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A Study on the Impact of Digital Transformation on Corporate ESG Performance: The Mediating Role of Green Innovation

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Abstract: Corporate performance in ESG has received increased attention; however, the discussion on how digital development will affect corporate practice of ESG needs to be deepened. This paper discusses the impact of digital transformation on corporate ESG performance using multiple linear regressions with STATA 17.0 for 2707 companies listed in China A-shares in the period 2010–2021. Based on principal–agent theory, resource-based theory and signaling theory, the study finds that digital transformation can improve corporate ESG performance. From an external perspective, the contribution of digital transformation to ESG performance diminishes when environmental uncertainty increases; from an internal perspective, the positive effect of digital transformation on ESG performance is more significant in larger-scale enterprises. In addition, digital transformation will further enhance ESG performance by promoting green innovation, i.e., green innovation has a mediating role in the relationship between the two factors. The findings of the study introduce new thinking on the factors that influence corporate ESG performance, advance relevant research and provide important references for corporate managers and government departments who are concerned about ESG performance to make appropriate decisions.

Keywords: digital transformation; ESG performance; green innovation; environmental uncertainty

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Citation: Wu, S.; Li, Y. A Study on the Impact of Digital Transformation on Corporate ESG Performance: The Mediating Role of Green Innovation. *Sustainability* **2023**, *15*, 6568. https://doi.org/10.3390/su15086568

Academic Editor: Antonella Petrillo

Received: 15 March 2023
Revised: 11 April 2023
Accepted: 12 April 2023
Published: 12 April 2023

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1. Introduction

China's economy has recently shifted from a stage of rapid growth to one of high-quality development. The original economic growth model, which relied mainly on factor inputs and scale expansion, is no longer sustainable and the pursuit of economic development speed is no longer the only goal. We should now adhere to quality and efficiency first in the development process. As micro-entities in the process of economic development, enterprises are responsible for promoting green transformation and high-quality development in the economy and society and need to shift from the pursuit of maximizing their own profits to maximizing social value. The ESG concept is a sustainable development concept that integrates environmental, social responsibility and governance factors into investment decisions and corporate development; it is an effective tool for achieving high-quality economic development and sustainable corporate development and is broader than the traditional concept of corporate social responsibility (CSR) [1]. In 2006, the former Secretary-General of the United Nations launched the United Nations Principles for Responsible Investment (UN PRI), which aims to encourage investors to follow ESG standards and practice ESG requirements in the investment process. In contrast, China's attention to ESG started relatively late; however, with the growing complexity of the external economic environment, stakeholders have paid more attention to ESG in recent years. In 2018, the China Securities Regulatory Commission (CSRC) issued a revised version of the Code on Governance of Listed Companies and introduced the ESG concept, stipulating that listed companies should disclose environmental information (E) and information on fulfilling social responsibilities, such as poverty alleviation (S) and corporate governance-related information (G), in accordance with laws and regulations and the requirements of relevant

authorities; this shift further highlights the importance of ESG in the process of corporate operation and development.

At the theoretical level, many studies have discussed the economic consequences of ESG, though the findings are not entirely consistent. Some studies are based on neoclassical economic theory, which suggests that environmental and social responsibility, as strong externalities, will increase additional expenses and weaken the competitiveness of companies, with ESG not having a positive impact on corporate performance [2,3]. Other studies have taken the opposite view. For example, Cho confirmed that environmental strategies in different industries have a positive impact on enterprise value over different time windows [4]. Moreover, stakeholder theory provides a solid theoretical basis for the positive effect of ESG performance on corporate development. According to the guidance of this theory, enterprises can meet stakeholders' expectations by improving ESG performance [5], while practicing ESG means that companies are taking an active role in green social responsibility and showing concern for the environment, which helps to enhance the legitimacy of the organization, improve its reputation and build a competitive advantage [1]. Based on the above views, the idea that ESG has a positive effect on corporate performance, corporate value and total factor productivity [6–9] has been generally supported. Given the importance of ESG in the development process of a company, identifying the factors that influence a company's ESG performance is gradually receiving more attention.

The current literature has found that institutional investor shareholding [10], environmental regulation [11], green financial reform [12], digital finance [13], executive equity incentives [14] and board composition and diversity [15,16] have significant impacts on corporate ESG responsibility fulfillment from both internal and external organizational perspectives. The world today has fully entered the digital economy era and, according to the White Paper on Global Digital Economy (2022) published by the China Academy of Information and Communication Research, the scale of global digital economy value added in 2021 was USD 38.1 trillion; this figure represents a nominal growth of 15.6% year-on-year and 45.0% of global GDP. Resultantly, the digital economy has become a new engine for industrial optimization and upgrading. Existing research has found that the use of digital technologies can help improve the efficiency of firms' access to and use of resources, reduce transaction and principal–agent costs and build heterogeneous resource advantages for firms. Thus, digital transformation can reduce cost stickiness [17] and trade credit financing [18] and has a positive impact on firm innovation [19,20] and performance [21,22]. However, the application of digital technology also requires a large amount of investment and a deep reorganization of existing business processes, product systems and management structures [23]. Therefore, some enterprises still "do not know how to transform, dare not transform" and it is important to further explore the impact of digital transformation on enterprise development. A few existing studies have discussed the relationship between digital transformation and corporate ESG performance. For example, Fang et al. found that digitalization can significantly improve corporate ESG scores in terms of agency costs and corporate reputation [24]. Sun and Saat conducted a study on manufacturing companies and found that intelligent manufacturing can boost their ESG performance [25]. Zhong et al. discussed the positive impact of digital transformation on corporate ESG performance from the perspective of internal control and other perspectives [26]. Although some scholars have focused on the relationship between digital transformation and corporate ESG performance, there are still some research gaps in this area, mainly in that: (1) existing studies have mainly examined the direct effect of digital transformation on corporate ESG performance, while the exploration of its internal influence mechanism still needs to be further enriched. In other words, the "black box" of the effect of digital transformation on ESG performance has not yet been fully uncovered; (2) the boundaries of the effect of digital transformation have not yet been explored in depth and there is still a need to analyze whether there are differences in the effect of digital transformation on ESG performance in specific contexts to provide more specific guidance for enterprises preparing for digital development.

In response to the above research gaps, this paper selects Chinese A-share listed companies from 2010–2021 as the research object and explores whether and how digital transformation acts on corporate ESG performance based on principal–agent theory, resource-based theory and signaling theory. The operation and development of enterprises is influenced by external environmental factors, while environmental uncertainty reflects the degree, speed and unpredictability of changes in the external environment [27], which will affect the operational difficulty and earnings volatility of enterprises. Therefore, this paper selects environmental uncertainty as a moderating variable and discusses whether the impact of digital transformation on ESG performance changes when enterprises face different levels of environmental uncertainty, thus exploring the boundaries of the effect of digital transformation. Furthermore, studies have found significant positive effects of digital transformation on corporate green innovation from the perspectives of principal–agent theory, dynamic capability theory and resource-based theory [28–30]. Therefore, this paper attempts to introduce green innovation into the research framework and explore the path mechanism for the effect of digital transformation based on this perspective, trying to open the "black box" of its influence on corporate ESG performance. This paper uses WIND and CSMAR databases, the authoritative financial and economic databases in China, to collect sample data and conduct regression analysis using STATA17.0. Through empirical research, we find that: (1) digital transformation is beneficial to improve corporate ESG performance; (2) there is a negative moderating effect for environmental uncertainty on the positive relationship between digital transformation and corporate ESG performance, i.e.,, the contribution of digital transformation to ESG performance diminishes when environmental uncertainty increases; (3) digital transformation will indirectly improve ESG performance by promoting corporate green innovation activities; and (4) the heterogeneity test shows that the positive effect of digital transformation on ESG performance is more significant in larger-scale companies. After robustness tests and consideration of endogeneity issues arising from omitted variables, the study findings are still supported.

The innovations and expected contributions of this study are: (1) it explores the factors that influence corporate ESG performance in the context of digital development, expanding the analysis of the antecedent variables related to ESG. With the increasing emphasis on corporate sustainability, research on corporate ESG performance has gradually become abundant; however, the relevant literature still focuses on how ESG acts on corporate development, while relatively little attention has been paid to its influencing factors. This paper provides new ideas on how to improve corporate ESG performance from the internal perspective of enterprises; (2) this paper discusses the digital transformation of companies based on an integrated development perspective of environment, social responsibility and corporate governance, which helps to further clarify the importance of digital transformation in the process of enterprise operation and provides theoretical support for enterprises to reasonably promote digital transformation. Moreover, by examining the uncertainty of external environment and enterprise scale, it helps to understand the differential impact of digital transformation in specific contexts; (3) the paper innovatively discusses the intermediary path of digital transformation on ESG performance from the perspective of green innovation, which makes up for the shortcomings related to the current lack of exploration of its mechanism.

The remainder of the paper is structured as follows: Section 2 presents the research hypothesis of this paper through theoretical analysis; Section 3 introduces the research methodology used, including the selection of the sample and the source of data, the definition and measurement of variables and the setting of the model; Section 4 reports the regression results and validation of the hypotheses, along with the robustness test and the endogeneity problem; and Section 5 describes the study's conclusions, implications and limitations.

2. Theoretical Analysis and Hypothesis

2.1. Digital Transformation and Corporate ESG Performance

Digital transformation is the process of applying digital technologies to transform business processes in production, operations and management; it is often seen as an effective way to drive quality and sustainable growth [31].

Firstly, digital transformation helps to reduce the cost of principal–agent problems within the enterprise [17], which in turn has a catalytic effect on corporate ESG performance. According to principal–agent theory, the separation of control and ownership leads to a certain conflict of interest between managers and shareholders [32]. Managers cannot diversify their business risks by investing in multiple enterprises; thus, they may neglect the long-term development of the enterprise for the sake of stable income, i.e.,, they will show some short-sighted behavior in the process of business operation [33]. The long-term nature of environmental protection and socially responsible investment implied by the ESG concept leads to a cyclical and lagging impact on corporate performance. Therefore, based on the principal–agent theory, managers who attach importance to their own earnings will have a tendency to avoid ESG investments. In the process of digital transformation of enterprises through the use of digital technology, the flow of information within the enterprise is smoother [20] and the information disclosure system is improved; thus, managers' decision making information will tend to be more open and transparent. The costs and difficulties for managers in concealing their self-interested behaviors are increased and the principal–agent problem between them and shareholders is effectively mitigated [18,34]. Moreover, digital transformation ensures that managers' decision making refers to a large number of quantitative analysis results, which will reduce their discretionary power and restrain their opportunistic behavior; thus, managers will focus their attention on long-term corporate development and improve ESG performance.

Secondly, digital transformation helps companies build competitive advantages and improve their risk-taking level, which in turn contributes to their ESG performance. Investing in environmental protection and social responsibility will take up corporate funds in the short term and may reduce current operating profits [35,36]; thus, practicing ESG has certain short-term risks and will weaken the competitiveness of the enterprise in the current period, which makes managers tend to avoid this activity. Based on resource-based theory, digital technology, as an important heterogeneous resource, can create competitive advantages for enterprise construction [37,38]. Specifically, digital transformation can help to break the "digital divide" between departments within the enterprise, enhance co-operation among departments and improve the efficiency of resource allocation, which can improve the stability of corporate financial resources [34]. At the same time, digital development can improve the access and utilization of information for enterprises, which can help managers fully grasp their own problems in the process of business development. Managers are also more likely to promptly understand the relevant information of the external market and accurately explore customer needs [39], which will reduce the production costs for enterprises and improve their productivity. In conclusion, digital transformation can create competitive advantages for enterprises and, thus, will improve their risk-taking level and prompt them to focus on ESG.

Thirdly, digital transformation helps alleviate corporate financing constraints, which in turn boosts corporate ESG performance. The high costs of practicing ESG and resource constraints are important reasons for the low ESG performance among enterprises. Currently, digital transformation is the main direction for the future development of Chinese enterprises and the government has introduced a series of policies to promote the deep integration of the digital economy with the real economy [40]. By actively responding to the digital development strategy, it helps enterprises to improve the legitimacy of their operations, obtain more government subsidies and enjoy corresponding preferential policies, which can provide direct financial support for enterprises to improve their ESG performance. Moreover, according to the signal theory, government support can send a signal to the outside world that the enterprise is doing well, which is conducive to attracting capital

investment; this further alleviates the financing constraint dilemma faced by the enterprise and promotes the improvement of ESG performance. In conclusion, we put forward the following hypothesis:

Hypothesis 1 (H1). *There is a significant contribution of digital transformation to the ESG performance of enterprise.*

2.2. The Moderating Role of Environmental Uncertainty

Environmental uncertainty describes the degree, speed and unpredictability of changes in a corporate external environment [27]; these differences affect managers' decision making choices and the implementation and development of corporate strategies and, therefore, are considered an important external situational factor in the business process.

Firstly, the increased level of environmental uncertainty makes it more difficult for external stakeholders to regulate enterprises and enhance the discretion of managers [41]. At this point, the principal–agent problem between managers and shareholders comes to the fore and executives are more likely to engage in opportunistic behavior [42]. Moreover, higher environmental uncertainty increases the cost of obtaining information, making it difficult for managers to use external information to make effective decisions [43]. The uncontrollability of the enterprise's future development increases and the executive team will be more inclined to focus on improving the corporate current efficiency, i.e.,, there is a stronger incentive to seek short-term gains. Secondly, when the level of environmental uncertainty is high, market demand and technological progress change more rapidly and the complex environment intensifies the resource constraints and operational risks faced by firms [44,45]. This problem leads to increased operational difficulties for managers, further weakening corporate competitive advantages and increasing their risk-averse tendencies. Thirdly, under high environmental uncertainty, the unpredictability of business operations and the volatility of profitability levels increase and the information asymmetry between enterprises and the market is enhanced [42]. This hinders external stakeholders' understanding of corporate development, which will reduce corporate external financing ability and enhance the financing constraints that the enterprise faces. In light of the above analysis, this paper concludes that higher environmental uncertainty will exacerbate the principal–agent problem between managers and shareholders, weaken the risk-taking propensity of enterprises and increase their financing constraints, which will in turn reduce their attention and investment in social responsibility and environmental protection measures. Therefore, the higher the environmental uncertainty, the weaker the positive impact of digital transformation. We put forward the following hypothesis:

Hypothesis 2 (H2). *There is a negative moderating effect of environmental uncertainty on the relationship between digital transformation and corporate ESG performance.*

2.3. The Mediating Role of Green Innovation

Green innovation refers to technological innovation activities related to green processes or products [46] and is an important way to drive enterprise towards a green transformation [47]. This paper argues that digital transformation will improve ESG performance by promoting green innovation in enterprise.

Firstly, there is a positive impact of digital transformation on corporate green innovation. According to the guidance of principal–agent theory, there are divergent interests between managers and shareholders [32] and the agency problem is a key factor affecting the innovation activities of enterprises [48]. Green innovation emphasizes low pollution, low energy consumption, and recyclability; it usually requires a long time cycle to obtain the corresponding return on investment. In pursuit of their own interests, managers have a tendency to avoid green innovation activities in the business process. In enterprises with a higher degree of digital transformation, information flow efficiency is improved

and shareholders are able to monitor managers' behaviors in a timely and effective manner, thus reducing managers' opportunistic motives and motivating them to focus on the long-term interests of the enterprise in the decision making process; accountable managers may also promote the implementation of green innovation activities. Meanwhile, according to resource-based theory, digital development provides enterprises with resource advantages [38,49]. The application of digital technology is conducive to breaking the boundaries between traditional enterprises, enhancing the communication and cooperation between innovative organizations [50]. Digital transformation can also improve employees' level of human capital [51], which will improve the access to resources, information and knowledge, provide technical information and other support for enterprises to carry out green innovation activities [49] and provide a guarantee for green innovation quality. In addition, based on the characteristics of the innovation dimension, green innovation requires continuous capital investment, while digital transformation can enhance the transparency of information disclosure, alleviate internal and external information asymmetry, improve the external financing ability of enterprises [52] and improve the efficiency of resource utilization and allocation of enterprises through the use of digital technology. Therefore, digital transformation is conducive to providing financial security required for enterprises to implement green innovation.

Secondly, green innovation can significantly contribute to corporate ESG performance. It is a comprehensive evaluation of an enterprise based on environmental, social responsibility and corporate governance dimensions that measures the corporate sustainability, while green innovation is a visual representation of corporate sustainability, which is in line with the core elements of the ESG concept. Therefore, commitment to promoting green innovation activities means that enterprises have the will and inclination to take social responsibility and concern for environmental protection, which will enhance their ESG performance. At the same time, through green innovation activities, enterprises can send positive signals to the outside world and establish a good corporate green image [53]; green innovation can also help enterprises gain technological and market advantages, which can help them attract more investors' attention and capital support and provide resources for them to practice ESG concepts. In addition, with the increase in green innovation activities, the level of green technology will improve and the cost of green production will be further reduced, enabling enterprises to better take on environmental responsibility [54] and improve their ESG performance. Thus, the following hypothesis is proposed:

Hypothesis 3 (H3). *Digital transformation further enhances ESG performance by promoting corporate green innovation.*

3. Methodology

3.1. Sample and Data

This paper selects Chinese A-share listed companies for the period 2010–2021 as the study population. The main reason for choosing listed companies as the research object was that the information disclosure of the main contents of this paper, such as "digital transformation" and "ESG performance", is more comprehensive among listed companies and can provide reliable data for research through a more authoritative database. The sample started in 2010 to take into account the completeness of data collection for the main variables, while the cut-off year was the year of the latest data available at the beginning of this study. The data on corporate ESG performance were evaluated using the results provided by the China Securities ESG Evaluation System, sourced from the WIND database, a leading financial database in China with data covering a wide range of sectors, such as stocks, funds and bonds; this database also provided ESG rating results that effectively measure corporate commitment and performance in terms of ESG. In addition to ESG performance, the rest of the data is collected from CSMAR database, which is currently the largest and most accurate financial and economic database in China, containing basic

information on the governance structure, financial status and operating conditions of listed companies; we effectively match these data with ESG data.

To ensure the accuracy of the research findings, the sample data were processed as follows: (1) enterprises in the financial sector were excluded. The main reason was that though financial enterprises have large amounts of capital flow, they do not create actual wealth themselves; thus, the accounting standards of financial enterprises and non-financial enterprises are significantly different and the relevant indicators are not comparable, which would affect the research results if they were not excluded. (2) We also excluded the sample enterprises of ST and *ST category in the statistical year. These enterprises are specially treated enterprises with certain financial problems or other abnormal problems, which may lead to inaccurate research conclusions, hence their exclusion. (3) We also excluded the sample enterprises with missing relevant data. (4) Finally, this paper contains 18,632 firm-year sample observations. Continuous financial variables were winsorized at 1% and 99% of the quartiles and the data processing and regression analyses were completed using STATA17.0.

3.2. Variable Definition

(1) ESG performance: The Huazheng ESG rating index was selected to measure ESG performance (ESG). The ESG indicator system covers 26 key indicators under the three pillars of environmental, social and corporate governance and is divided into nine grades from low to high—C, CC, CCC, B, BB, BBB, A, AA and AAA—in the order of 1–9, with higher ratings indicating better ESG performance.

(2) Digital transformation: The number of digital-related terms disclosed in the annual reports of enterprises was used to measure digital transformation (digital) with reference to relevant studies. The vocabulary covered five main areas: artificial intelligence technology, blockchain technology, cloud computing technology, big data technology and digital technology applications, with a total of 79 specific terms. This paper measures the degree of digital transformation as the natural logarithm of the number plus one of occurrences of the relevant terms in a corporate annual report.

(3) Environmental uncertainty: The measurement of environmental uncertainty (EU) is performed using the following steps: (1) an OLS regression was run using model (1) and residuals were calculated. For this method, sale is the sales revenue of the enterprise in the current year and the previous 4 years, year is the number of years from the previous 4 years to the current year to assign a value of 1–5 and the resulting residual is the corporate abnormal sales revenue in 5 years. (2) We calculated the standard deviation of each corporate five-year abnormal sales revenues and the average of the five-year sales revenue, dividing the former by the latter to obtain the corporate non-industry-adjusted environmental uncertainty for the year. (3) We then divided the non-industry-adjusted environmental uncertainty by the median environmental uncertainty for enterprises in the same industry in the same year to obtain the industry-adjusted environmental uncertainty index. Larger values indicated a higher degree of environmental uncertainty, using the secondary industry classification for manufacturing industries and the primary industry classification for other enterprises in the calculation process.

$$Sale = \varphi_0 + \varphi_1 Year + \varepsilon \quad (1)$$

(4) Green innovation: Green innovation (Gpatent) is measured as the natural logarithm of the number of green invention patents applied for and granted to the enterprise plus one.

(5) Control variables: Relevant control variables are selected from the corporate governance and financial levels, specifically: size of enterprise (size), asset-liability ratio (Lev), return on total assets (roa), two jobs in one (dual), board size (board), percentage of independent directors (indept), percentage of shareholding of the largest shareholder (top1), the fixed effects of Year (year) and industry (industry). Table 1 presents how each variable is measured.

Table 1. Definition and measurement of variables.

Symbol	Variable	Measurement
ESG	ESG performance	According to Huazheng ESG rating, the assignment is 1–9 from low to high
Digital	Digital transformation	Natural logarithm of the number of occurrences of digitization-related terms in a corporate annual report plus one
EU	Environmental uncertainty	Measurement using model (1)
Gpatent	Green innovation	Natural logarithm of the number of patents for green inventions plus one
Size	Size of enterprise	Natural logarithm of the total assets of the enterprise
Lev	Asset-liability ratio	Total business liabilities/total assets
Roa	Return on total assets	Corporate net profit/total assets
Dual	Two jobs in one	1 for the Chairman who is also the Managing Director, 0 otherwise
Board	Board size	Natural logarithm of the number of board members
Indept	Percentage of independent directors	Number of independent directors/total number of board members
Top1	Percentage of shareholding of the largest shareholder	Number of shares held by the largest shareholder as a percentage of the total number of shares in the enterprise
Industry	Industry	Dummy variables are set based on the 2012 edition of the SFC industry classification codes, with manufacturing industries considered to be secondary classification codes and the remaining industries considered to be primary classification codes
Year	Year	Year dummy variable with 2010 as the base year

3.3. Model Setting

Model (2) was used to verify the impact of digital transformation on corporate ESG performance, while model (3) added the interaction term of digital transformation and environmental uncertainty to verify the moderating role of environmental uncertainty through its coefficients. Models (4) and (5) were used to test the mediating role of green innovation.

$$ESG_{i,t} = \beta_0 + \beta_1 Digital_{i,t} + \beta Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (2)$$

$$ESG_{i,t} = \beta_0 + \beta_1 Digital_{i,t} + \beta_2 Digital_{i,t} \times EU_{i,t} + \beta Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (3)$$

$$Gpant_{i,t} = \beta_0 + \beta_1 Digital_{i,t} + \beta Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (4)$$

$$ESG_{i,t} = \beta_0 + \beta_1 Digital_{i,t} + \beta_2 Gpatent_{i,t} + \beta Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (5)$$

4. Results and Discussion

4.1. Descriptive Statistics and Correlation Analysis

Table 2 reports the results of the descriptive statistics for the variables. The minimum value for ESG performance is 1, the maximum value is 8 and the mean value is 4.049, indicating that the majority of the sample enterprises have a medium level of ESG performance. Digital transformation has a minimum value of 0, a maximum value of 6.252, a mean value of 1.178 and a standard deviation of 1.366, indicating that while there are some sample enterprises that have not advanced their digital development, there is no significant fluctuation in the distribution of values. Environmental uncertainty ranges from a very small value of 0.009 to a very large value of 23.440, which shows that the external environment faced by some enterprises has obvious differences. The minimum value of green innovation is 0, the maximum value is 7.079 and the mean value is 0.275; thus, it is clear that the overall level of green innovation in enterprises is still low (see Table 2 for details).

Table 2. Descriptive statistics of variables.

Variables	N	Mean	SD	Min	Max
ESG	18,632	4.049	1.102	1.000	8.000
Digital	18,632	1.178	1.366	0.000	6.252
EU	18,632	1.375	1.418	0.009	23.440
Gpatent	18,632	0.275	0.671	0.000	7.079
Size	18,632	22.428	1.326	19.677	26.381
Lev	18,632	0.471	0.204	0.069	0.920
Roa	18,632	0.034	0.061	−0.234	0.208
Dual	18,632	0.216	0.412	0.000	1.000
Board	18,632	2.148	0.204	1.099	2.890
Indept	18,632	0.375	0.057	0.182	0.800
Top1	18,632	0.339	0.152	0.003	0.900

The results of the Pearson correlation analysis between the variables are reported in Table 3. Among them, digital transformation is significantly and positively correlated with corporate ESG performance, tentatively verifying the previous H1; environmental uncertainty is significantly and negatively correlated with ESG performance; and green innovation is significantly and positively correlated with corporate ESG performance. In addition, most of the control variables were significantly correlated with the dependent variable ESG performance, confirming the reasonableness and necessity of the selection of control variables.

Table 3. Pearson correlation analysis.

	ESG	Digital	EU	Gpatent	Size	Lev	Roa	Dual	Board	Indept	Top1
ESG	1.000										
Digital	0.082 ***	1.000									
EU	−0.178 ***	0.010	1.000								
Gpatent	0.168 ***	0.170 ***	−0.060 ***	1.000							
Size	0.316 ***	0.072 ***	−0.060 ***	0.325 ***	1.000						
Lev	−0.009	−0.120 ***	0.045 ***	0.071 ***	0.435 ***	1.000					
Roa	0.200 ***	0.035 ***	−0.069 ***	0.021 ***	0.077 ***	−0.334 ***	1.000				
Dual	−0.068 ***	0.130 ***	0.021 ***	0.009	−0.121 ***	−0.096 ***	0.005	1.000			
Board	0.060 ***	−0.079 ***	−0.058 ***	0.058 ***	0.243 ***	0.135 ***	0.047 ***	−0.182 ***	1.000		
Indept	0.079 ***	0.055 ***	0.008	0.043 ***	0.038 ***	0.005	−0.048 ***	0.104 ***	−0.493 ***	1.000	
Top1	0.097 ***	−0.123 ***	−0.001	0.033 ***	0.270 ***	0.110 ***	0.119 ***	−0.101 ***	0.058 ***	0.031 ***	1.000

Note: *** represents that is significant at the 1% level.

4.2. Regression Analysis

Table 4 reports the results. The content of the first column shows that digital transformation is significantly and positively related to corporate ESG performance at the 1% level, indicating that there is a facilitative effect of increased digital transformation on corporate ESG performance; H1 is also tested. Column (2) tests the moderating role of environmental uncertainty. The coefficient between environmental uncertainty and ESG performance is significantly negative at the 1% level; the interaction term between environmental uncertainty and digital transformation is also significantly negative at the 5% level, confirming that environmental uncertainty has a negative moderating effect on the positive relationship between digital transformation and ESG performance, i.e.,, when the level of environmental uncertainty increases, the positive impact of digital transformation decreases. H2 was also tested. The latter two columns test for the mediating role of green innovation. Column (3) shows that digital transformation is significantly positively associated with green innovation at the 1% level, while column (4) shows that both digital transformation and green innovation have a positive effect on ESG performance at the 1% level when both are considered. In summary, digital transformation will promote the development of green innovation in enterprise, which will in turn enhance their ESG performance, i.e., there is a

mediating role of green innovation between digital transformation and ESG performance. Hypothesis 3 was also tested.

Table 4. Regression analysis.

Variables	(1)	(2)	(3)	(4)
	ESG	ESG	Gpatent	ESG
Digital	0.028 ***	0.029 ***	0.020 ***	0.026 ***
	(3.73)	(3.95)	(4.69)	(3.44)
EU	-	−0.103 ***	-	-
		(−18.76)		
Digital×EU	-	−0.009 **	-	-
		(−2.33)		
Gpatent	-	-	-	0.114 ***
				(8.93)
Size	0.330 ***	0.318 ***	0.139 ***	0.314 ***
	(44.68)	(43.15)	(22.41)	(40.94)
Lev	−0.953 ***	−0.888 ***	−0.124 ***	−0.939 ***
	(−19.87)	(−18.72)	(−5.18)	(−19.58)
Roa	2.014 ***	1.954 ***	−0.135 **	2.030 ***
	(13.52)	(13.30)	(−2.00)	(13.63)
Dual	−0.120 ***	−0.114 ***	0.021 **	−0.122 ***
	(−6.46)	(−6.24)	(2.05)	(−6.60)
Board	0.167 ***	0.126 ***	0.142 ***	0.151 ***
	(3.78)	(2.90)	(4.90)	(3.42)
Indept	1.809 ***	1.756 ***	0.372 ***	1.767 ***
	(12.04)	(11.82)	(4.17)	(11.77)
Top1	0.062	0.079	0.018	0.060
	(1.22)	(1.57)	(0.55)	(1.18)
Cons	−4.100 ***	−3.780 ***	−3.379 ***	−3.714 ***
	(−22.62)	(−20.86)	(−22.35)	(−19.75)
Industry	Control	Control	Control	Control
Year	Control	Control	Control	Control
N	18,632	18,632	18,632	18,632
Adj.R^2	0.217	0.234	0.337	0.220

Note: *** represents that is significant at the 1% level, ** is significant at the 5% level.

4.3. Robustness Tests and the Treatment of Endogeneity Problems

(1) Robustness test of the main effects. Replacing the measure of corporate ESG performance, the evaluation scores of the Social Responsibility Report of Listed Companies published by Hexun, a third-party measurement agency, were used to measure corporate ESG performance; the natural logarithm of their total scores was then taken. Due to the data collection situation, the sample time range is 2010–2020 and the total number of sample items is 17,539 after excluding relevant missing values. Column (1) in Table 5 shows the results, which show that digital transformation has a facilitating effect on corporate ESG performance at the 10% level. The conclusion is the same as above.

(2) Robustness test of the moderating effect. The moderating effect of environmental uncertainty is verified based on a grouping approach, where the grouping is based on the median of environmental uncertainty. The results of column (2) and (3) in Table 5 are shown, with digital transformation being significantly positively correlated with ESG performance at the 10% level with a correlation coefficient of 0.019 when environmental uncertainty is high, and at the 1% level with a correlation coefficient of 0.033 when environmental uncertainty is low. This shows that the contribution of digital transformation to ESG performance is weaker under high environmental uncertainty, which supports the previous conclusion.

Table 5. Robustness tests.

Variables	(1)	(2)	(3)	(4)	(5)
	Full Sample	**Full Sample**	**Full Sample**	**High EU**	**Low EU**
	ESG	**Gpatent**	**ESG**	**ESG**	**ESG**
Digital	0.008 *	0.050 ***	0.023 ***	0.019 *	0.033 ***
	(1.83)	(8.36)	(3.11)	(1.81)	(3.23)
Gpatent	-	-	0.115 ***	-	-
			(12.07)		
Size	0.172 ***	0.202 ***	0.304 ***	0.343 ***	0.308 ***
	(35.66)	(25.57)	(39.26)	(33.60)	(28.69)
Lev	−0.237 ***	−0.060 *	−0.952 ***	−0.854 ***	−1.032 ***
	(−6.72)	(−1.81)	(−19.83)	(−13.41)	(−14.21)
Roa	7.916 ***	0.481 ***	1.924 ***	1.468 ***	2.548 ***
	(50.08)	(4.99)	(12.85)	(7.74)	(10.68)
Dual	−0.024 **	0.019	−0.120 ***	−0.115 ***	−0.106 ***
	(−2.11)	(1.37)	(−6.51)	(−4.42)	(−4.10)
Board	0.032	0.138 ***	0.143 ***	0.084	0.192 ***
	(1.07)	(3.63)	(3.23)	(1.32)	(3.15)
Indept	0.014	0.251 **	1.748 ***	1.831 ***	1.745 ***
	(0.14)	(2.14)	(11.65)	(8.37)	(8.51)
Top1	0.126 ***	−0.071 *	0.047	−0.055	0.145 **
	(3.99)	(−1.67)	(0.92)	(−0.76)	(2.04)
Cons	−1.013 ***	−4.712 ***	−3.467 ***	−4.215 ***	−3.661 ***
	(−8.45)	(−24.94)	(−18.39)	(−16.44)	(−14.27)
Industry	Control	Control	Control	Control	Control
Year	Control	Control	Control	Control	Control
N	17,539	18,329	18,329	9316	9316
Adj.R^2	0.446	0.344	0.226	0.203	0.233

Note: *** represents that is significant at the 1% level, ** is significant at the 5% level, * is significant at the 10% level.

(3) Robustness test of the mediating effect. The mediating variable was again measured by replacing the total number of green innovations for which enterprises obtained approval with the total number of green innovations for which enterprises applied in the year. The remaining variables were measured in the same way and the sample size was 18,329 entries after excluding missing values. The last two columns in Table 5 report the regression results of mediation effect; the results show that there is a mediating role for green innovation between digital transformation and corporate ESG performance, supporting the previous conclusions.

(4) Treatment of endogeneity issues. Corporate ESG performance may be affected by managerial characteristics and lead to endogeneity problems. To enhance the robustness of the findings, we further control for managerial age, female managerial share, managerial financial background and managerial overseas background; we then regress models (2)–(5) again. The variables are measured as follows: age is the natural logarithm of the average age of the executive team; female is the ratio of the number of female managers in the executive team to the total number of managers; and financial and overseas backgrounds are measured as dummy variables—the value is 1 if the executive team has the above backgrounds and 0 otherwise. The regression results are reported in Table 6; the age of managers has a positive effect on ESG performance at the 1% level, while the financial background of managers has a negative effect on ESG performance at the 1% level. After controlling for each characteristic variable, the test results of main effect, mediating effect and moderating effect did not change significantly, confirming the reliability of the findings.

Table 6. Impacts of managerial characteristics.

Variables	(1)	(2)	(3)	(4)
	ESG	**ESG**	**Gpatent**	**ESG**
Digital	0.035 ***	0.034 ***	0.021 ***	0.032 ***
	(4.61)	(4.64)	(4.93)	(4.32)
EU	-	−0.098 ***	-	-
		(−17.74)		
Digital×EU	-	−0.008 **	-	-
		(−2.05)		
Gpatent	-	-	-	0.111 ***
				(8.64)
Age	1.229 ***	0.910 ***	0.275 ***	1.198 ***
	(9.28)	(6.88)	(4.00)	(9.05)
Female	−0.047	−0.069	−0.043	−0.042
	(−0.66)	(−0.98)	(−1.26)	(−0.59)
Financial	−0.068 ***	−0.053 ***	−0.017 **	−0.066 ***
	(−4.27)	(−3.35)	(−1.97)	(−4.16)
Overseas	−0.015	−0.018	0.033 ***	−0.018
	(−0.99)	(−1.19)	(4.24)	(−1.23)
Size	0.317 ***	0.309 ***	0.133 ***	0.302 ***
	(41.20)	(40.30)	(21.93)	(38.08)
Lev	−0.927 ***	−0.873 ***	−0.112 ***	−0.914 ***
	(−19.39)	(−18.45)	(−4.76)	(−19.14)
Roa	2.008 ***	1.953 ***	−0.138 **	2.023 ***
	(13.53)	(13.32)	(−2.03)	(13.64)
Dual	−0.100 ***	−0.098 ***	0.024 **	−0.102 ***
	(−5.38)	(−5.38)	(2.32)	(−5.53)
Board	0.121 ***	0.095 **	0.123 ***	0.108 **
	(2.71)	(2.14)	(4.19)	(2.41)
Indept	1.740 ***	1.711 ***	0.345 ***	1.702 ***
	(11.59)	(11.51)	(3.89)	(11.35)
Top1	0.009	0.037	0.007	0.008
	(0.17)	(0.74)	(0.22)	(0.16)
Cons	−8.402 ***	−6.967 ***	−3.379 ***	−3.714 ***
	(−16.61)	(−13.76)	(−22.35)	(−19.75)
Industry	Control	Control	Control	Control
Year	Control	Control	Control	Control
N	18,632	18,632	18,632	18,632
Adj.R^2	0.222	0.237	0.338	0.224

Note: *** represents that is significant at the 1% level, ** is significant at the 5% level.

4.4. Heterogeneity Tests Based on Size of Enterprise

Digital transformation brings both opportunities and challenges to the development of enterprise. Firstly, the construction of digital infrastructure requires continuous investment of resources; enterprises cannot fully unlock the digital dividend if they do not have sufficient resources in reserve. Secondly, digital transformation has changed the production and operation models of enterprise, which has increased their business risks. Therefore, we argue that larger-scale enterprises often have more resources in stock, which can provide security for digital transformation, and higher risk-taking and resilience ability, which can help them cope with the challenges in the process of digital transformation. Therefore, the positive effects of digital transformation are more pronounced when enterprises are larger. To test these hypotheses, we grouped the sample according to the median size of enterprises and examined the impact of digital transformation on ESG performance. Table 7 reports the regression results. The correlation coefficient between digital transformation and corporate ESG performance is 0.044, which is significantly positive when the size of the enterprise is large; there is no significant correlation between the two when the size of the enterprise is small. Thus, it is confirmed that the impact of digital transformation on corporate ESG performance will be moderated by the size of the enterprise.

Table 7. Extensibility analysis.

Variables	(1)	(2)
	High Size	Low Size
	ESG	ESG
Digital	0.044 ***	0.013
	(4.10)	(1.19)
Size	0.329 ***	0.380 ***
	(27.69)	(21.76)
Lev	−0.780 ***	−1.056 ***
	(−9.67)	(−17.29)
Roa	2.497 ***	1.741 ***
	(9.70)	(9.41)
Dual	−0.175 ***	−0.092 ***
	(−5.92)	(−3.87)
Board	0.083	0.283 ***
	(1.39)	(4.30)
Indept	1.815 ***	1.884 ***
	(8.71)	(8.52)
Top1	0.037	0.123
	(0.54)	(1.58)
Cons	−4.280 ***	−5.317 ***
	(−13.52)	(−13.35)
Industry	Control	Control
Year	Control	Control
N	9316	9316
Adj.R^2	0.206	0.164

Note: *** represents that is significant at the 1% level.

5. Research Conclusions and Insights

5.1. Research Conclusions

Based on the perspectives of the principal–agent problem, resource access and risk-taking, this study empirically discusses how digital transformation affects corporate ESG performance and further explores the boundaries and mechanisms of its effects. The study finds that, firstly, digital transformation helps to reduce internal and external information asymmetry, alleviate principal–agent conflicts and financing constraints and improve corporate risk-taking, thus contributing to good ESG performance. Secondly, environmental uncertainty affects the positive effect of digital transformation, while the positive correlation between digital transformation and ESG performance is weakened when the environmental uncertainty faced by enterprises is high.

Thirdly, digital transformation helps improve the level of green innovation and further boosts ESG performance, i.e., there is a mediating role for green innovation between digital transformation and ESG performance. Fourthly, further research shows that the contribution of digital transformation to corporate ESG performance is more significant in larger-scale enterprises.

5.2. Theoretical Significance

The theoretical significance of this study lies in the fact that existing studies on corporate ESG performance mainly discuss the economic consequences to which it leads [2,3,6–8,55,56], while relatively little analysis has been performed on its antecedent variables. Considering the gradually increasing importance placed on corporate ESG performance by the Chinese government and external stakeholders, this paper provides new ideas to explore the influencing factors of corporate ESG performance in the context of the digital economy. Unlike other studies on digital transformation and corporate ESG performance [24–26], this paper further incorporates contextual factors, such as environmental uncertainty and enterprise size, into the analytical framework and discusses the boundaries of the role

of digital transformation in exerting effects on corporate ESG performance from a new perspective. At the same time, the existing studies are still lacking in the discussion of the path mechanisms through which digital transformation affects corporate ESG performance. Although some studies have found that digital transformation is a key factor in promoting corporate green innovation [28–30], whether it further affects corporate ESG performance remains unexplored. Therefore, this paper introduces green innovation as a mediating mechanism, bringing new thinking to analyze the path through which digital transformation affects the integrated development of the corporate environment, social responsibility and corporate governance. Moreover, the study enriches the literature on corporate digital transformation.

5.3. Practical Significance

The findings of the study have certain practical guidance implications for both enterprise managers and government departments. For business managers, they should first pay attention to the application of digital technology and actively promote the digital transformation of enterprises. ESG performance has become one of the most important factors for external stakeholders to judge corporate development as they pay more attention to social responsibility and investment in environmental protection. Enterprise can empower ESG performance improvement through use of modern technologies, such as big data, cloud computing and artificial intelligence, and grasp the new opportunities for corporate ESG development in the digital economy era. Secondly, the study found that the positive effect of digital transformation is influenced by the scale of enterprises themselves. For smaller-scale enterprises, the digital economy's dividends may not be fully released due to their capital level, organizational structure and other factors. Managers of such enterprises should be more cautious about digital development and avoid major losses caused by blindly making digital investments, such as increasing enterprise investment costs. Thirdly, managers should pay more attention to the external environment of the enterprise. When enterprises face heightened uncertainty, managers should pay more attention to digital development to avoid the adverse effects of operational fluctuations.

For government departments, in the current reality of attaching importance to corporate ESG performance, they can guide the digital transformation of enterprises to achieve their integrated development in terms of environment, social responsibility and corporate governance. To this end, government departments should first accelerate the optimization of regional digital infrastructure construction to create a favorable external environment for enterprises to utilize digital technology. Secondly, government should formulate more targeted incentives and support policies and provide enterprises with senior managers and core technical personnel who have mastered digital technology; this strategy can help enterprises with insufficient funds, difficulties in using technology and high uncertainty to eliminate barriers to digital development. In this way, the government can alleviate the digital development situation of some enterprises that are "reluctant to switch and afraid to switch", help enterprises to successfully overcome the difficulties of digital transformation, promote implementation of green innovation activities and enhance attention to ESG performance.

5.4. Research Limitations and Perspectives

Although this paper provides some theoretical and practical contributions, there are still some limitations. Firstly, the study sample covers all industries except finance and does not take into account the possible differences in digital transformation trends among different industries. Future research can further focus the discussion on specific industries to enhance the reliability of the research findings within the segmented industry sectors. Secondly, this study measures the frequency of words related to "digital transformation" as disclosed in corporate annual reports; however, there is no assurance that enterprises are implementing digital development in practice. In the future, we will continue to pay attention to and discuss the measurement of digital transformation and try to ensure the validity of the measurement in a more objective and accurate way. Thirdly, the digital

development of enterprises is affected by the overall level of digitalization in the region; however, this paper does not analyze this external environmental factor. In future studies, we will further reflect on this issue.

Author Contributions: Conceptualization, S.W.; methodology, Y.L.; software, S.W.; validation, Y.L.; formal analysis, S.W.; investigation, S.W. and Y.L.; resources, S.W.; data curation, Y.L.; writing—original draft preparation, S.W.; writing—review and editing, Y.L.; visualization, S.W. and Y.L.; supervision, S.W. and Y.L.; project administration, S.W. All authors have read and agreed to the published version of the manuscript.

Funding: The authors gratefully acknowledge the support for this research provided by the 2022 Youth Research Fund Project (Social Sciences) of Liaoning University, No. LDQN2022006.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available from authors upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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