures of the accountability system. Appendix A provides the precise application times of the accountability system for all levels of the SASAC. In reference to the study of Zheng et al. [80], if the accountability system was applied during the first half of a year, we considered it to be effective from the relevant year. The accountability system was considered to be effective from the next year if it was introduced during the second half of a year. Then, we identified firms that are subject to the accountability system according to their actual controller. If the actual controller of a company is a specific SASAC that implemented the accountability system during our sample period, the company was considered to be treated after the policy was introduced.

3.3. Empirical Model

To examine the influence of the accountability system on corporate green innovation, we estimated the following DID model:

$$\begin{aligned} EnvrPat_{i,t} &= \beta_0 + \beta_1 DID_{i,t} + \beta_2 Size_{i,t} + \beta_3 ROA_{i,t} + \beta_4 Lev_{i,t} + \beta_5 Growth_{i,t} + \beta_6 Age_{i,t} + \beta_7 Big4_{i,t} \\ &+ \beta_8 First_{i,t} + \beta_9 Dual_{i,t} + \beta_{10} Salary_{i,t} + \beta_{11} Boardsize_{i,t} + \beta_{12} Indep_{i,t} + \tau_t + \theta_i + \varepsilon_{i,t} \end{aligned}$$

EnvrPat is the level of corporate green innovation measured by the natural logarithm of one plus the number of green patent applications. Moreover, we also used EnvrInvPat and EnvrUtyPat to capture the number of green invention patent applications and green utility model patent applications, respectively. The independent variable DID equals 1 if a firm is affected by the accountability system and 0 otherwise. The coefficient of interest is β_1, which measures the change in the green innovation of firms affected by the accountability system compared to that of firms in the control group. Drawing on prior studies, we controlled for a vector of variables that may affect corporate green innovation, including Size, ROA, Lev, Growth, Age, Big4, First, Dual, Salary, Boardsize, and Indep [63,78,81]. We also included firm (θ_i) and year fixed effects (τ_t) to control for differences in corporate green innovation over time and among firms. In addition, the standard errors were clustered at the firm level. Appendix B provides definitions of the main variables used in our study.

4. Empirical Results

4.1. Descriptive Statistics

Table 1 shows the summary statistics of the main variables used in our baseline analysis. The mean value of EnvrPat is 0.845, indicating that firms in our sample have 1.328 green patent applications per year on average. The maximum and minimum values of EnvrPat are 4.511 and 0, respectively, with a standard deviation of 1.14, suggesting that the number of green innovation applications varies among sample firms. The median value of EnvrPat is 0, implying that there is no green innovation in most of the samples and that corporate green innovation in China still needs to be improved. As for EnvrInvPat and EnvrUtyPat, firms in our sample have 0.738 green invention patent applications and 0.766 green utility model patent applications per year on average. The distributions of control variables are generally similar to those in prior studies.

Table 1. Summary statistics.

VarName	Obs	Mean	SD	Min	Median	Max
EnvrPat	29,190	0.817	1.122	0.000	0.000	4.511
EnvrInvPat	29,190	0.533	0.908	0.000	0.000	4.043
EnvrUtyPat	29,190	0.549	0.886	0.000	0.000	3.664
DID	29,190	0.161	0.367	0.000	0.000	1.000
IC	29,136	6.257	1.151	0.000	6.488	6.691

Table 1. *Cont.*

VarName	Obs	Mean	SD	Min	Median	Max
Myopia	29,162	0.035	0.076	0.000	0.002	0.431
SA	29,172	3.854	0.244	3.194	3.856	4.462
ROA	29,190	0.032	0.068	−0.295	0.034	0.197
Size	29,190	22.294	1.297	19.899	22.104	26.302
Lev	29,190	0.430	0.205	0.061	0.420	0.915
Growth	29,190	0.163	0.423	−0.594	0.098	2.667
Age	29,190	10.925	7.724	1.000	9.000	28.000
Big4	29,190	0.058	0.233	0.000	0.000	1.000
First	29,190	33.684	14.313	9.190	31.370	73.010
Dual	29,190	0.284	0.451	0.000	0.000	1.000
Salary	29,190	14.531	0.691	12.881	14.507	16.449
Boardsize	29,190	8.420	1.620	5.000	9.000	14.000
Indep	29,190	0.378	0.054	0.333	0.364	0.571

Note: Continuous variables are winsorized at the 1% and 99% level.

4.2. Baseline Result

Table 2 shows the results for H1, examining the impact of the accountability system on green innovation. Column (1) presents its effect on total green patent applications, while Columns (2) and (3) display the results for green invention patent applications and green utility model patent applications, respectively. As shown in Column (1), the coefficient of DID is significantly positive at the 1% level, implying that the accountability system remarkably promotes environmental innovation in SOEs. This effect is both statistically and economically relevant. Economically, these results indicate that after the introduction of the accountability system, the green patent applications of SOEs increase by 13% compared to non-SOEs. The results of Columns (2) and (3) indicate that the accountability system considerably facilitates both corporate green invention patent applications and green utility patent applications. Overall, these results support H1a, and we discuss potential explanations for these findings in the following section.

Table 2. The impact of the accountability system on green innovation.

	(1)	(2)	(3)
	EnvrPat	**EnvrInvPat**	**EnvrUtyPat**
DID	0.130 ***	0.112 ***	0.094 ***
	(5.711)	(5.859)	(4.684)
ROA	−0.091	−0.107	−0.015
	(−0.965)	(−1.372)	(−0.192)
Size	0.304 ***	0.223 ***	0.211 ***
	(14.540)	(11.677)	(12.241)
Lev	−0.045	−0.041	−0.014
	(−0.729)	(−0.839)	(−0.275)
Growth	−0.006	−0.008	−0.002
	(−0.579)	(−0.929)	(−0.263)
Age	−0.015	−0.036	−0.010
	(−0.351)	(−0.830)	(−0.288)
Big4	−0.032	0.007	−0.047
	(−0.380)	(0.093)	(−0.688)
First	−0.000	−0.000	0.000
	(−0.062)	(−0.374)	(0.351)

Table 2. *Cont.*

	(1)	(2)	(3)
	EnvrPat	**EnvrInvPat**	**EnvrUtyPat**
Dual	0.009	0.030 **	−0.020
	(0.502)	(1.967)	(−1.444)
Salary	0.034 **	0.027 *	0.025 *
	(1.970)	(1.841)	(1.821)
Boardsize	0.003	0.003	0.002
	(0.388)	(0.434)	(0.253)
Indep	0.137	0.084	0.128
	(0.676)	(0.482)	(0.730)
Constant	−6.360 ***	−4.493 ***	−4.485 ***
	(−8.929)	(−6.645)	(−8.021)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
N	28,696	28,696	28,696
Adj.R^2	0.694	0.669	0.645

Note: T-statistic is enclosed in parentheses. * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Table 3 presents the results of the subgroup test distinguishing between types of SOEs. According to the nature of the ultimate controller, SOEs are generally categorized into central SOEs and local SOEs. We first used EnvrPat as the dependent variable in Columns (1) and (2). In Column (1), the experimental group is central SOEs, and non-SOEs are considered the control group. In Column (2), we used local SOEs as the treatment group and non-SOEs as the control group. The results show that the accountability system is significantly positively related to green innovation in both groups. But the coefficient of DID is larger in Column (1) than in Column (2). Moreover, the seemingly irrelevant test found that the difference between these two groups is significant. These results imply that the accountability system greatly improves the level of green innovation in SOEs, but the effect is greater in central SOEs. We changed the dependent variable in Columns (3) and (4) into EnvrInvPat and obtained similar results. Thus, our second hypothesis has been proved.

Table 3. Types of SOEs, the accountability system, and green innovation.

	(1)	(2)	(3)	(4)
	EnvrPat		**EnvrInvPat**	
	Central	**Local**	**Central**	**Local**
DID	0.201 ***	0.121 ***	0.220 ***	0.079 ***
	(4.633)	(4.732)	(5.610)	(3.880)
		(1) vs. (2)	(3) vs. (4)	
		Chi^2 = 7.54 ***	Chi^2 = 9.53 ***	
		p-value = 0.006	*p*-value = 0.002	
Controls	Yes	Yes	Yes	Yes
YearFE	Yes	Yes	Yes	Yes
FirmFE	Yes	Yes	Yes	Yes
N	22,219	25,389	22,219	25,389
Adj. R^2	0.690	0.665	0.663	0.633

Note: T-statistic is enclosed in parentheses. *** $p < 0.01$.

4.3. Robustness Test

4.3.1. Parallel Trend Test

An essential assumption of the DID regression is that before the introduction of the accountability system, the trend in green innovation in the treatment group and the control group should be parallel. Following Beck et al. [82], we traced the dynamic effect of the accountability system on green innovation to examine whether the DID model is valid in our study. For each treated firm, we defined the first year that the firm was subject to the accountability system as the event year (current) and set pre- and post-event periods accordingly. Figure 2 reports the 95% confidence intervals for the estimated coefficients. We estimated the dynamic effect of the accountability system on green innovation relative to pre1. As can be seen in Figure 2, the coefficients for periods prior to the event year do not significantly differ from 0, implying that green innovation between the treatment and control groups has a similar time trend prior to the accountability system. Therefore, the parallel trend assumption is satisfied in our DID analysis. Moreover, the coefficients for periods after the event year are significantly positive, supporting our baseline conclusion.

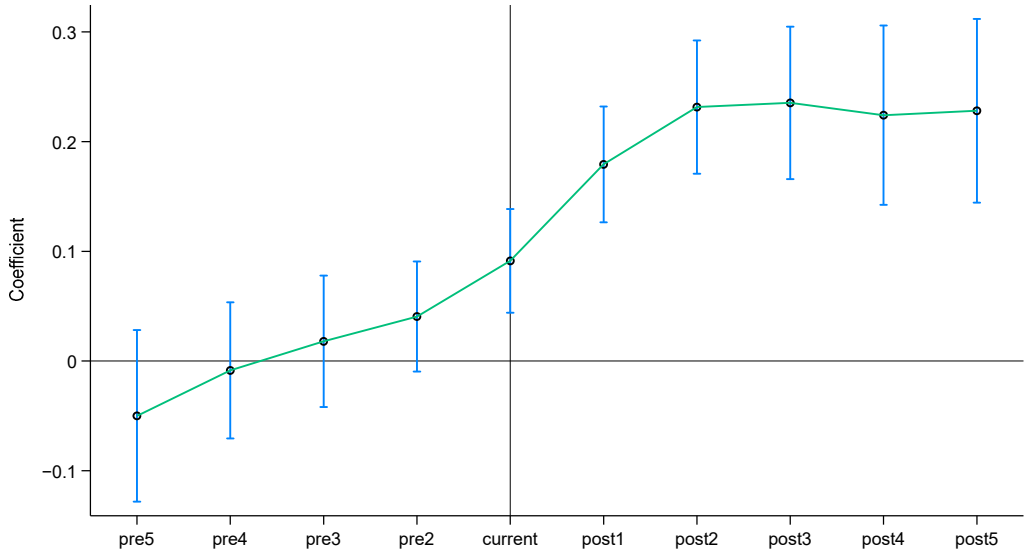


Figure 2. Coefficients of the parallel trend test.

4.3.2. Propensity Score Matching

A potential endogeneity concern is that unobserved characteristics that differ between SOEs and non-SOEs are related to corporate green innovation. To reduce the possible estimation bias arising from sample selection, we performed the propensity score matching (PSM) strategy to ensure the robustness of our results. First, we used non-SOEs with state-owned organizations in their top 10 shareholders as the control group candidates to reduce their difference from the SOEs. Then, we used PSM to select non-SOE candidates with similar characteristics to SOEs as the control group. Specifically, we performed nearest neighbor matching (caliper distance <0.05) using several covariates such as Size, ROA, Lev, Growth, Age, Big4, First, Dual, Boardsize, Indep, and Salary, as well as the year and industry dummy. The unreported balance test suggests that there is no significant difference in these characteristics between the treatment and control groups after PSM. Finally, we reran the regression of Equation (1) using the paired samples. As shown in Table 4, the coefficients of DID are positively significant at the 1% level, in line with the baseline conclusion.

Table 4. Results for the PSM sample.

	(1)	(2)
	EnvrPat	**EnvrInvPat**
DID	0.063 ***	0.057 ***
	(2.842)	(2.993)
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
N	11,565	11,565
Adj. R^2	0.750	0.728

Note: T-statistic is enclosed in parentheses. *** $p < 0.01$.

4.3.3. Placebo Test

To ensure that the estimated impact of the accountability system on green innovation is not driven by confounding factors, we performed a placebo test to confirm our baseline findings. Following La Ferrara et al. [83] and Zhou et al. [84], we randomly assigned the status of having implemented the accountability system to regions to generate the false variable FDID. To mitigate the influence of chance, we repeated the random simulations 1000 times. Figure 3 displays the coefficient distribution from the 1000 random simulations. As shown in Figure 3, the coefficients of FDID concentrate around 0 and are significantly far from the coefficient (0.13) estimated by Equation (1). These results suggest that our baseline findings are not driven by randomness.

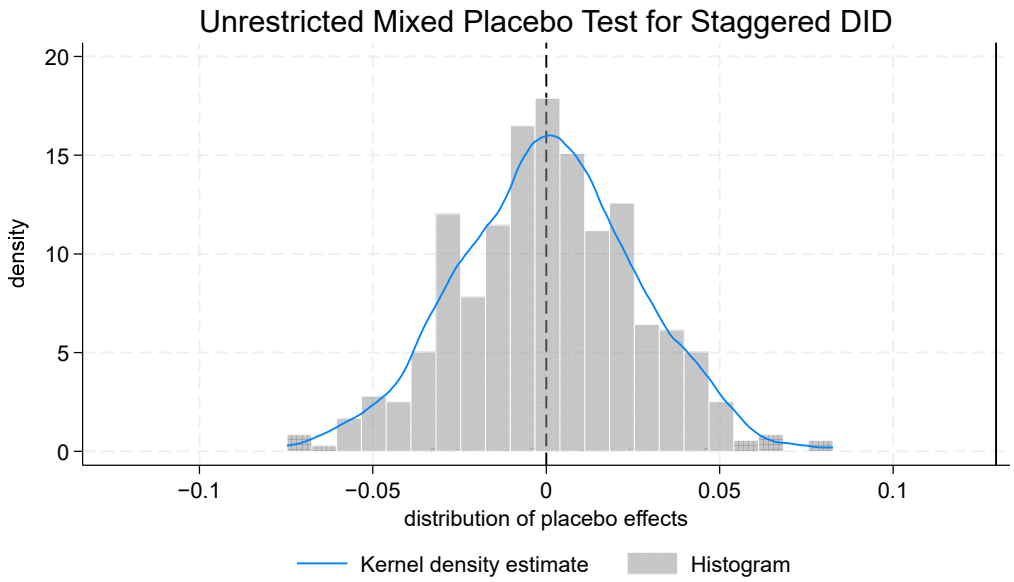


Figure 3. Coefficients of the placebo test.

4.3.4. Heterogeneous Treatment Effects

When staggered DID regression with two-way fixed effects (TWFEs) is used, an arising concern is that heterogeneous treatment effects and variation in treatment timing may lead to estimate biases [85,86]. Following prior studies, we conducted several tests to address the estimate bias concern arising from staggered DID regression. Drawing on a study by Goodman-Bacon [85], we performed a Goodman-Bacon decomposition of the staggered DID regression coefficient estimates. As shown in Panel A of Table 4, the weight of the treated group vs. never-treated group comparison accounts for 88.6% of the TWFE estimates, while the weight of the contaminated group (later treated vs. earlier treated) has a very small weighting (3.8%). These results indicate that the unrealistic treatment

effects did not affect the validity of our baseline analysis, and the staggered DID estimator is robust. To further strengthen the validity of our findings, we employed a staggered DID estimation developed by Callaway and Sant'Anna [87] (CSDID) as an alternative design. Panel B of Table 5 reports the average treatment effect on the treated group (ATT) obtained using the CSDID estimation. Consistent with the baseline results, the coefficient estimates are significantly positive. In summary, our conclusion remains robust after considering the possible estimation bias of the TWFE estimator in the staggered DID.

Table 5. Heterogeneous treatment effects.

Panel A: Goodman-Bacon (2018) DD Estimates and Weights				
	EnvirPat		**EnvirInvPat**	
DD Comparison	**Weight**	**Avg DD Est**	**Weight**	**Avg DD Est**
Earlier T vs. Later C	0.063	0.023	0.063	0.040
Later T vs. Earlier C	0.038	−0.026	0.038	−0.001
T vs. Never treated	0.886	0.099	0.886	0.075
Panel B: CSDID				
	Coefficient	**Z value**	**Coefficient**	**Z value**
ATT	0.111	2.62	0.113	3.20

Note: T = treatment; C = comparison.

4.3.5. Other Robustness Tests

In addition, we conducted a battery of tests to strengthen the robustness of our baseline conclusions. First, since the explained variable EnvrPat is a truncated variable with a lower bound of zero, we used the negative binomial model as a robustness test. As shown in Column (1) of Table 6, the coefficient of DID remains significantly positive at the 1% level, indicating that our baseline conclusion is robust.

Table 6. Robustness test.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	NBModel	**FE**	**F.EnvrPat**	**2016**	**Ratio**
DID	0.217 ***	0.162 ***	0.099 ***	0.129 ***	0.007 **
	(9.656)	(5.591)	(4.300)	(5.211)	(2.140)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	NO	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year × Firm	NO	Yes	NO	NO	NO
N	29,190	28,328	23,846	28,696	28,696
Adj. R^2		0.694	0.705	0.694	0.442

Note: T-statistic is enclosed in parentheses. ** $p < 0.05$, and *** $p < 0.01$.

Second, to mitigate potential problems that may arise from omitting time-varying firm-specific characteristics, we controlled for firm-year fixed effects and re-estimated the regressions of Model (1). The results in Column (2) show that the estimated coefficient of DID is significantly positive, implying that our results are not driven by time-varying firm-level characteristics.

Third, considering that it takes a long period of time for green research and development inputs to be transferred into green patent applications, we lagged the DID and control variables by one period in our regression, and the results are displayed in Column (3) of Table 6. The coefficient of DID is still significantly positive at the 1% level, suggesting that our benchmark results are robust.

Fourth, in our benchmark analysis, we identified the treated firm according to the implementation time of the accountability system for all levels of SASACs. In actuality, after the General Office of the State Council issued the accountability system in August 2016, its implementation for SASACs at all levels is predictable. Therefore, under the deterrent effect of a predictable accountability system, SOEs may adjust their green innovation decisions in response. Following a study by Shen et al. [10], we used 2016, the year that the General Office of the State Council issued the accountability system, as the policy shock year and constructed a standardized DID model to examine the impact of the accountability system on green innovation. The results are reported in Column (4) of Table 6. In line with our baseline results, the coefficient of DID is significantly positive at the 1% level.

Finally, following Wu et al. [88], we used the ratio of the granted green innovation initiatives to total granted patents of a firm (Ratio) as an alternative measurement of green innovation. As shown in Column (5), the coefficient of DID remains significantly positive, indicating that our findings are robust after addressing the potential measurement bias.

4.4. Mechanism Analysis

As shown above, our empirical results indicate that the implementation of the accountability system has a significant positive impact on SOEs' green innovation. According to the theoretical analysis, we suppose that the accountability system may promote green innovation by improving internal control, inhibiting managerial myopia, and providing sufficient resources. In this section, we tested these mechanisms through empirical analyses.

4.4.1. Internal Control

As mentioned above, the implementation of the accountability system may promote green innovation by improving internal controls. According to studies by Chan et al. [89] and Liu et al. [90], we used the corporate internal control index (IC) of the DIB database to capture the quality of corporate internal controls. As shown in Column (1) of Table 7, the coefficient of DID is positive and significant, indicating that the accountability system significantly promotes internal control quality. In Column (2), the coefficients of both DID and IC are significantly positive. These results mean that the accountability system significantly improves internal control in SOEs, thus improving the level of green innovation.

Table 7. Mechanism analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
	IC	**EnvrPat**	**Myopia**	**EnvrPat**	**SA**	**EnvrPat**
DID	0.145 ***	0.127 ***	−0.013 ***	0.125 ***	−0.022 ***	0.103 ***
	(4.690)	(5.590)	(−6.994)	(5.525)	(−9.327)	(4.577)
IC		0.018 ***				
		(4.328)				
Myopia				−0.285 ***		
				(−3.538)		
SA						−1.199 ***
						(−8.363)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
N	28,641	28,641	28,665	28,665	28,675	28,675
Adj.R^2	0.208	0.693	0.494	0.693	0.962	0.697

Note: T-statistic is enclosed in parentheses. *** $p < 0.01$.

4.4.2. Managerial Myopia

Under accountability pressure, SOE managers may be more inclined to conduct green innovations that are conducive to long-term sustainable development. Drawing on the previous literature, we used the proportion of short-term investments to total assets to capture managerial myopia (Myopia) [91]. Column (3) of Table 7 shows that the accountability system significantly reduces managerial myopia. After the variable Myopia was added into our basic regression, the findings in Column (4) indicate that a boosted awareness of long-term orientation can result in a significant advance in green innovation. There may be a partly mediating influence of Myopia, indicated by the fact that the coefficient of DID in Column (4) is smaller than the coefficient of DID in our main regression results (Column (1), Table 2).

4.4.3. Financial Constraint

Finally, we explored the role of alleviating financial constraints in the relationship between accountability and green innovation. Following Hadlock and Pierce [92], we used the absolute value of the SA index (SA) to capture financial constraint, with a larger SA indicating higher financing constraints. The results in Columns (5) and (6) of Table 7 show that the accountability system significantly inhibits financial constraints in SOEs, thereby leading to a boost in green innovation.

4.5. Heterogeneity Test

In this section, we conducted a series of heterogeneity tests to investigate how the influence of the accountability system on corporate green innovation varies with executive career horizon, accountability pressure, environmental regulation intensity, and industrial character.

4.5.1. Career Horizon

The promoting effect of the accountability system on environmental innovation may be more pronounced when top executives are approaching retirement. In the past, SOE executives approaching retirement had few career concerns. They were inclined to be shortsighted and prioritize individual interests over the firm's long-term development. The accountability system introduces lifelong accountability for them. After the implementation of the accountability system, SOE executives need to be accountable for the long-term consequences of their decisions, even if they are retired. Therefore, the accountability system may effectively curb the shortsightedness of executives approaching retirement and lead them to conduct green innovations that are favorable to sustainable development. Following a study by Beladi et al. [93], we used the age of the CEO to capture their career horizon. Retire equals 1 if the CEO is older than 55 years old, indicating that the CEO is approaching retirement and is less likely to be promoted, and 0 otherwise. In Column (1) of Table 8, the coefficient of DID $\times$ Retire is positively significant at the 1% level. These results imply that the accountability system has a more substantial impact on green innovation in firms with top executives approaching retirement.

Table 8. The results of heterogeneity tests.

	(1)	(2)	(3)	(4)
	Retire	**High Pressure**	**ERI**	**HPI**
DID	0.083 ***	0.069 *	0.094 ***	0.084 ***
	(3.328)	(1.845)	(4.813)	(3.374)
Retire	−0.014			
	(−0.943)			
DID × Retire	0.115 ***			
	(3.654)			
HighPressure		0.084		
		(1.376)		
DID × HighPressure		0.082 *		
		(1.846)		
ERI			−0.006	
			(−0.516)	
DID×ERI			0.047 **	
			(2.077)	
HPI				−0.026
				(−0.426)
DID × HPI				0.173 ***
				(3.425)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	28,696	28,696	28,696	28,696
Adj.R^2	0.694	0.694	0.669	0.694

Note: T-statistic is enclosed in parentheses. * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

4.5.2. Pressure of the Accountability System

Accountability pressure may be different across SOEs since the implementation intensity of the accountability system varies among regions. A rigorous accountability system could provide better supervision of SOE executives. Therefore, we anticipated that the positive impact of accountability on green innovation will be more pronounced in regions with a more rigorous accountability system. We used the heterogeneity criteria of loss determination in different regions to capture accountability pressure. Loss determination is an important process of the accountability system and is the basis for the subsequent responsibility determination. Stricter criteria for loss determination mean that SOE managers are more likely to be penalized for state asset losses and, in other words, face greater pressure to be held accountable. Specifically, HighPressure equals 1 if the loss determination criteria value is less than the sample mean, indicating high accountability pressure, and 0 otherwise. The interaction effect of DID and HighPressure on green innovation is shown in Column (2) of Table 8. The coefficient of DID × HighPressure is positively significant at the 10% level, suggesting that the promoting effect of the accountability system on green innovation is stronger for regions with higher accountability pressure.

4.5.3. Environmental Regulation Intensity

On the basis of institutional theory, a large body of studies has shown that environmental regulation is an important driver of corporate green innovation [15,94,95]. In our study, environmental regulation intensity may influence the effect of the accountability system. In regions with stricter environmental supervision, an environmental violation draws huge attention from the government, which makes SOE executives with environmental violation behaviors more likely to be investigated by the accountability system. Under the combined

pressures of environmental legitimacy and accountability systems, SOE executives may be more willing to conduct green innovation. Therefore, the effect of the accountability system on green innovation may be more pronounced in regions with intense environmental regulation. Following the study of Zhong et al. [96], we used the strength with which local governments enforce environmental regulations to capture environmental regulation intensity (ERI). Specifically, ERI is the proportion of the sewage fee or environmental tax to the regional gross domestic product (GDP) (With the implementation of the Environmental Protection Tax Law starting from 1 January 2018, the sewage charge system was replaced by an environmental protection tax system in China. Therefore, for samples prior to 2018, we used the sewage charge, and for samples after 2018, we used environmental tax). A higher ERI represents more intense environmental regulation. We divided the full sample into two groups based on the median value of ERI for each year. In Column (3) of Table 8, the coefficient of DID × ERI is significantly positive at the 5% level, indicating that the effect of the accountability system on green innovation is more pronounced in regions with intense environmental regulation.

4.5.4. High-Pollution Industry

Similarly to regional environmental regulation intensity, the effect of the accountability system may also vary across industries. As environmental problems become more and more prominent, highly polluting industries usually become vital ecological inspection targets for the government. The prior literature has shown that the pollution-curbing effect of low-carbon city pilot policy is more pronounced in high-pollution firms [97]. After the implementation of the accountability system, exposure to stricter government supervision makes SOE executive violations more likely to be detected in high-pollution industries. Under the pressure of the severe punishment of the accountability system, SOE executives in high-pollution industries may make more effort in green innovation to avoid attracting the attention of the government for environmental violations. Taken together, the promoting role of accountability systems in green innovation may be more effective in highly polluting industries. Drawing on prior studies [77,98], we identified high-pollution industries on the basis of the "catalogue of industries for listed firms" issued by the Ministry of Environmental Protection (MEP) in 2008. HPI equals 1 if a firm is in the category of high-pollution industries and 0 otherwise (specifically, industry classification codes B06, B07, B08, B09, C17, C19, C22, C25, C26, C28, C29, C30, C31, C32, C33, and D44 are classified as high-pollution industries). As can be seen in Column (4) of Table 8, the coefficients of DID and its interaction with HPI (DID×HPI) are significantly positive at the 1% level. These findings imply that the impact of the accountability system on promoting green innovation is more prominent in high-pollution industries.

4.6. Further Analysis

4.6.1. Green Innovation Quality

The existing literature shows that in order to enhance reputation and obtain green financing, some firms may increase the number of green patents regardless of whether they could add to the value of the firm [99]. Therefore, the increase in the quantity of green patent applications or grants may not reflect an improvement in green innovation quality. To further analyze the impact of the accountability system on green innovation quality, we replaced the explanatory variable of Model (1) with green patent citations (Citation). Following prior studies, we defined Citation as the natural logarithm of one plus the number of citations to the green patents submitted by the firm in the relevant year [100,101]. Column (1) of Table 9 reports the regression results of the impact of DID on Citation. The regression coefficient of DID is significantly positive at the 10% level,

implying that the accountability system not only promotes the quantity of corporate green innovation but also improves its quality.

Table 9. Further analysis.

	(1)	(2)	(3)
	Citation	**GIPersist**	**E-score**
DID	0.061 *	0.087 ***	1.198 ***
	(1.885)	(3.844)	(3.336)
Controls	Yes	Yes	Yes
YearFE	Yes	Yes	Yes
FirmFE	Yes	Yes	Yes
N	13,891	14,814	28,279
Adj. R^2	0.791	0.016	0.672

Note: T-statistic is enclosed in parentheses. * $p < 0.1$ and *** $p < 0.01$.

4.6.2. Green Innovation Persistence

Green development needs ongoing and persistent environmental protection and green innovation. Persistent green innovation facilitates knowledge accumulation and technological learning and may contribute to long-term pollution reduction, energy savings, and environmental improvements. Hence, we further examined whether the influence of the accountability system on green innovation is persistent. Drawing on studies by Triguero and Córcoles [102] and Ma et al. [103], we captured green innovation persistence by comparing the relevant and preceding two years' green innovation patent applications. Specifically, green innovation persistence (GIPersist) is measured as follows:

$$\text{GIPersist} = (\text{GIP}_t - \text{GIP}_{t-1}) / (\text{GIP}_{t-1} - \text{GIP}_{t-2}) \quad (1)$$

where GIP_t, GIP_{t-1}, and GIP_{t-2} are the natural logarithm of the number of green innovation patent applications in the years t, t−1, and t−2, respectively. As shown in Column (2) of Table 9, DID is positively associated with green innovation persistence at the 1% level. These results suggest that the accountability system also remarkably improves the green innovation persistence of SOEs.

4.6.3. Environmental Performance

The above analysis suggests that SOEs conduct more green innovations after the introduction of the accountability system. On the basis of these findings, we further examined whether the accountability system can truly improve environmental performance. We used the E-score obtained from the ESG rating data of the CNRDS database to capture environmental performance. Column (3) of Table 9 presents the influence of the accountability system on corporate environmental performance. As can be seen, the coefficient of DID is remarkably positive at the 1% level, indicating that the accountability system substantially improves the environmental performance of SOEs.

5. Conclusions and Discussion

5.1. Conclusions

Corporate green innovation has attracted more and more public attention due to the mounting environmental issues. There is now a consensus regarding achieving green growth and sustainable development through green innovation. Given the important role that SOEs play in green development, especially in emerging markets like China, the question of how to promote green innovation in SOEs is an urgent problem to be solved. In 2016, the Chinese government introduced the accountability system to strengthen the

supervision of SOE executives. It remains unknown whether the accountability system can promote green innovation by mitigating agency problems and encouraging executives to focus on long-term development, or hinder it, since overregulation may inhibit corporate risk-taking.

Based on the sample of listed A-share companies in China from 2013 to 2022, we examined the impact of the accountability system on green innovation. Our empirical results show that the accountability system notably promotes corporate green innovation, especially for central SOEs. After the implementation of the accountability system, both green utility patent applications and green invention patent applications in SOEs increased significantly. These findings are sustained across a battery of robustness tests. The mechanism analysis suggests that the accountability system can promote green invention by improving corporate internal controls, curbing managerial myopia, and alleviating financing constraints. In heterogeneity tests, we further found that the positive effect of the accountability system on green innovation is more pronounced when the CEO is close to retirement or subject to high accountability pressure, in heavily polluting firms, and in regions with intense environmental regulations. Furthermore, we found that the accountability system improves green innovation quality, persistence, and environmental performance.

5.2. Practical Implications

These conclusions can provide implications for policies and managerial practices. First, our results indicate the role that the executive accountability system has played in promoting the quantity and quality of corporate green innovation. Hence, in order to foster sustainable development and green growth, we suggest that regulators strengthen the supervision of SOE executives through the accountability system. Second, our findings show that the impact of the accountability system on promoting green innovation is more effective in regions with high accountability pressure and with intense environmental regulations. Therefore, regulators should strengthen the enforcement of accountability systems and integrate them with other regulations, such as the Environmental Protection Tax Law. Finally, the conclusions suggest that strengthening supervision of SOE managers is important to facilitating corporate green innovation. Therefore, we recommend that more attention be paid to SOE managers, especially those approaching retirement. For example, SOE managers should be strictly supervised so as to inhibit their opportunistic behavior, improve internal control, alleviate financing constraints, and incentivize them to carry out green innovation with a long-term sustainable development vision.

5.3. Limitations and Future Research

Future research may extend our study in several ways. First, our study focuses on the impact of the accountability system on corporate green innovation. Future research could further explore its influence on other green outcomes, such as green investment and pollution emissions. This could provide a more comprehensive understanding of its impact on sustainable development. Moreover, future studies could also investigate its impact on other firm behaviors, such as traditional innovation and financing. Second, although we performed some heterogeneity analyses, the effect of the accountability system may be influenced by other factors. Future studies could provide insights into its effect in various contexts, for example, taking the individual characters and government subsidies into consideration. Finally, future studies could be extended to other countries. We examined the impact of the accountability system on green development on the basis of a Chinese sample. SOEs are common worldwide, such as in Russia, India, France, and Viet Nam. Moreover, other countries have similar accountability systems for SOE managers. On the one hand, there are similarities between China and other emerging markets. For

instance, SOEs are an important force in green development, and corporate environmental performance may affect the promotion of SOE managers. On the other hand, accountability systems and government intervention vary across economies, and thus, the impact on green innovation may also differ. Therefore, exploring whether the findings of our studies can be transferred to other countries is an interesting research direction.

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Appendix A. Schedule of Implementation of the Accountability System by SASACs of Different Levels (2016–2022)

Recognition Year	Events and Regions That Built the Accountability System
2016	The General Office of the State Council issued "Opinions on Establishing an Accountability System for Business Operations and Investment in Violation of Regulations by State-Owned Enterprises"
2017	Anhui, Beijing, Guangxi, Heilongjiang, Henan, Hunan, Inner Mongolia, Jiangsu, Jiangxi, Liaoning, Ningxia, Sichuan, Tianjin, Yunnan
2018	Central SOEs, Hebei, Qinghai, Shanxi, Xinjiang
2019	Chongqing, Fujian, Guangdong, Guizhou, Jilin, Shandong, Shaanxi
2020	Gansu, Hubei, Shanghai, Zhejiang
2021	Hainan

Appendix B. Variable Definitions

Variable	Description
EnvrPat	Ln(1 + the number of green innovation applications)
EnvrInvPat	Ln(1 + the number of green invention patent applications)
EnvrUtyPat	Ln(1 + the number of green utility model patent applications)
DID	An indicator equals 1 if the firm is affected by the accountability system and 0 otherwise
Size	Ln(1 + total assets)
ROA	The ratio of net profit to average total assets
Lev	Total debt divided by total assets
Growth	The growth rate of total assets
Age	The number of years the firm has been listed

Variable	Description
Big4	An indicator equals 1 if the auditor is one of the big 4 accounting firms and 0 otherwise
First	The shareholding ratio of the largest shareholder
Dual	An indicator equals 1 if the CEO and the chairman are the same person and 0 otherwise
Boardsize	The number of total directors
Indep	The proportion of independent directors on the board of directors
Salary	Ln(the compensation of the top 3 executives)
IC	Ln(corporate internal control index provided by the DIB database)
Myopia	The proportion of short-term investments of total assets
SA	$SA = \lvert -0.737Size - 0.043Size^2 - 0.04Age \rvert$
Retire	An indicator equals 1 if the CEO is older than 55 and 0 otherwise
Highpressure	An indicator equals 1 if the loss determination criteria is less than the sample mean and 0 otherwise
ERI	The proportion of sewage fee or environmental tax to regional GDP
HPI	An indicator equals 1 if a firm is in high-pollution industries and 0 otherwise
Citation	Ln(1 + the number of citations to the green patents submitted by the firm in the relevant year)
GIPersist	$GIPersist = (GIP_t - GIP_{t-1})/(GIP_{t-1} - GIP_{t-2})$
E-score	The environmental performance score obtained from the CNRDS database

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