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Exploring the Impact of Firm Transparency on Green Innovation Legitimacy: Empirical Evidence from Listed Companies in China

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Abstract: Although the existing literature on innovation has little focus on information transparency, we aimed to determine how information transparency affects the legitimacy of green innovation in China. Accounting data, analyst data, and external audit data are used to evaluate a company's information transparency. This paper examines the impact of corporate transparency on the legitimacy of green innovation in the context of three external information sources to which stakeholders have access, utilizing data from 4017 Chinese companies listed between 2005 and 2020. Our estimation results indicate a significant positive correlation between informational accessibility and green innovation legitimacy. The results demonstrate a stronger relationship between corporate green innovation legitimacy and greater earning quality, more analyst monitoring, more accurate analyst surplus estimations, and international audits by the Big Four. This study seeks to present new empirical findings for Chinese listed companies in order to strengthen the legality of green innovation and validate the significance of corporate information transparency via a robustness test.

Keywords: firm transparency; green innovation legitimacy; earning quality; analyst estimations; auditing information

1. Introduction

Businesses are dependent on their natural environment and cannot thrive independently. Climate-related disasters have pushed the industry and raised public awareness of environmental concerns [1]. The occurrence of multiple weather-related disasters has increased public awareness of environmental preservation, hence accelerating industrial sector breakthroughs in sustainable production [2]. The application of numerous national and international environmental standards affects the conduct of businesses, enforcing a balance between financial prosperity and environmental protection [3]. These policies require businesses to integrate environmental sustainability into their overall company strategy, thereby providing stakeholders with both short-term and long-term benefits. As a result, a rising number of businesses have incorporated eco-friendly business strategies and innovations.

Innovation derives its validity from the legitimacy of an organization. It refers to the innovation strategy that ensures a competitive advantage by bringing new, compatible products or services inside a regulatory framework. Stakeholders drive the pursuit and acceptance of new outcomes [4,5] and play a crucial role in thoroughly analyzing the innovation's validity [6,7]. Various corporate elements, such as executive equity incentives [8], innovative capability [9], employee rewards [10], financial limitations of the company [11], protection of intellectual property [12] and tax incentives, can facilitate the legitimacy of innovation [13,14]. This can improve the legitimacy of a company's technological invention to some degree. Information asymmetries resulting from the external information available to stakeholders can cause organizations to struggle with finance and, as a result, experience

significant principal-agent issues [15,16]. This study aims to determine whether the transparency of external information collected by stakeholders affects the legitimacy of green innovation within firms.

Transparency, understood as the availability and accuracy of specific information to the firm's stakeholders [17], is one of the major corporate governance techniques used to reduce information asymmetry [18,19]. Due to its function as a signal to stakeholders, information transparency can help companies lower the cost of corporate finance [20,21] and strengthen corporate governance [22,23], hence reducing underinvestment and discouraging overinvestment. High firm transparency is always required to attract the interest of stakeholders, whereas companies that fail to maintain transparency risk incurring a noncompliance penalty [24]. Stakeholder theory posits that companies should consistently satisfy the needs of diverse stakeholders in order to maintain their support [25].

However, scholars have examined R&D investment in recent years, but they continue to approach it from a financial and governance standpoint [26]. Most researchers who have examined the relationship between information transparency and business innovation [27] have focused on R&D expenditure and R&D productivity. As environmental consciousness continues to increase, stakeholders' priorities have migrated away from profit and toward sustainability [28,29]. This change has increased the demand for the comprehensive disclosure of corporate information in order to monitor the actions of corporations [30]. Therefore, it can be concluded that a company's relationship with its stakeholders has an effect on the legitimacy of its ecological innovations. There are three primary external sources from which stakeholders can obtain information about a company's operations and performance: accounting [31], analysts [32], and external audits [33]. The question arises as to whether such transparency contributes to the perceived legitimacy of the green innovation initiatives of a company. In addition, it is of interest to investigate the specific role that transparency plays in each of these sources in influencing stakeholders' perceptions of the legitimacy of a company's green innovations.

China has one of the world's fastest-growing economies. It has relied on a development strategy that prioritizes heavy industry to achieve rapid economic growth, which has been accompanied by significant environmental damage [34]. The Chinese government has taken active steps to promote a green and low-carbon economy in response to the increasing pressures on the ecological environment. It is possible to analyze the connection between corporate transparency and green innovation in China. The first is that compared to Western capital markets, the external environment for Chinese capital market investor structure and manager evaluation is quite different. Studies on developed economies such as the US make the implicit assumption that their financial markets are sufficiently developed to be able to finance corporate innovation more effectively [35], but this is not the case in China, where moral hazard and adverse selection as a result of information asymmetries between the supply and demand of capital are the main financial constraints on Chinese companies [36]. Because of this, it is crucial to examine, using China as an example, the connection between green innovation and corporate information transparency.

This empirical study examines Chinese listed enterprises from 2005 to 2020. Taking into account the potential lag effect of green innovation, the empirical regressions presented in this research take into account a one-year lag. The contributions of this work consist mostly of the following three aspects: Using the concept of stakeholder information asymmetry, we examine the association between company information transparency and green innovation legitimacy. Second, utilizing the three external information sources available to stakeholders—accounting, analysts, and external audits—we evaluate the impact of corporate information transparency on the legitimacy of corporate green innovation. Additionally, we also enhance the effect of the quality of information from diverse sources on green innovation in companies. Thirdly, a cluster experiment was undertaken to investigate the heterogeneity in the effect of information transparency on the green innovation legitimacy. It can assist in the investigation of the different effect generated by

company variances, and business decisions and government policies can be formed with differentiated suggestions that account for the features of different companies.

The remainder of this paper is structured as follows. Section 2 undertakes a thorough examination of the extant literature, with the objective of constructing a robust theoretical framework and advancing the prior discussions on the topic. Section 3 details the data and methodology employed in this study. Section 4 presents a comprehensive analysis of the empirical results obtained. Finally, the study concludes with a synthesis of the key findings in Section 5.

2. Literature Review and Research Hypothesis

2.1. Information Transparency and Green Innovation Legitimacy

The presence of adverse selection and moral hazard issues arising from information asymmetries between firms and investors can significantly increase the vulnerability of firms to substantial external financing needs [37]. Consequently, this may result in underinvestment, impeding a firm's capacity to engage in innovative activities. The ability to access external financing is a critical determinant of a firm's innovation capabilities, given the substantial and ongoing capital investments required, which are challenging to sustain solely through internal funding [38]. Notably, investment in innovation entails greater risks and uncertainties compared to conventional investment endeavors, primarily due to heightened information asymmetry between investors and firms, along with more pronounced constraints on securing external financial resources.

Improving information transparency can reduce the information asymmetry between investors and businesses, thereby encouraging green innovation in businesses. First, increased information transparency facilitates the identification and assessment of innovative initiatives [23]. When information is more transparent, investors can gain a greater understanding of companies. Their in-depth knowledge of the company can reduce the difficulty of evaluating the innovation's unpredictability and facilitate decision-making in the face of information asymmetry. Second, increased information transparency can aid in innovation outcome prediction [19]. External information users of the company can better comprehend the entire innovation process and monitor the innovation project, thereby ensuring that it evolves in accordance with investors' greatest interests. Information about companies is primarily provided to the outside world by accountants, auditors, and analysts; therefore, we categorize and evaluate the information transparency of companies based on their information sources.

2.2. The Transparency of Accounting Information and Green Innovation Legitimacy

This study is based on accounting governance research that examines the accounting data attributes that enable effective governance and robust economic performance [18]. High-quality accounting data may increase investment by reducing the information gap between capital sources and firm executives [39]. Improving accounting quality may limit managerial incentives to overinvest through enhanced oversight or contracting, so assisting financially restricted firms in obtaining funding from investors and mitigating the difficulties associated with underinvestment in green innovation [40–42].

The lack of transparency in accounting information presents significant opportunities for selective disclosure and obfuscation, particularly for data that are not yet standardized by Generally Accepted Accounting Principles (GAAPs) [40]. This can result in higher costs for firms with low information transparency to undertake green innovation, compared to failing to report environmental information [41]. Based on economic considerations, corporations tend to prioritize the act of hiding information over investing in sustainable technologies or implementing measures to decrease environmental pollution [42]. However, enhanced transparency in accounting information would allow stakeholders to identify and scrutinize any undisclosed environmental information. The cost of concealing environmental information could also increase as a result. When non-disclosure costs exceed the benefit, firms tend to disclose environmental information [36]. This results in

a stronger incentive for companies to adopt green innovation and transform their operations in an environmentally responsible manner when the marginal benefit is closer to the marginal cost.

The high level of uncertainty associated with green innovation projects provides issues for external stakeholders who are at an informational disadvantage in terms of projecting future returns. The enormous degree of information asymmetry in such initiatives exacerbates the possibility of moral hazard and adverse selection, such as the concealing of hazards and manipulation of R&D expenses to inflate surpluses [43]. To reduce the related risks, investors sometimes apply risk premiums or restrict investment, leading to increasing financing costs for firms. Enhanced accounting transparency can serve to reduce uncertainty and information asymmetry [44], thereby lowering the risk premium demanded by market participants and reducing the external financing costs for firms, easing financing constraints, and promoting the development of green innovation. Accordingly, we propose Hypothesis 1.

H1: *The accounting information transparency of listed companies has a positive impact on green innovation.*

2.3. The Transparency of Analysts' Information and Green Innovation Legitimacy

In the academic literature, the role of analysts in the market has garnered considerable attention. It is commonly acknowledged that analysts, as information intermediates and outsider monitors [45], can lessen investors' information asymmetry and mitigate agency concerns for companies [46]. As an important data middleman in the market, analysts utilize their industry expertise to generate surplus projections [47], which serve as a crucial basis for corporate decision making and increase the information content of corporate share prices [48]. Analysts' estimates are frequently communicated to investors, and when these forecasts are publicly provided, the information asymmetry between firms and investors is diminished. This reduction in asymmetry can relieve enterprises' financial limitations and boost their innovation output. In this sense, professional analysts can play a vital role in decreasing information asymmetry and supporting high-quality business innovation via investment in patents and technologies that can boost competitiveness. Hence, an increase in the number of analysts' will boost the transparency of firms' information, thereby contributing to the development of green innovation [49].

Nevertheless, firms are frequently constrained by the amount and duration of their capital, causing investors and managers to prioritize short-term success above long-term interests [50]. This short-term orientation can lead to short-sighted action on the part of businesses, to the detriment of their long-term interests, and hinder investment in innovation and patents that can improve their competitiveness. However, if analysts offer realistic or beatable earnings estimates, managers do not have to compromise long-term growth to suit analysts' expectations. The provision of accurate information by analysts has been shown to improve the capability of corporate managers to make informed long-term strategic decisions [51]. As green innovation activities serve as a catalyst for sustainable business growth, the precision of information provided by analysts has a positive impact on the promotion of green innovation initiatives within a firm. Consequently, this study proposes the given hypothesis:

H2: *The analysts' information transparency of listed companies positively impacts green innovation legitimacy.*

2.4. The Transparency of Audit Information and Green Innovation Legitimacy

External audits have a variety of advantages, including decreased economic interdependence and improved independence of the auditor, specific industry expertise and technical proficiency, and the capacity to provide the public with assurance of audit information's accountability [34,52]. These characteristics contribute to the investor perception

that reports prepared by external auditors with a high degree of independence are of higher quality and have higher credibility.

The following is the rationale for external auditing in the context of corporate green innovation legitimacy: Independent external audits are seen as reliable and high-quality disclosures that reduce funding limitations and foster innovation among businesses [53]. First, high-quality disclosure equips ordinary shareholders with pertinent information, allowing them to evaluate technology value and exercise their decision-making and monitoring rights, thereby encouraging investment in technological innovation [54–56]. In addition, high-quality information transparency lessens the regulatory burden on managers imposed by controlling shareholders, decreasing their incentives to forego technological innovation due to the high cost of regulation and enhancing their micro-intention to invest in technological innovation. Hence, the following hypothesis is proposed in this study:

H3: *The audits' information transparency has a positive impact on green innovation legitimacy for listed companies.*

3. Data and Empirical Strategy

3.1. Samples

To conduct an empirical test of the above theoretical hypothesis, the data of Chinese A-share listed companies from 2005 to 2020 are matched with data on green patent applications. The research period begins in 2005 because it is necessary to calculate excess quality indicators and specific control variables for a specific year using operating cash flow data from the five preceding years. The comprehensive cash flow statement is only available beginning in 2000. However, after 2020, data availability and stability will decline due to the negative economic consequences of the COVID-19 outbreak. This paper uses two primary data sources. We acquired the crucial financial data of a corporation from the CSMAR databases. The criteria and procedures for data screening and processing are as follows: Listed firms in the financial and insurance industries are eliminated, as well as samples with missing financial data and other pertinent information. ST companies are also excluded. The term ST firms refers to Chinese listed companies that have experienced losses for two years running and have unusual financial or other circumstances. The website of China's State Intellectual Property Office provided the information used in this study regarding patent applications. In addition, in order to mitigate the interference of outliers on the study findings, the 1% and 99% percentile of variables were winsorized. After excluding ST and related data from listed firms with incomplete data, the above data were matched to provide a final sample of 38,845 observations.

3.2. Variable Selection

3.2.1. Green Innovation Legitimacy

Due to stakeholder acceptance and recognition, green innovation legitimacy is a concentrated reflection of the level of innovation of listed companies [57]. the number of green patent applications is utilized to determine the level of green technical innovation among businesses [58], because applications for green patents have a high technical bar and are in use during the application procedure. Thus, green patent applications tend to better represent enterprises' real green technology innovation capability. In green patent applications, inventive innovations can be distinguished from other inventions by their superior technical content. In the empirical process, the natural logarithm of the number of patent applications for green inventions plus one is utilized as a measurement (GIIL). The robustness test uses the natural logarithm of the amount of green patent applications plus one (GISL).

3.2.2. Transparency

Transparency is defined as the degree to which external information users have effective access to certain information about a publicly traded listed company, such as annual reports, disclosure announcements, analyst reports, and information willingly given by the

company [59]. We measure the transparency of companies based on the earning quality, analysts' earnings forecasts, and auditors, using the previous literature.

Our first transparency indicator is the indicator (DD) based on the model adapted from Dechow and Dichev [60]. We first determine the following model by industry and year in order to calculate this variable:

$$TCA_{i,t} = a_0 + a_1 CFO_{i,t-1} + a_2 CFO_{i,t} + a_2 CFO_{i,t+1} + a_4 \Delta REV_{i,t} + a_5 PPE_{i,t} + e_{i,t} \quad (1)$$

In model (1), TCA represents total current accrued profit, which equals operating profit minus operating cash flow and depreciation and amortization expenses. CFO represents operating cash flow, REV is the amount of variation in operating income, PPE represents the value of fixed assets at the end of the year, and i and t represent the company and year, respectively. Furthermore, e denotes the error term. All the factors listed above are divided by the average total assets. After grouping the regressions by "industry-year" using the model in (1), we obtain the residuals of each firm's regression for each year $e_{i,t}$ (the manipulated accrued profit in that year). The earning quality indicator (DD) for the company i in year t is obtained by calculating the standard deviation of the regression residuals for year t and the prior four years. For comparison with other metrics of transparency, this indicator is multiplied by -1. Consequently, the higher the DD, the greater the earning quality.

The second and third indicators are analyst-related. The literature indicates that stock analysts add to the transparency of firms by gathering and integrating public and private information to determine the worth of the firm's shares [61]. To this purpose, we use the number of analysts tracked (ANALYST) [62] and the accuracy of analysts' earnings estimates (ACCURACY) to quantify transparency [63]. The ANALYST criterion relates to the number of analysts providing top-line estimates of a company's annual earnings. As an information broker, more analysts enrich the information environment of a corporation to a certain level, therefore the higher the ANALYST, the higher the transparency.

The accuracy of analysts' earnings forecasts reflects the information-gathering behavior of analysts and the quality of transparency of firms [64]. The more accurate analysts' earnings estimates are, the more likely the information is to be transparent. To determine the accuracy of analysts' earnings projections, we first calculate the median earnings per share projected by numerous analysts for the same year, then deduct the actual profits per share and divide by the share price from the prior year. This absolute value is then multiplied by -1 to determine ACCURACY. The higher the ACCURACY, the more accurate the analysts' earnings forecast and the greater the transparency [59].

The fourth sign of openness in this study is whether or not a corporation has engaged the Big Four as its auditors for the year. Previous study has demonstrated that the quality of financial reports audited by the Big Four may be higher, and hence may promote company openness [62]. Furthermore, a corporation may be prepared to commit to giving accurate and understandable financial information if it chooses to work with one of the Big Four, and as a result, the Big Four may capture traits related to corporate transparency.

We also built a composite transparency indicator, TRANS, based on the four transparency variables stated above. Its value is equal to the scaled percentile rank of the four variables DD, ANALYST, ACCURACY, and B1G4 [30,62]. If any of the stated companies are absent, TRANS is equal to the mean of the remaining variables' percentile scores. Naturally, the TRANS is more transparent the larger it is.

3.2.3. Control Variables

This paper also included nine control variables in the research model, namely, firm size, sales growth, leverage, rate of return on common stockholders' equity (ROE), percentage of inventory and fixed assets to total assets, top five shareholders' shareholding, TobinQ, and age of listing. Previous study has argued that business size plays a key influence in the accumulation of creative knowledge assets [65]. This article employed a natural logarithmic form of total assets to measure firm size [66]. Sales growth may have ties with

innovative knowledge assets and sustainability-friendly practices because it is related with innovation [67]. Leverage is typically employed as a proxy variable for reflecting the risk level [68], and high leverage may hinder investment in green management [69]. ROE shows the profitability of business owners [70], which may impact the resources commitment to creative knowledge assets [71]. It has been suggested that the proportion of inventory and fixed assets to total assets influences the propensity for green innovation. It has been proven that TobinQ is related to being innovatively active. All the definition and measurement of variables you can find in Table 1.

Table 1. Definition and measurement of variables.

Code	Index
GIIL	The natural logarithm of the number of invention patent applications plus one.
GIIS	The natural logarithm of the amount of green patent applications plus one.
DD	The earning quality indicator (DD) for the company i in year t is obtained by calculating the standard deviation of the regression residuals for year t and the prior four years.
ANALYST	Total number of analysts making a forecast for year t's earnings. Higher values indicate greater transparency.
ACCURACY	Product of (−1) times the absolute value of the forecast error scaled by beginning stock price, where the forecast error is the analysts' mean annual earnings forecast less the actual earnings as reported by analysts.
Big Four	Whether the auditors come from the Big Four or not.
TRANS	A composite measure of transparency, calculated as the average of the scaled percentile rank of four variables, ANLYSIT, ACCURACY, BIG4.
Size	The natural logarithm of total assets plus one.
Lev	Ratio of total debt to total assets.
ROE	Return of equity.
growth	Growth rate of sales.
INV	Inventory to total assets.
FIXED	Fixed assets to total assets.
Top5	Shareholdings of Top 5 shareholders.
TobinQ	Book value of assets+ (market value of equity-book value of equity)/book value of assets. It reflects the valuation placed on the assets by the market relative to their book value.
Listage	Age of listing companies

3.3. Model

To test H1a, we estimated the following model (1) using a fixed-effect panel regression that links green innovation legitimacy in year t + 1 to firm transparency measures as well as a set of control variables in year t:

$$GrInnovation_{i,t+1} = \beta_0 + \beta_1 Transparency_{i,t} + \beta_2 Controls_{i,t} + \tau_t + \theta_d + \varepsilon_{i,t} \qquad (2)$$

where GrInnovation$_{i,t+1}$is the green innovation legitimacy of enterprise i in year t + 1, *Transparency$_{i,t}$* is proxied by the individual transparency component or composite transparency, which is the indicator of the transparency of companies i in year t. β1 is the key coefficient that we are concerned with. *Controls$_{i,t}$* represents a series of control variables and a comprehensive leverage of enterprise i in year t. τ_t and θ_d represent the fixed effects at the year level and industry level, respectively. They are utilized to remove temporal and industrial heterogeneity interference. Finally, $\varepsilon_{i,t}$ is the error term. Given the possibility of serial correlation between error terms, standard errors are clustered by enterprise [72–74].

4. Empirical Results

4.1. Descriptive Statistics and Correlations

According to the descriptive statistics of the main variables in Table 2, the GIIL has a mean value of is 0.4919 and a standard deviation of 0.9279. The mean value of GISL is 1.2342, with a standard deviation of 1.2342. This demonstrates that companies have fewer green invention innovations and more designable green innovations. The number of observations for DD has fallen from 38,845 to 21,244 due to the fact that the quality of earnings (DD) is calculated by the standard deviation of manipulated accrued profits over the past five years. Moreover, when assessing manipulated accrued earnings by industry and year, more than 20 data per year are required for each industry. The mean of the DD is −0.0382, with a standard deviation of 0.0290. ANALYST has a mean of 1.3599 and a median of 1.3863. The mean value of ACCURACY is −0.0366 and the standard deviation is 0.0636. In addition, BIG4 has a mean of 0.057, reflecting that only 5.7% of the sample use Big Four audit companies. The TRANS final composite indicator has a mean value of 0.3332 and a standard deviation of 0.1899.

Table 2. Descriptive statics of variables.

	N	Mean	Std	Min	Median	Max	VIF
GIIL	38,845	0.4919	0.9279	0.0000	0.0000	7.2313	
GISL	38,845	1.2342	0.9068	0.6931	0.6931	7.3645	
DD	21,244	−0.0382	0.0290	−0.2967	−0.0301	−0.0006	2.12
ANALYST	38,845	1.3599	1.1667	0.0000	1.3863	4.3307	2.52
ACCURACY	38,845	−0.0366	0.0636	−2.4744	−0.0181	0.0000	1.80
BIG4	38,845	0.0570	0.2319	0.0000	0.0000	1.0000	1.82
TRANS	38,845	0.3332	0.1899	0.0050	0.3250	1.0000	4.15
Size	38,845	21.9685	1.2758	19.2360	21.7827	26.3978	2.43
Lev	38,845	0.4331	0.2062	0.0274	0.4307	0.9911	1.51
ROE	38,845	0.0655	0.1379	−1.3545	0.0746	0.4464	1.78
INV	38,845	0.1500	0.1383	0.0000	0.1157	0.7720	1.42
FIXED	38,845	0.2288	0.1696	0.0015	0.1948	0.8064	1.31
Growth	38,845	0.1798	0.4310	−0.7368	0.1155	4.3304	1.08
Top5	38,845	0.5417	0.1528	0.1749	0.5469	0.9065	1.22
TobinQ	38,845	1.9477	1.3314	0.8024	1.5303	17.7288	1.41
ListAge	38,845	1.9876	0.8990	0.0000	2.1972	3.3322	1.16

Note: t statistics in parentheses.

The distributions of other variables are identical to those reported in previous studies. As a result of the fact that all VIFs are below the 10-point threshold [75,76], there are no evident linkages between variables. In addition, a Hausman test indicates that a fixed effect model should be utilized in this research.

The Pearson correlations between the transparency component variables are shown in Table 3. The majority of the measures of transparency are substantially associated in the predicted direction, indicating that they reflect consistent theoretical underpinnings. Four metrics of transparency—DD, ANALYST, ACCURACY, and TRANS—are significantly associated with one another, as predicted. At the 1% level, the majority of pair-wise correlations are significant in the predicted direction. Moreover, TRANS is significantly and strongly connected with innovation metrics, providing evidence of a positive relationship between transparency and innovation. Thus, hypotheses H1, H2, and H3 are substantially accepted.

Table 3. Pearson Correlation.

	GIIL	GISL	DD	ANALYS	ACCURACY	BIG4	TRANS	Size	Lev	ROE	INV	FIXED	Growth	Top5	TobinQ	ListAge
GIIL	1															
GISL	0.943 ***	1														
DD	0.104 ***	0.117 ***	1													
ANALYST	0.247 ***	0.248 ***	0.154 ***	1												
ACCURACY	−0.00700	−0.016 ***	0.274 ***	0.208 ***	1											
BIG4	0.166 ***	0.158 ***	0.074 ***	0.171 ***	0.023 ***	1										
TRANS	0.226 ***	0.221 ***	0.496 ***	0.706 ***	0.405 ***	0.486 ***	1									
Size	0.412 ***	0.433 ***	0.239 ***	0.385 ***	−0.069 ***	0.340 ***	0.435 ***	1								
Lev	0.116 ***	0.136 ***	0	−0.067 ***	−0.186 ***	0.085 ***	0.00200	0.437 ***	1							
ROE	0.052 ***	0.052 ***	0.246 ***	0.358 ***	0.576 ***	0.061 ***	0.370 ***	0.105 ***	−0.210 ***	1						
INV	−0.068 ***	−0.073 ***	−0.014**	−0.052 ***	−0.012 **	−0.024 ***	−0.036 ***	0.093 ***	0.310 ***	0.024 ***	1					
FIXED	−0.086 ***	−0.075 ***	0.112 ***	−0.043 ***	−0.031 ***	0.058 ***	0.039 ***	0.064 ***	0.107 ***	−0.083 ***	−0.318 ***	1				
Growth	0.00800	0.00800	−0.00800	0.126 ***	0.178 ***	−0.00500	0.116 ***	0.041 ***	0.036 ***	0.250 ***	0.042 ***	−0.053 ***	1			
Top5	0.009 *	0.013 **	0.032 ***	0.155 ***	0.091 ***	0.177 ***	0.154 ***	0.118 ***	−0.092 ***	0.189 ***	−0.041 ***	0.039 ***	0.072 ***	1		
TobinQ	−0.061 ***	−0.080 ***	−0.192 ***	0.081 ***	0.123 ***	−0.078 ***	0.00600	−0.311 ***	−0.232 ***	0.054 ***	−0.080 ***	−0.116 ***	0.012 **	−0.140 ***	1	
ListAge	0.092 ***	0.093 ***	−0.042 ***	−0.118 ***	−0.087 ***	0.047 ***	0.055 ***	0.380 ***	0.378 ***	−0.166 ***	0.135 ***	0.101 ***	−0.056 ***	−0.368 ***	0.043 ***	1

Note: t statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.2. Baseline Analysis

Table 4 presents the results of transparency and green innovation legitimacy. Column 1 shows the regression of the earning quality indicator for model (2). The DD coefficient is 0.684, which is statistically significant at the 0.01 level. The two indicators from the analyst's perspective demonstrate that the quantity of analysts (ANALYST) has a minor impact on green invention innovation. Its coefficient is 0.0052, which is statistically significant at the 0.01 level. In comparison, the accuracy of analysts (ACCURACY) has a stronger impact on green innovation, as estimated by a coefficient of 0.265%. The impact of analysts providing correct information can increase the transparency of the firm on green innovation. According to the BIG4 indicator, the information provided by the company's auditor can help improve the company's green innovation. The transparency of firm information has a significant positive effect for green inventions, thus proving hypotheses H1, H2, and H3.

Table 4. Baseline results.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**GIIL**	**GIIL**	**GIIL**	**GIIL**	**GIIL**
DD	0.684 ***				
	(0.194)				
ANALYST		0.00520 ***			
		(0.000553)			
ACCURACY			0.265 ***		
			(0.0798)		
BIG4				0.103 ***	
				(0.0193)	
TRANS					0.0495 *
					(0.0257)
Size	0.255 ***	0.260 ***	0.304 ***	0.282 ***	0.282 ***
	(0.0104)	(0.00800)	(0.0102)	(0.00751)	(0.00773)
Lev	−0.0168	−0.0212	−0.0344	−0.0215	−0.0340
	(0.0422)	(0.0318)	(0.0412)	(0.0318)	(0.0318)
ROE	0.00233	0.0829	0.0901	−0.0945	0.0576
	(0.0694)	(0.0574)	(0.0840)	(0.0678)	(0.0574)
INV	−0.343 ***	−0.294 ***	−0.294 ***	−0.309 ***	−0.301 ***
	(0.0552)	(0.0452)	(0.0619)	(0.0451)	(0.0452)
FIXED	0.0910 *	0.129 ***	0.204 ***	0.118 ***	0.124 ***
	(0.0495)	(0.0371)	(0.0475)	(0.0371)	(0.0371)
Growth	−0.0236 ***	−0.0326 ***	−0.0242 ***	−0.0334 ***	−0.0339 ***
	(0.00904)	(0.00759)	(0.00921)	(0.00759)	(0.00761)
Top5	−0.193 ***	−0.121 ***	−0.143 **	−0.164 ***	−0.126 ***
	(0.0610)	(0.0443)	(0.0576)	(0.0428)	(0.0444)
TobinQ	0.0137 ***	0.000153	0.00687	0.00673 *	0.00737 **
	(0.00488)	(0.00366)	(0.00459)	(0.00346)	(0.00358)
ListAge	0.0693	−0.00705	−0.104 ***	−0.0233 **	−0.0174
	(0.0666)	(0.0111)	(0.0194)	(0.0108)	(0.0111)
Constant	−5.171 ***	−5.267 ***	−6.285 ***	−5.778 ***	−5.715 ***
	(0.259)	(0.177)	(0.232)	(0.167)	(0.171)
Year Fixed	Yes	Yes	Yes	Yes	Yes
Industry Fixed	Yes	Yes	Yes	Yes	Yes
R-squared	0.405	0.433	0.442	0.431	0.431
Number of stock	4017	4017	4017	4017	4017

Note: t statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3. Heterogeneity Analysis

4.3.1. Analysis of the Separation of Ownership and Control

The transparency of information may be vital in companies with severe agency problems [72]. Agency concerns brought on by issues such as insider misappropriation can enhance the risks that investors in a firm face. Transparency is unlikely to totally address

agency conflicts since the creation of knowledge-based products is exclusive and the disclosure of sensitive information could impair the value of an innovation [73,74]. Additionally, investors are more interested in learning about companies with major agency concerns [77]. To determine the severity of the agency problem, we study the current literature [78,79] and use the ownership and control separation of the company's (DUAL) ultimate controller as an indicator variable.

To test this, we explored the influence of transparency on corporate green innovation in groups, using the separation of ownership and control as a proxy scalar for the severity of agency costs; the results are presented in columns 1 and 2 of Table 5. The results indicate a significant positive correlation between the statistics of companies that separate ownership and control. The results are consistent with our theoretical hypotheses and highlight the importance of transparency in green innovation promotion.

Table 5. Heterogeneity analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
	DUAL = 0	DUAL = 1	Low GM	High GM	Low INST	High INST
VARIABLES	GIIL	GIIL	GIIL	GIIL	GIIL	GIIL
TRANS	0.00353	0.169 ***	−0.0286	0.0783 **	−0.0212	0.104 **
	(0.0285)	(0.0590)	(0.0390)	(0.0354)	(0.0315)	(0.0436)
Size	0.253 ***	0.337 ***	0.308 ***	0.270 ***	0.240 ***	0.321 ***
	(0.00887)	(0.0203)	(0.0130)	(0.0112)	(0.0111)	(0.0140)
Lev	−0.0225	−0.145 *	−0.0499	−0.0710	−0.0644	−0.0272
	(0.0358)	(0.0780)	(0.0535)	(0.0434)	(0.0410)	(0.0544)
ROE	−0.0406	0.0124	0.0196	−0.0347	−0.0294	0.00858
	(0.0327)	(0.0663)	(0.0485)	(0.0371)	(0.0334)	(0.0507)
INV	−0.250 ***	−0.127	−0.493 ***	−0.0610	−0.201 ***	−0.236 ***
	(0.0504)	(0.123)	(0.0797)	(0.0619)	(0.0561)	(0.0821)
FIXED	0.0850 **	0.363 ***	0.192 ***	0.0875	0.0827 *	0.222 ***
	(0.0411)	(0.0992)	(0.0588)	(0.0541)	(0.0478)	(0.0653)
Growth	−0.0233 ***	−0.0569 ***	−0.0454 ***	−0.0159 *	−0.00578	−0.0421 ***
	(0.00849)	(0.0174)	(0.0141)	(0.00906)	(0.00918)	(0.0121)
Top5	−0.0991 **	−0.227 **	−0.188 **	−0.158 ***	−0.153 ***	−0.134 *
	(0.0487)	(0.115)	(0.0735)	(0.0605)	(0.0551)	(0.0797)
TobinQ	0.00184	0.00977	−0.0108	0.00944 **	0.00561	0.00810
	(0.00413)	(0.00730)	(0.00721)	(0.00428)	(0.00516)	(0.00540)
ListAge	−0.0189	−0.0311	−0.0518 ***	0.00738	0.0284 **	−0.000164
	(0.0128)	(0.0248)	(0.0180)	(0.0152)	(0.0135)	(0.0246)
R-squared	0.233	0.181	0.285	0.175	0.156	0.241
No. of stock	2371	1646	1844	2173	2286	1731

Note: t statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3.2. Analysis of Ecologically Responsible Management

Green management is a crucial aspect in enhancing the resource acquisition, allocation, and utilization efficiency of enterprises [80]. The adoption of green management techniques and methods boosts the overall environmental awareness [81] and sustainability performance of companies [82]. In a highly competitive business environment, the implementation of green management strategies in alignment with national environmental policies provides access to valuable resources such as government tax incentives and environmental management funds [83]. Additionally, it helps establish positive relationships with stakeholders, caters to their green market needs, and strengthens their recognition of the company's commitment to environmental sustainability. The implementation of green management practices enables managers to effectively assess the environmental impact of their decisions and avoid potential penalties while enhancing the company's overall environmental performance. It also sends a positive signal to the external stakeholders that the company prioritizes social responsibility, contributing to the growth of its reputation and sustainable development performance.

The assessment of green management innovation was quantified using five indicators [84]. Given the availability of data, the overall score was obtained through the summation of ISO14001 [85] and ISO9001 [86] certifications present in the environmental

regulation and certification disclosure table of the CSMAR environmental database, as well as the presence of an environmental management system, environmental education and training programs, and special environmental initiatives in the management disclosure table of listed companies. The resulting total score serves as a surrogate indicator for green management innovation (GM).

The categorization of businesses according to their aptitude for ecologically responsible management is a beneficial aspect of green innovation. Companies in the high-GM category are above the industry median, whereas companies in the low-GM group are below the industry median. According to the regression study in columns 3 and 4 in Table 5, TRANS and GIIL are significantly positively correlated in the high-GM group.

4.3.3. Analysis of Institutional Ownership

We assess the impact of information transparency on green innovation by classifying institutional investors according to their shareholdings (INST). Institutional investors are better at exploiting and analyzing the financial reporting information than individual investors, and they can rely on analysts to forecast information, giving them a stronger ability to do so [87,88]. Furthermore, institutional shareholders help promote firms' long-term investment, including innovation [89,90].

In Table 5, columns 3 and 4 present the regression results for institutional investors with a high and low median shareholding, respectively. The results of the regression indicate that the TRANS coefficient is substantially related in the group with high institutional ownership. For the category of low institutional investment, however, there is no clear relationship.

4.4. Robustness Checks

4.4.1. Instrumental Variable Method

To address the endogeneity of transparency factors, we use regressions with instrumental variables. We used the firm's one-year lagged return on total assets (L.ROA), the type of audit report (OPINION), the number of management shares (Mshare), and whether the firm is a component of the SSE 180 or Shenzhen 100 index (Index) as instrumental variables for the transparency composite indicator TRANS [23,61,91]. The first column of Table 6 displays the findings of the regression on the transparency component TRANS. The TRANS fitted values are then passed over to stage two and shown in column 2. We can observe from the findings that TRANS and the four instrumental factors have statistically significant correlations. The results of the second stage of the regression are consistent with the results discussed before in that they are all significantly positively correlated. As a result, the results obtained using the instrumental variables do not differ significantly from those obtained in the earlier research.

Table 6. instrumental variable method.

	1st Stage	2rd Stage
VARIABLES	**TRANS**	**GIIL**
L.ROA	0.388 ***	
	(0.0164)	
OPINION	0.268 ***	
	(0.00338)	
Mshare	−0.00458 ***	
	(0.0018)	
Index	0.0805 ***	
	(0.00553)	
TRANS		0.598 ***
		(0.100)
Size	0.0545 ***	0.310 ***
	(0.000927)	(0.00943)

Table 6. *Cont.*

	1st Stage	2rd Stage
VARIABLES	**TRANS**	**GIIL**
Lev	−0.0451 ***	0.0332
	(0.00511)	(0.0301)
ROE	0.716 ***	0.376 ***
	(0.0303)	(0.0728)
INV	0.0147 **	−0.493 ***
	(0.00717)	(0.0407)
FIXED	0.0334 ***	−0.614 ***
	(0.0054)	(0.0330)
Growth	0.0016 ***	−0.0312 ***
	(0.0018)	(0.0111)
Top5	−0.129 ***	−0.324 ***
	(0.0060)	(0.0384)
TobinQ	0.0113 ***	0.0265 ***
	(0.0007)	(0.00402)
ListAge	−0.0169 ***	−0.0373 ***
	(0.0015)	(0.00855)
INST	0.148 ***	0.0263
	(0.0045)	(0.0278)
Constant	−0.0871 ***	−6.205 ***
	(0.0202)	(0.179)
Year fixed	Yes	Yes
Firm fixed	Yes	Yes
R-squared	0.529	0.301

Note: t statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$.

4.4.2. Replacing Variables Analysis

This study will conduct robustness tests to further evaluate the robustness of the initial regression's results. GISL is a replacement for GIIL, and the findings are shown in Table 7. The results are consistent with the usual regression model.

Table 7. Replacing variables analysis.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**GISL**	**GISL**	**GISL**	**GISL**	**GISL**
DD	0.525 ***				
	(0.178)				
ANALYST		0.0317 ***			
		(0.00420)			
ACCURACY			0.193 ***		
			(0.0729)		
BIG4				0.108 ***	
				(0.0178)	
TRANS					0.0187
					(0.0234)
Size	0.251 ***	0.260 ***	0.299 ***	0.279 ***	0.279 ***
	(0.00953)	(0.00744)	(0.00932)	(0.00693)	(0.00712)
Lev	−0.0226	0.0165	−0.0162	0.0110	−0.00111
	(0.0383)	(0.0289)	(0.0367)	(0.0293)	(0.0289)
ROE	−0.298 ***	−0.257 ***	−0.228 ***	−0.0432	−0.264 ***
	(0.0509)	(0.0416)	(0.0565)	(0.0625)	(0.0417)
INV	0.146 ***	0.166 ***	0.243 ***	−0.277 ***	0.158 ***
	(0.0456)	(0.0342)	(0.0433)	(0.0416)	(0.0342)
FIXED	−0.0217 ***	−0.0322 ***	−0.0208 **	0.149 ***	−0.0315 ***
	(0.00832)	(0.00698)	(0.00839)	(0.0342)	(0.00699)
Growth	−0.259 ***	−0.194 ***	−0.168 ***	−0.0309 ***	−0.185 ***
	(0.0546)	(0.0395)	(0.0510)	(0.00700)	(0.0395)

Table 7. *Cont.*

VARIABLES	(1) GISL	(2) GISL	(3) GISL	(4) GISL	(5) GISL
Top5	0.00607	−0.00418	0.00156	−0.191 ***	0.00100
	(0.00440)	(0.00327)	(0.00403)	(0.0395)	(0.00322)
TobinQ	0.0936	−0.00920	−0.0876 ***	0.00230	−0.0197 **
	(0.0615)	(0.0100)	(0.0175)	(0.00319)	(0.00993)
ListAge	0.251 ***	0.260 ***	0.299 ***	−0.0216 **	0.279 ***
	(0.00953)	(0.00744)	(0.00932)	(0.00996)	(0.00712)
INST	−0.0226	0.0165	−0.0162	0.279 ***	−0.00111
	(0.0383)	(0.0289)	(0.0367)	(0.00693)	(0.0289)
Constant	−4.499 ***	−4.595 ***	−5.534 ***	−5.057 ***	−4.965 ***
	(0.237)	(0.163)	(0.211)	(0.153)	(0.156)
Year Fixed	Yes	Yes	Yes	Yes	Yes
Industry Fixed	Yes	Yes	Yes	Yes	Yes
R-squared	0.245	0.248	0.251	0.246	0.246
Number of stock	4017	4017	4017	4017	4017

Note: t statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$.

5. Conclusions

5.1. Research Conclusions

This study focuses on Chinese A-share listed companies from 2005 to 2020. The purpose of this study is to examine the mechanism by which corporate information transparency influences green innovation. We examine the informational transparency of businesses using three distinct approaches: accounting information, analyst information, and information from external auditing. The primary research query is whether or not corporate information transparency enhances green innovation. The following are our findings: Transparency in accounting information has a significant positive effect on the legitimacy of corporate green innovation. From the perspective of analysts, the accuracy of analysts has a significantly greater impact on the legitimacy of green innovation than the quantity of analysts. Audit information can also contribute to the legitimacy of green innovation within corporations. Our subgroup studies confirm that firms without significant agency concerns gain from information transparency. The effect of information transparency on corporate green invention innovation is more pronounced in businesses with strong green management capabilities and a higher proportion of institutional ownership, consistent with Roh et al. [92]. Our research contributes to the literature on the actual effects of accounting by shedding light on the impact of the firm's information environment on innovation.

5.2. Management Enlightenment

Initially, this study highlights that firm transparency has a significant impact on the perceived legitimacy of green innovation initiatives. As such, organizations striving for sustainability should prioritize transparency in their operations. This can be accomplished through a variety of approaches, including actively engaging in stakeholder communication and clearly communicating the engagement of key stakeholders. In addition, it may improve firm–stakeholder interaction, enable numerous information access points, and assure the authenticity, accuracy, comprehensiveness, timeliness, regulatory compliance, and impartiality of the information given.

Despite the encouragement of social responsibility report disclosures in China, the general level of such disclosures remains inadequate. The majority of revealed information is still generated from accounting, analysts, and audits. The government must strengthen the legal and policy framework surrounding information disclosure and establish a transparent information disclosure mechanism in conjunction with social responsibility reports. Adherence to international accounting standards and the application of green accounting practices could provide practical advice for environmental information recognition and measurement. The implementation of rigorous legislation regarding the timeliness and quality of environmental information, the increase in the cost of environmental pollution,

and the strengthening of environmental governance through the disclosure of information are vital to improve the situation.

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