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The Effect of Green Innovation on Firm Value: The Moderating Role of Internal Control

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Abstract

Green innovation encourages the growth of eco-environmental protection, low-carbon transformation, and other related fields, thereby fostering a healthy increase in firm value. Thus, this study examines the effect of green innovation on firm value of Chinese listed companies. In addition, it attempts to examine the moderating effect of internal control on the relationship. A total of 3,583 observations of China's A-share listed companies from year 2012 to 2021 serve as the research sample for the establishment of panel data. Using Ordinary Least Squares and Fixed Effects regression, findings show that green innovation has a positive but non-significant contributing effect on firm value. However, the presence of internal control has served a positive moderating effect on the relationship between green innovation and firm value. This study expands the research in the field of green innovation and firm value and provides new ideas and inspirations for enterprises to promote firm value through improving green innovation.

Keywords: Firm Value, Green Innovation, Internal Control

Introduction

The core of business development is the growth of firm value (Gong et al., 2021). Continuously improving firm value has become a common topic for academics and companies around the world (Janardhanan & Uma, 2020). Unlike financial performance, which focuses on a company's operating results, firm value typically reflects the market's assessment of the overall value of the company. Firm value depends on the value of all asset claims owned by the firm at the time and the value of asset claims is the sum of the value of all aspects of economic claims (Frykman & Tolleryd, 2012). As the study of firm value deepens, scholars are digging deeper into green innovation as a way to achieve sustainable development and create long-term firm value for stakeholders (Stucki, 2019). Green innovation is the design and process innovation of corporate green products and processes that address environmental issues and achieve specific environmental objectives and sustainable development (Zhang et al., 2020). Green innovation is centered on green technology, but also involves innovation in

corporate management system and organizational structure. The effect of green innovation on firm value has been a topic of interest in the academic literature, with numerous studies conducted in recent years (Agustia et al., 2019; Zhang et al., 2020; Asni & Agustia, 2021; Chouaibi & Chouaibi, 2021). However, most of the existing literature focuses on the meaning Foster & Green (2000), effects Li & Shen (2021) and evaluation system (Tumelero et al., 2019) of green innovation. Few studies have examined the link between green innovation and firm value, and research results have been inconsistent (Agustia et al., 2019; Xie et al., 2022).

Internal control refers to the set of policies, procedures, and activities to ensure that company operations are effective, efficient, and compliant with applicable laws and regulations (Chen et al., 2020). Internal control is a crucial mechanism of corporate governance that encompasses key aspects of business management. It has a notable impact on improving the business performance of the company, ensuring compliance with laws and regulations, and presenting information in an accurate and effective manner (Huang & Chen, 2017). Meanwhile, effective implementation of green innovation in companies also relies on strong internal control systems, and good internal control systems ensure that sustainability objectives are integrated into core business operations and financial reporting processes (Wang et al., 2022). Therefore, internal controls act as a moderating mechanism to ensure that green innovations are not only compatible with environmental objectives, but also generate substantial long-term returns for the firm (Li & Shen, 2021). However, it is essential to observe that few studies have examined whether internal control as a moderating variable strengthens or weakens the effect of green innovation on firm value. Therefore, the second issue of this study is extended to investigate the moderating effects of internal control on the relationship between green innovation and firm value.

To address these gaps, this study first aims to examine the effects of green innovation on firm value among Chinese listed companies. Green innovation has become increasingly important in the global business landscape, and this study seeks to contribute to understanding of its impact on firm value in the context of a developing country. Through this examination, the study provides new insights into the relationship between green innovation and firm value and helps to inform decision making for businesses, governments, and other stakeholders. Next, the findings of this study will contribute to the body of knowledge by identifying the moderating effects of internal control on the relationship between green innovation and firm value. Expands the research in this area and provides a theoretical justification for internal control as a moderating variable. The benefits of green innovation can be affected by internal control systems, and a strong internal control system can help companies better identify and implement green innovation (Qin, 2018).

Following is the remainder of this paper. The literature review and hypothesis formulation are discussed in Section 2. Section 3 describes the methodology, which includes sample selection, data sources, definitions of key variables, and empirical methodology. Section 4 provides descriptive statistics samples and empirical findings. Section 5 provides concluding remarks and implications.

Literature Review and Hypothesis Development

Effects of Green Innovation on Firm Value

The body of research has shown that green innovation and the firm's total of value are positively correlated (Cancino et al., 2018; Jiang et al., 2018; Agustia et al., 2019; Zhang et al., 2019; Asni & Agustia, 2021). According to the theory of sustainable development, corporate development should take into account both the growth of economic performance and the

impact on the ecological environment (Shi et al., 2019). With the advent of the green era, the business development of enterprises has undergone tremendous changes. The previous technological innovation of maximizing economic benefits has objectively accelerated the depletion of natural resources and the destruction of ecological balance, which may eventually become resistance to the sustainable development of enterprises (Fay, 2012). Conversely, enterprises that innovate in an environmentally and ecologically sound manner will achieve "green competitiveness" and increase firm value. Specifically, the "technological initiative" generated by a company in the process of green innovation helps the company to actively seek and capture market opportunities and achieve market leadership so that it can gain high profits by exploiting market disequilibrium, establish market leadership (Lumpkin & Dess, 2001), and increase firm value.

From the literature, although Xie et al (2022) applied China's heavily polluting industry to conclude that increasing the proportion of green patent applications leads to firm value depreciation. Duque-Grisales et al (2020) also concludes that implementing effective green innovation is not associated with improved financial performance. According to Li et al. (2022), green innovation dramatically lowers businesses' green economic performance. On the other hand, more researchers have produced actual data supporting the idea that green innovation may raise firm value. By analysing firm-level data from the S&P 500 from 2001 to 2022, Liu (2023) found that implementing green innovations improves business value and emissions performance while lowering firm volatility and credit risk. This study emphasizes how crucial corporate attributes are in promoting environmentally friendly innovation and sustainable business practices. Yuniarti et al (2022) investigated a sample of mining enterprises that participated in the assessment of corporate performance ratings listed on the Indonesian Stock Exchange between 2012 and 2018 and discovered that green innovation had a favorable influence on firm value. Furthermore, Hao et al (2022) observed that the company value (Tobin's Q) would improve by 0.023 for every 1% increase in the proportion of businesses' green patent applications in China's A-share market from 2007 to 2018. Therefore, in the light of previous literature which show dominant positive results, hypothesis is developed as follows

H1: Green innovation has a positive effect on firm value across listed companies in China.

Moderating Role of Internal Control

The relationship between internal control and firm value has been studied in the literature from different perspectives (Lin et al., 2007; Li et al., 2016; Lai et al., 2017; Janardhanan & Uma, 2020). Gong et al (2013) analyze a sample of listed companies that disclosed information on internal control deficiencies in the U.S. securities market and find that: When multinational listed companies are located in countries with weak investor protection, the two are significantly positively correlated; when in countries with strong investor protection, the positive correlation is not significant, so investors should pay close attention to the quality of financial disclosures about internal control deficiencies of listed companies. Zhou et al (2016) investigates the impact of internal control and corporate life cycle on firm performance in China's emerging markets. The study finds that internal control has a positive impact on corporate performance. The impact of internal control on firm performance varies with different stages of the firm life cycle. Internal control has a greater favorable influence on firm performance throughout the maturity and shake-out stages than during the other stages.

For the effects of green innovation on firm value, less attention has been paid in numerous studies to the moderating role of internal controls between green innovation and firm value. Li and Shen (2021) digital transformation can improve green innovation, especially when internal control is weak. Findings support the theoretical expectation that internal control monitoring weakens the level of green innovation. However, Wang et al (2021) discovered that green innovation has a significant positive impact on financial performance, internal control has a significant positive impact on financial performance, and internal control can substantially enhance the positive impact of green innovation on financial performance. Between 2007 and 2017, Ma et al (2022) investigated the link between internal control and the value relevance of innovation input in Chinese A-share listed businesses with non-zero innovation investment. Internal controls are suggested to raise the value relevance of innovation inputs; that is, the better the internal controls, the higher the contribution of innovation inputs to the firm's business performance and market value.

In addition, Wang et al (2022) finds that internal control can greatly improve the level of green innovation in firms, mainly in the stage of mandatory disclosure of internal control information. Internal control, according to mechanism testing, can boost green innovation by lowering business risk, eliminating agency conflicts, easing finance limitations, and increasing the rationale of innovation investments. Excessive executive authority has also been found to reduce the favorable impact of internal control on green innovation by limiting internal control's capacity to monitor and penalize executives. Therefore, in the light of empirical results and discussion, the second hypothesis is formulated as:

H2: Internal control strengthens the relationship between green innovation and firm value across listed companies in China.

Research Methodology

Sample and Data Collection

This study has selected listed companies in the Shanghai Stock Exchange and Shenzhen Stock Exchange, which are the only places in mainland China where listing options are available, from 2012 to 2021 as a research sample. In 2011, the Organization for Economic Cooperation and Development (OECD) released the Global Green Growth Strategy, which aims to promote change and innovation across all sectors, and the Chinese government has responded positively by establishing several green innovation policies. However, there is generally a lag in the reflection of green innovation, so 2012 was used as the starting year for this study. And only green innovation data can be collected up to 2021 at the latest. Hence, the designated period to achieve the objectives of this study is from the 2012 until 2021. The sample only includes A-share listed companies in China, which reflect multiple aspects and sectors of the Chinese economy and examine how the relationships between variables behave in China's specific market and institutional environment.

The population of listed companies in China is dynamic, with 5,012 listed companies by 2022 and only 2,494 companies in 2012, so this study selects the sample from companies that have been listed since 2012. And the data was analyzed as follows: First, observations for publicly traded companies categorized as ST and *ST were eliminated. Second, for comparative reasons, finance and insurance business observations were removed since the financial industry's accounting rules differ from those utilized by other industries. Finally, observations with missing data were removed. Finally, the main continuous variables were winsorized with two-way 1% quantiles to assure the robustness of the results and to eliminate

the negative interference of outliers. Finally, 3583 valid observations were acquired, and the data was analyzed using Stata 17.0. Internal control data were collected from the DIB Internal Control Database (which is an internal control index that reflects the level of internal control and risk control ability of listed companies), and other data were collected from the China Stock Market & Accounting Research Database (CSMAR) database.

Variables and Model

The firm value is dependent variable, since the present studies mainly used Tobin's Q value to measure firm value (Agustia et al., 2019; Liao et al., 2020). Compared with financial indicators, market indicators can assess the value of a firm more effectively. Among them, Tobin's Q value is both theoretical and practical, and is an important indicator for assessing the growth and value of firms. Therefore, this study uses Tobin's Q value as a proxy variable for firm value.

The independent variable is green innovation. The number of green patent applications or grants and the number of green patent citations as innovation output indicators better represent the degree of green innovation conducted by enterprises (Zhang et al., 2019). Referring to the measurement method used by other scholars in previous studies (Li et al., 2022; Xie et al., 2022), this study first summarizes the number of green patent applications, then adds the total amount by one and takes the natural logarithm as the independent variable for measuring the green innovation of firms.

The moderating variable is internal control. Many academics have conducted studies using the DIB internal control index Zhou et al (2016); Huang & Chen (2017) and this index is measured in a way that takes into account the actual situation of Chinese listed companies and is more in line with the definition of internal control in this study. Therefore, the DIB internal control index is used as a proxy variable for internal control in this study.

Referring to the previous literature Schroeder & Shepardson (2016); Arfi et al (2018); Zhang et al (2019); Janardhanan & Uma (2020); Zheng et al (2021), this study selects Size of the Firm, Debt Asset Ratio, Revenue Growth, Listed Age, Shareholding Concentration, Board Size, The Year Dummy Variable and Industry Dummy Variables as the control variables based on other scholars' related studies on firm value. All variables are shown in Table 1.

Table 1
Summary of Variables

Type	***Variables***	***Symbol***	***Formulation***
Dependent Variable	Firm Value	TOBINSQ	Tobin's Q Value: Equity Market Value + Liabilities Market Value / Equity Book Value + Liabilities Book Value
Independent Variable	Green Innovation	GI	(Total Number of Green Patent Applications+1) is Taken as Natural Logarithm
Moderating variable	Internal Control	IC	DIB Internal Control Index Score and Take the Natural Logarithm.
Control variables	Size of the Firm	SIZE	The Natural Logarithm of the Total Assets
	Debt Asset Ratio	LEV	Total Liabilities / Total Assets
	Revenue Growth	GROWTH	(Current Operating Income - Previous Operating Income) / Previous Operating Income
	Listed Age	AGE	The Difference between the Accounting Year and the Year the Firm Went Public + 1, Taken as a Natural Logarithm.
	Shareholding Concentration	TOP10	The Sum of The Shareholdings of The Company's Top 10 Shareholders.
	Board Size	BOARD	Natural logarithm of the number of Directors on the Board
	The Year Dummy Variable	YEAR	Firm's Financial Report Year
	Industry Dummy Variables	INDUSTRY	China Securities Regulatory Commission Industry Classification–Level 1 Industry Category

Models

The following model is used in this study to test Hypothesis 1:

$$TOBINSQ_{i,t} = \beta_0 + \beta_1 \mathrm{GI}_{i,t} + \sum \beta_2 CONTROL_{i,t} + \varepsilon_{i,t} \quad (1)$$

The following model is used in this study to test Hypothesis 2:

$$TOBINSQ_{i,t} = \beta_0 + \beta_1 \mathrm{GI}_{i,t} + \beta_2 \mathrm{IC}_{i,t} + \beta_3 \mathrm{GI}_{i,t} * \mathrm{IC}_{i,t} + \sum \beta_4 CONTROL_{i,t} + \varepsilon_{i,t} \quad (2)$$

Results

Descriptive Statistics

Table 2

Descriptive Statistics

VARIABLES	*N*	*mean*	*sd*	*min*	*max*
TOBINSQ	3,583	1.924	1.145	0.846	7.543
GI	3,583	1.834	1.081	0.693	5.328
IC	3,583	6.485	0.138	5.746	6.761
SIZE	3,583	22.73	1.329	20.39	26.59
LEV	3,583	0.461	0.186	0.0911	0.864
GROWTH	3,582	0.145	0.267	-0.406	1.318
AGE	3,583	2.243	0.715	0.693	3.296
TOP10	3,583	56.87	15.13	24.60	90.60
BOARD	3,583	2.026	0.159	2	3

Table 2 shows the descriptive statistics of the main variables. As shown in Table 2, the mean value of Tobin's Q is 1.924, the maximum value is 7.543, the minimum value is 0.846, and the standard deviation is 1.145, which indicates that there are some differences in the firm value of different listed companies. The mean value of green innovation (GI) is 1.834, the maximum value is 5.328, the minimum value is 0.693, and the standard deviation is 1.081, indicating that there is also some variability in the level of green innovation among listed companies. The mean value of internal control (IC) is 6.485, the maximum value is 6.761, the minimum value is 5.746, and the standard deviation is 0.138, which indicates that there is less variability in the level of internal control among the listed companies in the sample.

The mean value of firm size (Size) is 22.73, indicating that the total assets of the sample firms do not differ much. The mean value of the gearing ratio (LEV) is 0.461%, the minimum value is 0.0911%, and the maximum value reaches 0.864%, which indicates that most firms have large financial leverage ratios and that there are significant differences in financial leverage among different firms. Similarly, there is a significant difference between revenue growth (GROWTH) firms. The mean value of years listed (Age) is 2.243, and according to the formula the average years listed can be 8.5 years, which is in line with the time span of the sample selection. The mean value of shareholding concentration (TOP10) is 56.87% and the maximum value is 90.6%, indicating that the shareholding structure of listed firms in China has a high proportion of large shareholders. Lastly, the mean value of board size (BOARD) is 2.026, indicating that the sample firms have a more complete board size and structure. The statistical results of the control variables are in line with a study done by (Li, 2022).

Empirical Results

Table 3

Regression Results

Dependent: TOBINSQ				
Variables	OLS		FE	
	(1)	(2)	(3)	(4)
GI	0.0247	-1.695**	0.0176	-1.239**
	(0.0179)	(0.748)	(0.0173)	(0.612)
GI * IC		0.264**		0.195**
		(0.115)		(0.0940)
IC		-0.0547		0.0894
		(0.250)		(0.210)
SIZE	-0.209***	-0.224***	-0.192***	-0.232***
	(0.0195)	(0.0198)	(0.0338)	(0.0216)
LEV	-1.719***	-1.671***	-1.329**	-1.222***
	(0.113)	(0.114)	(0.428)	(0.136)
GROWTH	0.438***	0.394***	0.348**	0.303***
	(0.0655)	(0.0671)	(0.127)	(0.0728)
AGE	0.206***	0.209***	0.212***	0.177***
	(0.0319)	(0.0318)	(0.0412)	(0.0308)
TOP10	0.00170	0.00140	0.00588***	0.00611***
	(0.00135)	(0.00135)	(0.00174)	(0.00134)
BOARD	-0.191*	-0.193*	-0.115	-0.0984*
	(0.112)	(0.111)	(0.0754)	(0.0560)
YEAR	NO	NO	YES	YES
INDUSTRY	NO	NO	YES	YES
Constant	7.196***	7.888***	6.240***	5.878***
	(0.403)	(1.663)	(0.724)	(1.490)
Observations	3,582	3,582	3,582	3,582
R-squared	0.178	0.182	0.112	0.319

*** p<0.01, ** p<0.05, * p<0.1

To test the hypothesis 1 of this study, the effect of green innovation on firm value, this study tests the hypothesis by OLS regression. The regression results are shown in Table 3. Column (1) shows the regression results of the core explanatory variables on the explanatory variables with the addition of control variables, column (2) shows the regression results with the addition of moderating variable, and columns (3) and (4) are the regression results of the fixed-effects model using the dummy variables controlling for the year and the industry, and the results show that the regression results of columns (3) and (4) are consistent with those of columns (1) and (2). From the results of the regression, the regression coefficient of the core explanatory variable green innovation (GI) on the explanatory variable firm value (Tobin's Q) is positive but not significant, which indicates that green innovation has a positive effect on firm value. This finding is consistent with previous studies (Sukmadilaga et al., 2023), also found that the contribution of green innovation to firm value may not be

significant. This may be because green innovation requires investment over the long term and its impact on firm value may not be visible in the short term. But still, it can be stated the better the green innovation of the company, the higher the firm value, Hypothesis 1 is verified.

To test Hypothesis 2, whether internal control quality has a moderating effect on the relationship between green innovation and firm value, this paper introduces internal control (IC) and the interaction term between internal control and the independent variable green innovation (GI) for regression analysis. From the results, after adding internal control as a moderating variable, the interaction term is significantly positive and significant above the 5% level, indicating that the quality of internal control of firms plays a positive moderating role between green innovation and firm value. Although the direct contribution of green innovation to firm value may not be significant, by strengthening internal controls, firms can maximize the potential value of green innovation. This is in line with previous research (Wang et al., 2021) that emphasizes that internal control effectiveness significantly enhances the positive effect of green innovation on financial performance. Internal control strengthens the relationship between green innovation and firm value across listed companies in China, Hypothesis 2 is verified.

Conclusions

Green innovation has received more attention from businesses and academics because of the urgent need for sustainable global development and the real demand for high-quality economic development in China. In this study, panel data are established with a total of 3,583 observations of China's A-share listed companies from 2012 to 2021 as the research sample, an empirical study of the relationship between green innovation and firm value, and further testing the moderating effect of internal control of firms. Based on the existing literature and the fundamental arguments outlined above, the following findings were uncovered through research: (1) Green innovation has a non-significant contribution to firm value (Sukmadilaga et al., 2023). (2) Verifies there is a moderating effect of internal control on the relationship between green innovation and firm value (Wang et al., 2021).

This study points out that the positive effect of green innovation on firm value is not statistically significant for several possible reasons: (1) Possibly due to the long-term investment and sustained efforts required for green innovation, its impacts may not be visible in the short term or may have a certain lag. (2) Possible measurement errors or problems with variable definitions, which may have affected the significance of the results. (3) More sophisticated models may be needed to capture the relationship between green innovation and firm value or may require the use of different methods or data to measure these variables more accurately. It is suggested that future research should explore the reasons for this non-significant finding and consider the use of different models, variables, and methods. Further in-depth analysis can be done in the future in terms of region, nature of ownership, and industry heterogeneity. Although this study points out that the contribution of green innovation to firm value is positive but not statistically significant, firms should persist in promoting green innovation. Green innovation not only improves the competitiveness and sustainability of enterprises but also helps them achieve long-term growth in the face of limited resources and environmental pressures. Companies should consider green innovation as a strategic priority and continue to explore more environmentally friendly and sustainable ways of doing business.

Considering the positive moderating effect of internal control on the relationship between green innovation and firm value, companies should strengthen their internal management and control systems. Ensuring the rational allocation of resources, the transparent flow of information and the effective control of risks are important means of realizing green innovation and enhancing firm value. Future analysis of the moderating role of internal controls can be carried out with more in-depth analysis of the mechanisms, such as governance regulations (Kabara et al., 2023), board education (Kabara et al., 2022), and so on. Lastly, through the continuous optimization of internal control, companies can better leverage the benefits of green innovation and enhance performance and returns.

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