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The Impact of Digital Transformation on ESG Performance Based on the Mediating Effect of Dynamic Capabilities

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Abstract: The United Nations Development Summit in 2015 adopted the "2030 Agenda for Sustainable Development", establishing a framework for Sustainable Development Goals (SDGs) with the aim of achieving coordinated economic, social, and ecological development worldwide by 2030. The "environmental, social, and governance" (ESG) approach is important within the concept of SDGs and is the subject of increasing attention from scholars. Despite China's significant contributions to the SDGs, it still faces numerous challenges in terms of environmental and governance development. With the ongoing development of digital technology, many Chinese enterprises aspire to harness the dividends of digital transformation in order to achieve SDGs. In this study, we aim to help companies understand how they can improve their ESG performance through digital transformation. We use a sample of A-share listed companies in China from 2011 to 2020 to construct a digital transformation index by profiling the frequency of digital-related words in companies' annual reports using textual analysis. Furthermore, we empirically examine the direct effect of digital transformation on companies' level of ESG disclosure and explore the mediating effect of dynamic capabilities on the impact of digital transformation on ESG performance. Empirical testing reveals that digital transformation indeed has a positive impact on enterprises' ESG performance, and digital technology innovation can enhance ESG performance through dynamic capabilities such as green innovation, social responsibility, and operational management. The findings indicate that companies need to actively develop and promote digital technologies to obtain the benefits of digital transformation, with company executives including advanced technology in their decision-making and operational processes in an effort to promote innovation and management efficiency, thereby improving their ESG performance.

Keywords: digital transformation; ambidexterity theory; environmental, social, and governance; dynamic capabilities; mechanism analysis

Citation: Su, X.; Wang, S.; Li, F. The Impact of Digital Transformation on ESG Performance Based on the Mediating Effect of Dynamic Capabilities. *Sustainability* **2023**, *15*, 13506. https://doi.org/10.3390/su151813506

Academic Editor: Sam Solaimani

Received: 25 July 2023
Revised: 5 September 2023
Accepted: 7 September 2023
Published: 9 September 2023

1. Introduction

The rapid development of AI, blockchain, and other digital technologies has seen governments attach increasing importance to digital infrastructure, emphasizing the integration of digital technologies with the physical economy and significantly strengthening the digital economy's governance system [1]. The Chinese government has achieved remarkable results in terms of the development of digital infrastructure, and numerous Chinese enterprises are now pursuing the strategic goals of environmental protection and green, sustainable development [2]. Therefore, in the latest stage of development of the physical economy, how enterprises should make use of digital transformation to achieve technological innovation and sustainable development has become an important discussion topic among scholars [3].

In September 2015, the United Nations Development Summit approved the "2030 Agenda for Sustainable Development", which outlined a set of Sustainable Development Goals (SDGs) with a significant level of enforceability [4]. The SDGs adhere to the principle

of multidimensional and coordinated development encompassing economic, social, and environmental aspects. They provide guidance to countries worldwide in their development planning and allocation of resources until 2030. The SDGs' significance lies in their ability to reverse the negative externalities generated during the processes of economic and social development, reshape the relationship between humans and the environment, establish a new social contract, and achieve shared prosperity for humanity [5]. However, as a result of unequal global development, countries vary in their adherence to the implementation standards and approaches for achieving the SDGs. To achieve the SDGs, the concept of environmental, social, and governance (ESG) performance has gained increasing attention and recognition among the public [6]. Initially, this approach emphasizes organizing and guiding investors' behavior from the perspectives of environmental, social, and governance considerations. The relatively new concept of ESG performance has become an important means of measuring the sustainable development of enterprises in an increasingly digital economy.

The concept of ESG performance was first introduced in 2004 as part of the UN Global Compact initiative, which comprises several criteria that measure ESG performance rather than financial performance. Performance in relation to social and environmental issues has a direct effect on corporate earnings, and thus, the ESG concept is an extension of corporate strategy in relation to social values [7]. More importantly, the core concept of ESG is in line with the Chinese government's goal of carbon neutrality and provides detailed operational guidelines. With corporate financial fraud and environmental damage becoming increasingly widespread, ESG performance is receiving increased attention from regulators. Thus, government and industry associations are actively promoting ESG disclosure schemes for listed companies with the aim of promoting the flow of capital to companies that fully implement an ESG approach [8]. However, while regulation and policy guidance are indispensable for improving ESG performance in the context of the digital economy, it is even more important to activate the dynamic capabilities inherent in enterprises through digital transformation in an effort to accomplish the dual goals of enhancing both the financial performance and social standing of enterprises. This leads to the following questions that are the focus of this study: (1) Can companies improve their ESG performance through digital transformation? (2) What impacts do different types of digital transformation have on ESG performance? (3) What mediating factors affect the impact of digital transformation on ESG performance?

To analyze the impact of digital transformation on corporate ESG performance, we used A-share listed companies in China from 2011 to 2020 as the sample and constructed a digital transformation index by profiling the frequency of occurrence of digital-related words in companies' annual reports using textual analysis. Based on ambidexterity theory, we empirically analyzed the direct effect of digital transformation on the level of corporate ESG disclosure and confirmed the validity of the benchmark regression results using robustness tests and addressing possible endogeneity problems [9]. Furthermore, based on the dynamic capability theory, we identified the factors mediating the impact of digital transformation on enterprises' ESG performance in the dimensions of green innovation, social responsibility, and operational management.

This study may generate the following three marginal contributions: (1) According to ambidexterity theory, this study creatively categorizes digital transformation into exploitative transformation and explorative transformation, thereby enhancing the existing measurement framework for assessing the level of digital transformation. (2) This study, based on the data-driven theory, individually examines the effects of digital transformation, exploitative transformation, and explorative transformation on enterprises' ESG performance, thereby highlighting the micro-level effects of digitalization in organizational development. (3) This study, from the perspective of SDGs, deconstructs dynamic capabilities into green innovation, social responsibility, and operational management capabilities. Additionally, it examines the mediating mechanism of dynamic capabilities and tests the transmission paths of digital transformation on ESG performance.

The rest of this research is organized as follows. Section 2 presents a thorough review and critical discussion of the relevant literature. Section 3 presents our theoretical analysis and research hypotheses regarding the effect of digital transformation on enterprises' ESG performance. Section 4 presents the methodological design, including the data sources, the two-way fixed effects model, and variable definitions. Section 5 presents the empirical results of benchmark regressions and robustness tests, as well as estimations of the mediating effects based on dynamic capabilities. Section 6 presents the findings and prospects of this research.

2. Research Review

The essence of digital transformation is to introduce advanced digital technology into an enterprise's production processes and internal controls so that the enterprise is upgraded from "industrial management" to "digital management" (see Figure 1). Su found that by reshaping its existing operational and management frameworks, the enterprise develops a modern operational mode featuring high efficiency, customized service, and intelligent management [10]. From the initial stage of digital development, enterprises generally continue to invest in the application of new technologies in an effort to optimize internal and external resource allocation, enabling increases in both scale and efficiency, thereby enhancing the ability of enterprises to achieve sustainable development [11]. However, our analysis revealed that this might not always be the case. While numerous enterprises might seek to undertake digital transformation, they are often constrained by immature technology, high investment costs, and a lack of suitably qualified staff, resulting in disappointing outcomes. Therefore, Danneels and Viaene deduced that the emergence of the "digital transformation paradox" makes it difficult for companies to improve their competitiveness and social value [12].

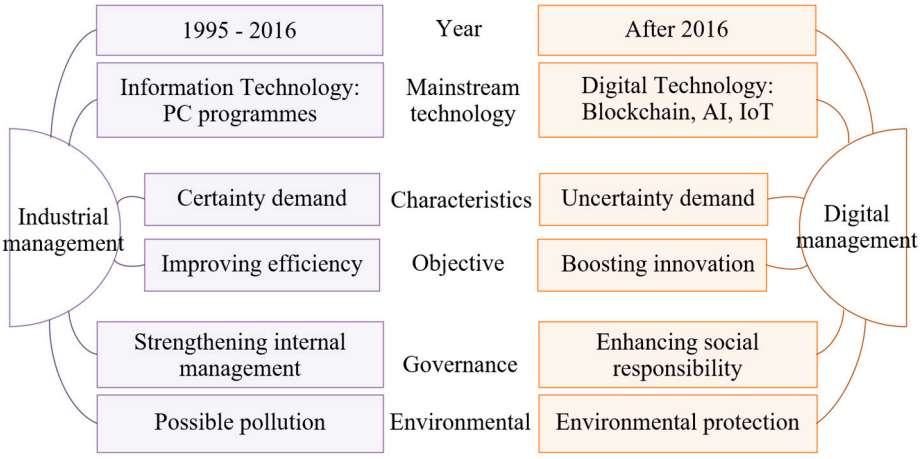

Figure 1. The development characteristics of digital technologies.

However, Zhao and Li believed the dilemma that enterprises face in the early stage of digital transformation is often gradually overcome with the introduction of increasingly mature digital technology and the continuous development of employees' skills [13]. Some previous studies have analyzed the relationship between the digital transformation of enterprises and their business performance and market value from various perspectives [14]. However, no consensus has been reached, with various studies finding different effects of digital transformation on enterprises' innovation capability and market performance [15]. The above analysis shows that by introducing digital technologies into research and development (R&D) and operations, enterprises aim to modularize technical specifications and business processes. However, the wide variety of digital technologies that are available result in differing outcomes among enterprises, hence the conflicting results of previous studies.

Most of the initial studies on digitalization were based on theory and qualitative analysis, with few empirical studies based on quantitative analysis because to test the effect of digitalization on financial performance, market value, and other variables, first, it was necessary to measure the variable of "digital transformation" [16]. In the growth period of this research field, academics explored the "measurement of enterprise digitization" to enhance the credibility of their papers. Bican and Brem used "whether the enterprise has implemented digital reform in the year" as a dummy variable to measure digital transformation [17]. However, this approach failed to measure the degree of digitization of enterprises, leading to possible bias in the results. Subsequent studies by Tavana et al. have attempted to measure the degree of digital transformation using the frequency of keywords related to digital technology in the annual reports of listed companies as a proxy for the level of digital transformation [18]. More recently, research on the effects of digital transformation has entered a new stage, with some studies dividing digital technologies into various elements and categories in an effort to achieve a more detailed analysis of the impact of digitalization on enterprises [19]. Based on the elemental theory perspective, Wu et al. divided digital technologies into artificial intelligence, blockchain, cloud computing, big data, and digital applications and found that digital transformation increased the market value and financial stability of enterprises, thereby increasing stock liquidity and the performance of enterprises in the capital market [20]. Conversely, Zhao et al. divided digital technologies into four categories, including Internet businesses, information systems, technology applications, and intelligent manufacturing, and found that digital transformation can enhance corporate value and social responsibility performance by improving innovation capacity [21]. It is clear that studies on the effects of digitalization have focused not only on financial performance but also on non-financial indicators, such as sustainable competitiveness and ESG performance, which are receiving increasing attention.

An increasing number of studies are focusing on enterprises' ESG performance, and some interesting results have been published [22]. However, research on ESG is still in an early stage, and scholars have not yet developed a comprehensive theoretical system and empirical analysis framework. Dogru and Akyildirim perceived that ESG is a unique evaluation system constructed by companies and their stakeholders based on the concept of sustainable development and environmental, social, and governance performance, thereby capturing overall performance [23]. Prior to the emergence of the ESG concept, the public was more familiar with environmentally and socially responsible investing. Since the United Nations General Assembly's initiative in 2004 incorporated ESG into the corporate strategic decision-making process, many third-party credit-rating agencies have begun to promote concepts and products such as ESG performance and disclosure scores. Avramov et al. argued that ESG's aim is to reshape investors' evaluation criteria to assist them in selecting the best companies in which to invest while also indirectly reinforcing the importance that listed companies place on ESG [24]. Early research results have mostly focused on the relationship with enterprises from the three dimensions of environment, society, and corporate governance. Saetra found that corporate governance is not objectionable to enhancing enterprise value, although the relationship between environmental and social factors and enterprise value is unclear [25]. However, the finding that higher levels of environmental and social responsibility enhance enterprise value is most common. In recent years, following the publication of ESG reports by both the enterprises themselves and third-party index organizations, the public has gradually become more familiar with the holistic concept of ESG. Meanwhile, scholars such as Pacelli have begun to use ESG performance as an independent variable to explore its impact on total factor productivity and enterprise value [26]. Shanaev and Ghimire found that a higher level of ESG performance enhances a company's stock returns and market performance, which, in turn, improves investors' perceptions of the company and reduces financing constraints [27]. Currently, ESG performance is mainly used as a causal variable in an attempt to explain the effects it has on the firm. Although it is an important non-financial indicator, there have been no

in-depth studies of the factors that can promote the development of ESG, which is the main reason for the lack of a comprehensive theoretical structure and framework.

Thus, in the context of the digital economy, ESG warrants attention as an important point of convergence in exploring corporate digitalization and sustainable development. However, few studies have explicitly linked digital transformation to ESG performance, and the causality and possible mechanisms of influence between them can only be inferred from the results of other studies. There are three reasons for this:

- First, because there is no comprehensive theoretical model, the effect of digital transformation on ESG performance is unclear, and no current theoretical model is able to explain the underlying mechanism.
- Secondly, the method used to measure the degree of digital transformation is imperfect. The various attributes of digital technologies mean that different applications will have differing effects on enterprises, but no studies have measured the effects of various digital technologies based on their attributes.
- Thirdly, there have been no in-depth studies of the transmission mechanism. The impact of digital transformation on ESG performance might be achieved via various intermediary pathways, with different pathways resulting in differing impacts.

Therefore, to enrich the existing literature, we analyzed the impact effect mechanism of "digital transformation–ESG performance" to present new evidence on the relationship between digital transformation and the ESG performance of listed companies in China.

3. Theoretical Analysis and Research Hypotheses

3.1. Digital Transformation and ESG Performance

The digital transformation of enterprises involves the application of advanced digital technology that enables enterprises to achieve significant innovations in terms of manufacturing, business processes, and information systems. The aim is to reduce operating costs and take greater social responsibility, thereby meeting the expectations of all stakeholders and ultimately maximizing enterprise value.

Based on the digital-driven effect, there are three reasons why digital transformation improves the ESG performance of enterprises. First, digital technology is environmentally friendly, providing a "technology reservoir" that aids green development [28]. At the organizational level, digital technology enables enterprises to achieve optimal divisions of labor, thereby reducing energy loss while increasing operational efficiency. At the production level, digital technology can be used to control the entire production process in real-time, thereby enhancing environmental protection throughout the production process. At the operational level, digital technology enables enterprises to pursue green production utilizing previously idle resources and thereby achieve the goal of zero emissions of carbon and other pollutants. Second, digital transformation can prompt enterprises to shift to a high-value-added "product + service" business model, providing an incentive for enterprises to assume greater social responsibility [29]. From the customers' perspective, digital technology narrows the distance between the enterprise and the customer. The enterprise can obtain customer feedback in a timely manner, enabling it to continually improve its products and services, thereby enhancing user satisfaction. From the shareholders' perspective, digital transformation reduces the marginal cost of R&D and innovation, improves product and service quality and market reputation, and enables enterprises to pay more attention to their image and brand reputation. Third, digital transformation helps to improve the enterprise's production, management, and information processes, thereby enhancing the level of corporate governance [30]. In terms of operational management, digital transformation enables the intelligent control of the production and service processes, and the integration and efficient use of various factors of production, and thus, the development of enterprises. In terms of data circulation, digital technology optimizes the information system from multiple dimensions, breaks down communication barriers within the enterprise, and facilitates the mining and application of data, as well as the sharing of the latest knowledge. Thus, the following hypothesis is proposed:

Hypothesis 1a (H1a). *The digital transformation of enterprises has a significant positive effect on ESG performance.*

3.2. Ambidextrous Digital Transformation and ESG Performance

The relationship between digital transformation and ESG performance has been outlined above. However, the wide range of digital technologies, variety of attributes, difficulty in applying various digital technologies within enterprises, and differing input and output effects have led to conflicting findings in previous studies. This is because digital transformation has not been classified based on technological attributes but rather has only been used as an overall indicator for regression analysis, which has led to possible bias in the results. To fill this gap, in this study, we divide digital transformation into exploitative and explorative transformations based on ambidexterity theory and incorporate the attributes of various digital technologies in an effort to analyze the relationship between the two types of transformation and enterprises' ESG performance [31]. The concept of "ambidexterity" first appeared in the field of organizational competitiveness, where it was argued that organizations should have two complementary capabilities to enable them to cope with dynamic changes in the external environment and was later applied to the field of innovation. "Exploitation" and "exploration" have gradually become the two most central concepts in ambidexterity theory, exhibiting a mutually dependent and mutually reinforcing relationship [32].

Ambidexterity theory defines exploitation as the enhancement of what is already known by building on existing capabilities and technologies, while exploration involves creating something new through risk-taking and innovative behavior, with the aim of breaking out of existing patterns of development [33]. In other words, exploitation focuses on the short-term, deterministic development of an organization, while exploration involves strategic long-term planning. Thus, in this study, we classify e-commerce, digital marketing, and similar technologies as exploitative digital transformation. These types of technologies are developed gradually by information management science, which is slowly evolving according to the original basic disciplines and gradually applied to enterprise operations, and its development is generally more mature, which can deliver benefits to enterprises without the need for significant investment. Meanwhile, AI, blockchain, and similar technologies are classified as explorative digital transformation. These types of technologies have only been available for a relatively short period of time and present significant challenges in terms of R&D and practical application. Enterprises developing these technologies must invest considerable amounts of money in the short term [34]. However, once a new technology is successfully introduced, the enterprise has access to significant development opportunities.

In summary, exploitative and explorative transformation are different strategies that companies can adopt in an effort to enhance their digitization process. They involve technologies that occupy different domains but can work together to drive a company's digitization process. Thus, the following hypotheses are proposed:

Hypothesis 1b (H1b). *Exploitative digital transformation has a significant positive effect on ESG performance.*

Hypothesis 1c (H1c). *Explorative digital transformation has a U-shaped relationship with ESG performance.*

3.3. The Mediating Effect of Dynamic Capabilities

Although digital transformation has a positive overall impact on ESG performance, as outlined above, the underlying mechanism requires further investigation. If enterprises want to realize the vision of ESG development, they must achieve mutual adaptation between dynamic capabilities and the business environment [35]. Dynamic capability theory provides a relevant theoretical perspective from which to explore the relationship between

digital transformation and ESG performance. The concept of dynamic capabilities refers to the integration, reorganization, and upgrading of internal and external resources in response to the ability to perceive the environment, control opportunities, and transform existing operations in an effort to promote the continuous development of the enterprise's assets and resources in response to changing environments, thereby maintaining a competitive advantage [36]. Studies on dynamic capability theory are mainly divided into elemental theory, process theory, and hierarchical theory, of which elemental theory is the most widely researched. Elemental theory is based on the premise that dynamic capability is a multidimensional, aggregated structure involving several dimensions, including perception capability, learning capability, and innovation capability, as well as knowledge acquisition capability, social adaptation capability, and resource integration capability [37].

Drawing on the intrinsic relationship between dynamic capabilities theory and the SDGs strategy, we exploratively incorporate the need to develop ESG objectives in relation to corporate digitalization by classifying dynamic capabilities into green innovation, social responsibility, and operational management capabilities, thus enriching the elemental composition of dynamic capability theory [38]. Green innovation capability refers to the ability to conduct green R&D and environmental management using technological innovations with full consideration of environmental protection and clean energy consumption in conjunction with existing resources and technologies. Green innovation aims to reduce emissions and other forms of pollution, thereby providing environmental and social benefits. Social responsibility capability refers to the ability of a company to continuously upgrade its digital infrastructure based on feedback from investors and consumers in an effort to meet the various demands of different stakeholders. Adopting a proactive approach to social responsibility enables companies to enhance their reputation and image, thereby increasing the value of their brand. Operational management capability refers to the ability of enterprises to improve their information interoperability, interdepartmental collaboration, and resource integration and allocation through the use of digital technologies such as blockchain [39]. Increased operational management capability enables enterprises to upgrade their management processes and improve their input-output ratio and total factor productivity, thereby achieving greater control of the enterprise. Thus, the following hypothesis is proposed:

Hypothesis 2a (H2a). *Dynamic capabilities mediate the effect of enterprises' digital transformation on ESG performance.*

In summary, digital transformation can improve enterprises' ESG performance via three dynamic capabilities: green innovation capability, social responsibility capability, and operational management capability.

Natural resource-based theory suggests that digital transformation can enable enterprises to achieve green innovation, thereby maintaining their competitive advantage [40]. In the process of corporate digital development, market demand, financial investment, and policy support are all associated with ESG development, but digital transformation is likely to have the greatest impact on an enterprise's environmental score in relation to ESG through green technological innovation. First, green innovation is a complex process involving the creation, integration, and application of different types of technologies, such as those related to green production, energy conservation, and emission reduction. It is difficult to achieve significant green innovation by focusing solely on one area of the enterprise. However, digital transformation can increase the enterprise's understanding of green innovation, promote the adoption of new technologies, and generate complementary innovations [41]. Secondly, digital transformation can broaden the scope of an enterprise's technical resources and knowledge and stimulate the sharing of resources between departments in an effort to achieve green innovation, thereby enhancing the enterprise's innovation capability. The knowledge generated through this process can optimize various types of technological R&D and promote collaborative green innovation within the enter-

prise [42]. Thirdly, to enable green innovation in relation to production and management processes, enterprises need to obtain information regarding the energy consumption of each manufacturing link and its impact on the environment, so they put forward higher requirements on the environmental protection of enterprises, which naturally cannot be separated from the support of digital technology for green innovation [43]. Thus, the following hypothesis is proposed:

Hypothesis 2b (H2b). *Digital transformation can enhance enterprises' green innovation capability, which, in turn, improves their environmental score in relation to their ESG performance.*

Based on symbiosis theory, the interdependence between enterprises and society is the key to enterprises fulfilling their social responsibility by pursuing sustainable development [44]. In the traditional market, enterprises can continue to operate free of social demands; that is, they can ignore their social responsibility. However, in the digital era, enterprises are being transformed into organizational ecosystems that develop in conjunction with the external environment, and this external drive by symbiosis and co-creation constitutes the strategic core of the social responsibility of enterprises. Digital transformation has increased enterprise stakeholders' engagement with the sustainable development of society, creating a new culture of coexistence between enterprises and the external environment, resulting in mutual benefits [45]. Digitalization affects the relationship between enterprises and consumers, with digital transformation enabling enterprises to provide consumers with high-quality services by such means as opening accounts on social media platforms and establishing exclusive applets to convey their brand stories to consumers. Meanwhile, enterprise managers can use artificial intelligence to assist in strategic decision-making, enhance the level of competition in the enterprise to make reasonable planning, and make corporate information disclosure more transparent. Digitalization can assist employees by standardizing and refining workflows and clarifying the allocation of responsibilities among various departments [46]. Meanwhile, employee performance can be monitored and analyzed using digital technology, enabling a more scientific approach to remuneration, reward, and punishment systems, thereby improving corporate social responsibility. Digital transformation requires talented, high-tech employees, and thus, enterprises will strive to create a positive culture in an effort to recruit high-quality workers, thereby enhancing their social responsibility. Thus, the following hypothesis is proposed:

Hypothesis 2c (H2c). *Digital transformation can enhance enterprises' social responsibility capability, which, in turn, improves their social score in relation to their ESG performance.*

Based on the data-driven theory, enterprises take digital technology as the basis and digital reconstruction as the path to promote the modernization of corporate governance. First, the application of digital technology has created a new type of industry model and removed the traditional corporate governance boundaries, thereby promoting the development of corporate governance in a more advanced direction [47]. Digital technology facilitates improved communication among an enterprise's stakeholders, enabling small- and medium-sized shareholders, as well as market regulators, to participate in corporate governance, thereby enhancing the regulation of business processes. Secondly, the use of digital technology enables enterprises to quickly analyze consumer feedback to determine their preferences and optimize the business value chain, thereby enhancing corporate governance [48]. Consumer preferences and brand recognition are intangible assets of enterprises, and digital technology enables greater communication between consumers and enterprises. Enterprises can collect personalized data, such as users' search records and purchasing preferences, within the scope of the law, enabling them to analyze users' needs, improve the enterprise's operational efficiency, and promote the development of the corporate governance management system. Finally, digital technology has enabled a reconfiguration of traditional business and management models and has introduced new requirements in relation to corporate governance [49]. Enterprises need to recruit

employees with a high level of technical skills, that is, increase their intellectual capital, in an effort to meet the demands of an innovative business model. The importance of technical expertise has steadily increased, as has the proportion of board members with a background in science and technology, indicating that enterprises aim to improve their corporate governance with the help of digital technology experts. Thus, the following hypothesis is proposed:

Hypothesis 2d (H2d). *Digital transformation can enhance enterprises' operational management capability, which, in turn, improves their governance score in relation to ESG performance.*

Based on the above analysis, the theoretical model for this research is presented in Figure 2.

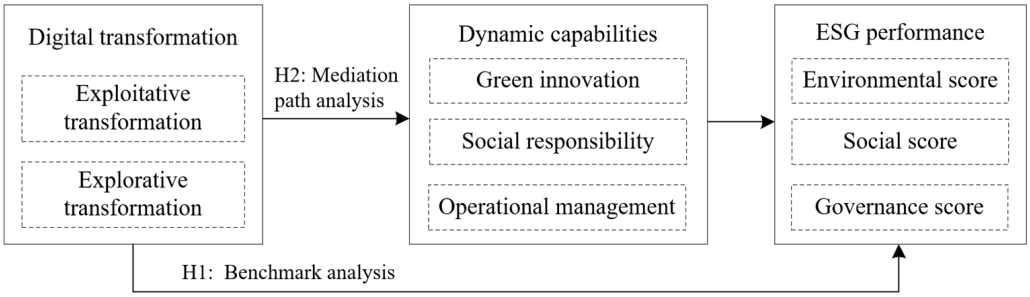

Figure 2. Theoretical analysis model.

4. Methodological Design

4.1. Study Sample and Data Sources

In this study, we used A-share listed companies in China from 2011 to 2020 as the research sample and Bloomberg's ESG disclosure scores, which currently have the greatest transparency of all ESG datasets, as the dependent variable. We applied textual analysis to identify the frequency of digital-related feature words appearing in the companies' annual reports and constructed a digital transformation index as the core independent variable. Finally, we matched our data with the operating indicators of A-share listed companies in the China Stock Market & Accounting Research Database and the China City Statistical Yearbook. To ensure the validity of the data, we excluded ST companies and companies with missing values or outliers in relation to key variables, resulting in a final sample of 10,319 firm-year panel data items. To eliminate interference from outliers, the main variables were winsorized at the 1st and 99th percentiles, and we used the Stata V17.0 software package to conduct the regression analyses.

4.2. Variable Definitions

4.2.1. Dependent Variable

The dependent variable was corporate ESG performance (*ESG*). Currently, Bloomberg's ESG disclosure dataset has the highest update frequency and the widest application among all ESG datasets, and thus, we used Bloomberg's ESG disclosure scores as the dependent variable [50]. Bloomberg's ESG index includes three items: an environmental (*E*) score, a social (*S*) score, and a governance (*G*) score, each of which accounts for one-third of the total ESG score. The E, S, and G scores represent a combination of seven, six, and eight sub-indicator scores (see Figure 3), respectively.

Figure 3. Main indicators of ESG performance. (Source of icons: Iconshock).

4.2.2. Core Independent Variable

The core independent variable was digital transformation (*Digital*). The method most frequently used to measure the level of enterprise digitalization is to analyze the text of annual reports of listed companies to obtain word frequency statistics regarding keywords related to digitalization [51]. To ensure the credibility of our results, we used this method to measure the level of enterprise digitization. However, given the rapid development of digital technologies, different types of technologies can have different impacts on the digital development of enterprises, and thus, it is difficult to determine which digital technologies have the greatest impact on ESG performance using a unidimensional digitalization measure.

Thus, we introduced ambidexterity theory into the measurement of the enterprise digitalization level, dividing digital transformation into exploitative transformation (*Exploit*) and explorative transformation (*Explor*) based on the attributes of various types of technologies. Exploitative transformation, which refers to digital transformation in which an enterprise can optimize and improve the quality of its products based on its existing resources and technologies, and thus requires less investment, is a more passive transformation. Exploitative transformation has the advantages of low R&D costs and a high level of operability. This shortens and simplifies the process of digitization but can result in increased operating costs and reduced efficiency. Explorative transformation, which refers to digital transformation in which enterprises are committed to exploring new and unknown areas in the hope of achieving technological breakthroughs, thereby obtaining first-mover advantages, is a more proactive transformation. Explorative transformation requires highly talented employees and significant R&D investment and typically involves a lengthy development period. However, explorative transformation is often disruptive, and once the new technology is sufficiently mature to be applied to the market, it can result in a significant improvement in the enterprise's operational efficiency and realize the breakthrough development of the enterprise.

Following previous studies, we measured the degree of ambidextrous digital transformation as follows. First, we drew on studies and policies on the topic of digitization to summarize the feature words with a high level of relevance to digitization, categorizing them based on the abovementioned explanations to form a bag of words of the feature words (see Figure 4). Next, the annual reports of A-share listed companies were analyzed using the "Jieba" tool in Python to determine the frequency of use of the feature words included in the bag of words [52]. Finally, the frequencies of the digitized feature words were aggregated to obtain the numbers of feature words related to exploitative transformation, explorative transformation, and both types of transformation combined, which were then logarithmized to obtain the level of exploitative transformation, explorative transformation, and overall transformation, respectively.

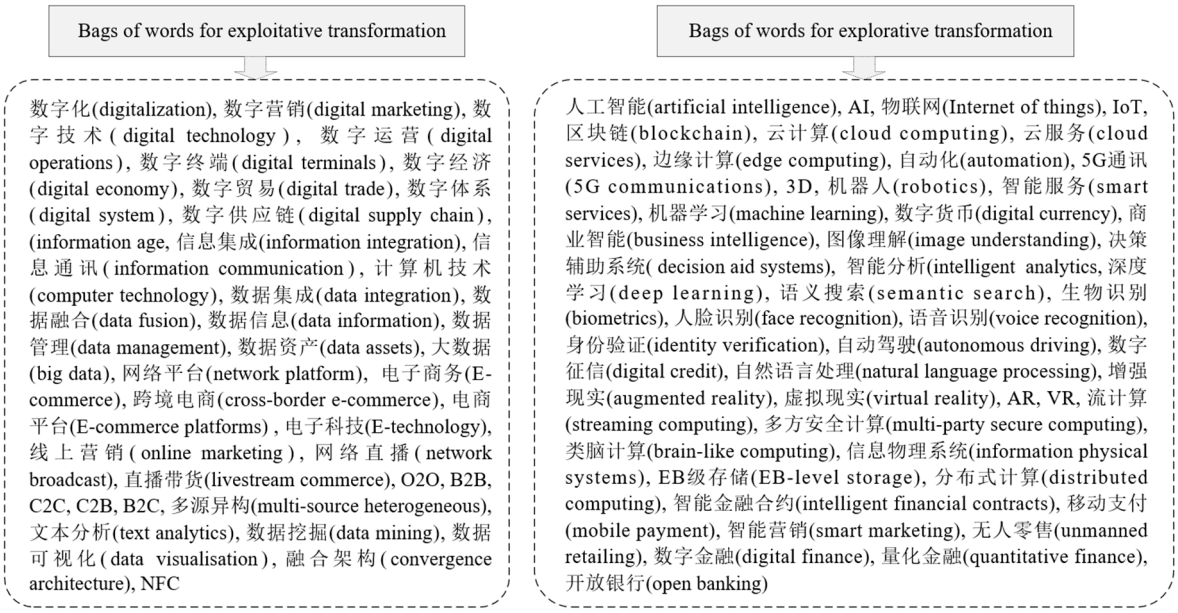

Figure 4. Bags of words of digital transformation feature words.

4.2.3. Control Variables

Several control variables that were considered likely to affect the impact of digital transformation on ESG performance were included in an effort to increase the accuracy of the regression results [53]. The control variables included enterprise size (*Size*), enterprise age (*Age*), debt-to-asset ratio (*Leverage*), total market capitalization (*Capital*), tobin's Q value (*TobinQ*), per capita GDP (*PerGDP*), fiscal revenue (*Revenue*), and foreign direct investment (*FDI*) in the city in which the enterprise is located. The definitions of the main variables are presented in Table 1.

Table 1. Variable definitions.

	Variable Name	Symbol	Variable Definition
Dependent variable	ESG performance	*ESG*	Bloomberg ESG disclosure composite score
	Environmental score	*E score*	Environmental disclosure score
	Social score	*S score*	Social disclosure score
	Governance score	*G score*	Governance disclosure score
Independent variable	Digital Transformation	*Digital*	ln(Total number of digital transformation feature words + 1)
	Exploitative transformation	*Exploit*	ln(Number of exploitative transformation feature words + 1)
	Explorative transformation	*Explor*	ln(Number of explorative transformation feature words + 1)
Company control variables	Enterprise size	*ROA*	ln(Total assets of the enterprise)
	Enterprise age	*Growth*	ln(Years of enterprise listing + 1)
	Debt to asset ratio	*Tangible*	Total liabilities/total assets
	Total market capitalization	*Leverage*	ln(Stock price total number of shares)
	Tobin's Q	*Cashflow*	Enterprise market value/replacement cost
Regional control variables	GDP per capita	*Size*	ln(Gross regional product per capita)
	Financial revenue	*Age*	ln(Total regional fiscal revenue)
	Foreign direct investment	*Leverage*	ln(Total foreign direct investment in a region)
Fixed effect	Individual FE	*Cid*	Individual dummy variable
	Year FE	*Year*	Year dummy variable
	Industry FE	*Ind*	Industry dummy variable
	Provincial FE	*Prov*	Province dummy variable

4.3. Model Construction

To test the impact of enterprises' digital transformation, including both exploitative and explorative transformation, on ESG performance, we developed the following benchmark models to facilitate two-way fixed-effects regression on the panel data. In particular, in an effort to test whether there was a significant U-shaped relationship as proposed in hypothesis H1c, the square of explorative transformation was added to Model 3:

$$ESG_{ij} = \beta_0 + \beta_1 Digital_{ij} + \lambda Controls_{ij} + Cid + Year + Ind + Prov + \varepsilon_{ij} \quad (1)$$

$$ESG_{ij} = \beta_0 + \beta_1 Exploit_{ij} + \lambda Controls_{ij} + Cid + Year + Ind + Prov + \varepsilon_{ij} \quad (2)$$

$$ESG_{ij} = \beta_0 + \beta_1 Explor_{ij} + \beta_2 Explor_{ij}{}^2 + \lambda Controls_{ij} + Cid + Year + Ind + Prov + \varepsilon_{ij} \quad (3)$$

The dependent variable is ESG performance (*ESG*); the independent variables are digital transformation (*Digital*), exploitative transformation (*Exploit*), and explorative transformation (*Explor*); the control variables (*Controls*) are as outlined above; and ε is the random disturbance term. In addition, the model included dummy variables for individual (*Cid*), year (*Year*), industry (*Ind*), and province (*Prov*) in an effort to mitigate the fixed effects generated by these factors. To increase robustness, the regressions were undertaken using clustered robust standard errors.

The following section begins the empirical testing of the hypotheses of this study, and the process framework is shown in Figure 5.

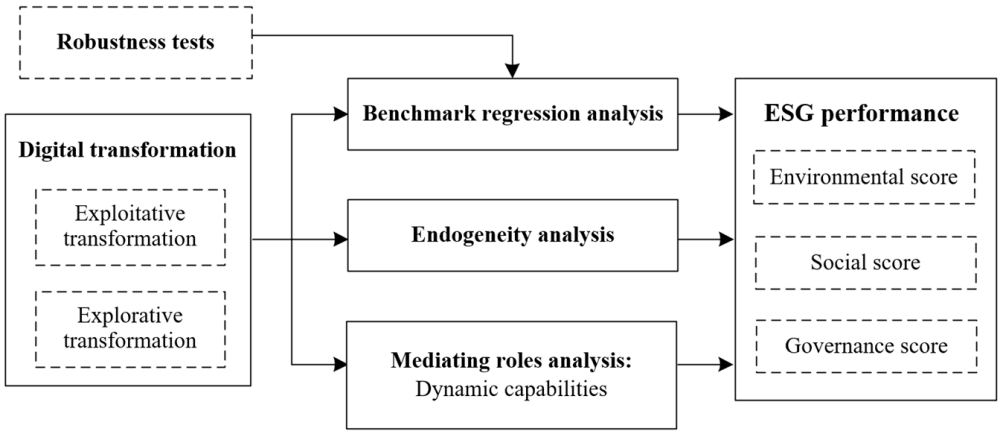

Figure 5. Process framework of empirical testing.

5. Empirical Results

5.1. Descriptive Statistics

Table 2 presents the descriptive statistics for the study variables. It can be seen that although there are differences among firms in terms of ESG performance, they are concentrated in the upper-middle level. The level of digital transformation varies significantly, indicating that some enterprises have not yet embarked on digitalization. Finally, the descriptive statistics for the control variables are largely consistent with those of previous studies.

Table 2. Descriptive statistics for the study variables.

Variable Name	N	Mean	Std	Min	P50	Max
ESG	10,319	2.992	0.308	2.335	3.008	3.740
Digital	10,319	0.244	0.107	0	0.238	1.477
Exploit	10,319	0.224	0.107	0	0.220	0.469
Explor	10,319	0.375	0.262	0	0.300	1.063
Size	10,319	3.145	0.063	3.032	3.138	3.322
Leverage	10,319	3.856	0.853	1.146	3.976	5.358
Age	10,319	2.907	0.326	1.946	2.944	3.434
Capital	10,319	23.277	1.047	21.373	23.186	26.037
TobinQ	10,319	0.574	0.101	0.439	0.550	0.851
PerGDP	10,319	6.462	0.457	5.499	6.502	7.361
Revenue	10,319	11.500	1.022	9.437	11.932	12.643
FDI	10,319	11.754	0.896	9.907	12.068	12.916

5.2. Benchmark Regression Analysis

Table 3 presents the regression results of the benchmark model; that is, the impact of the firms' overall digital transformation (*Digital*), exploitative transformation (*Exploit*), and explorative transformation (*Explor*), on ESG performance. Column (1) shows that there is a positive relationship between overall digital transformation (*Digital*) and enterprises' ESG performance, with a coefficient of 0.174 at the 1% level of significance. Column (2) shows that after adding the control variables, the coefficient is slightly reduced to 0.119 but is still significant at the 1% level, indicating that digital transformation (*Digital*) improves ESG performance. Thus, hypothesis H1a is supported. Column (3) shows a positive relationship between exploitative digital transformation (*Exploit*) and ESG performance with a coefficient of 0.127 at the 1% level of significance. Column (4) shows that after adding the control variables, the coefficient falls to 0.08 but is still significant at the 5% level, indicating that exploitative transformation (*Exploit*) improves ESG performance. Thus, hypothesis H1b is supported. In an effort to verify the existence of a U-shaped relationship as proposed in hypothesis H1c, the square of explorative transformation ($Explor^2$) was added to Model 3. Column (5) shows that the coefficient of the square of explorative transformation ($Explor^2$) is 0.119 at the 1% level of significance, as well as passing the test of the "U-test" command. This indicates that there is indeed a U-shaped relationship between explorative transformation (*Explor*) and ESG performance as a result of the significant technological barriers involved in explorative transformation. Enterprises are required to make significant investments in R&D, resulting in an initial decline in ESG performance, but the technological breakthroughs that are eventually achieved lead to improved ESG performance. Column (6) shows that after adding the control variables, the coefficient of the square of explorative transformation ($Explor^2$) remains positive at the 5% level of significance, and thus hypothesis H1c is supported.

Table 3. Benchmark regression analysis results.

	(1) *ESG*	(2) *ESG*	(3) *ESG*	(4) *ESG*	(5) *ESG*	(6) *ESG*
Digital	0.174 ***	0.119 ***				
	(3.678)	(2.598)				
Exploit			0.127 ***	0.080 **		
			(3.215)	(2.068)		
Explor					−0.037	−0.029
					(−1.242)	(−0.988)
$Explor^2$					0.119 ***	0.092 **
					(2.925)	(2.332)

Table 3. *Cont.*

	(1) *ESG*	(2) *ESG*	(3) *ESG*	(4) *ESG*	(5) *ESG*	(6) *ESG*
Size		0.828 ***		0.840 ***		0.822 ***
		(3.031)		(3.053)		(3.030)
Leverage		−0.008		−0.008		−0.008
		(−0.790)		(−0.778)		(−0.782)
Age		−0.022		−0.025		−0.033
		(−0.331)		(−0.370)		(−0.495)
Capital		0.049 ***		0.049 ***		0.049 ***
		(4.692)		(4.724)		(4.711)
TobinQ		−0.017		−0.018		−0.020
		(−0.230)		(−0.242)		(−0.274)
PerGDP		−0.034		−0.035		−0.040
		(−0.914)		(−0.923)		(−1.067)
Revenue		0.077		0.078		0.095
		(0.984)		(0.997)		(1.205)
FDI		−0.056 **		−0.055 **		−0.055 **
		(−2.416)		(−2.391)		(−2.398)
_cons	3.039 ***	−0.537	3.046 ***	−0.585	3.074 ***	−0.643
	(57.150)	(−0.446)	(57.110)	(−0.483)	(59.872)	(−0.533)
Cid/Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	10,319	10,143	10,319	10,143	10,319	10,143
adj. R^2	0.282	0.305	0.281	0.304	0.283	0.305

Notes: T-statistics are presented below the coefficient estimates and are calculated based on robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5.3. Robustness Tests

In order to ensure the robustness of the benchmark regression results, the following robustness tests are conducted in this study.

5.3.1. High-Dimensional and Iterative Fixed Effects

To check the robustness of the benchmark regression results, high-dimensional fixed effects, and iterative fixed effects tests were conducted. Cumulative fixed effects of individual, time, industry, and province were added to the benchmark model, which were designed to absorb other disturbances in the industry and region in which the firms were located [54]. Given that enterprises face various exogenous shocks, two interaction terms, year × industry (*Year* × *Ind*) and year × province (*Year* × *Prov*), were introduced to the benchmark regression model for the high-dimensional fixed-effects regression. We also conducted a regression using the principal component iteration method in an effort to mitigate the impact of external factors on the benchmark regression results. The results of the regressions are shown in Table 4.

Columns (1), (2), and (3) show that the coefficients of overall digital transformation, exploitative transformation, and the square of explorative transformation are all positive at the 1% level of significance. Column (4) shows that the coefficient of digital transformation (*Digital*) after the iterative regression is positive at the 1% level of significance. Columns (5) and (6) show that the coefficients of exploitative transformation (*Exploit*) and the square of explorative transformation ($Explor^2$), respectively, are positive at the 5% level of significance. This indicates that after the regression dimensions were added, the coefficient values changed slightly, but the results remained significant, consistent with the original hypothesis.

Table 4. Regression results with high-dimensional and iterative fixed effects.

	Panel A: High-Dimensional Fixed Effects			**Panel B: Iterative Fixed Effects**		
	(1) ***ESG***	**(2)** ***ESG***	**(3)** ***ESG***	**(4)** ***ESG***	**(5)** ***ESG***	**(6)** ***ESG***
Digital	0.162 ***			0.127 ***		
	(4.275)			(2.620)		
Exploit		0.126 ***			0.083 **	
		(3.843)			(2.021)	
Explor			−0.061 **			−0.034
			(−2.360)			(−1.088)
$Explor^2$			0.149 ***			0.100 **
			(4.599)			(2.361)
_cons	−0.747	−0.761	−0.674	0.084	0.028	−0.028
	(−1.274)	(−1.293)	(−1.156)	(0.062)	(0.021)	(−0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Cid/Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Year × Ind FE	Yes	Yes	Yes			
Year × Prov FE	Yes	Yes	Yes			
N	10,085	10,085	10,085	10,141	10,141	10,141
adj. R^2	0.769	0.769	0.769			

Notes: T-statistics are presented below the coefficient estimates and are calculated based on robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5.3.2. Replacement of Independent Variable

We also replaced the independent variable. We followed Wu's previous measure of the digitalization level, which divided digital technologies into artificial intelligence (*AI*), blockchain (*Blockchain*), cloud computing (*Cloud*), big data (*BigData*), and digital applications (*DigitalApp*) to construct a digital bag of words, and then obtained the logarithms of the word frequencies [20]. Table 5 shows the regression results following the replacement of the independent variable. It can be seen that the coefficients of the five dimensions of digital transformation are all positive. The coefficients of the sub-indicators of digital transformation all passed the robustness test at the 1% level of significance, with the exception of the coefficient of blockchain (*Blockchain*), which was significant at the 10% level. Blockchain technology is currently in the R&D stage, which requires significant investment and thus has not yet been widely applied.

Table 5. Regression results after replacing the independent variable.

	(1) ***ESG***	**(2)** ***ESG***	**(3)** ***ESG***	**(4)** ***ESG***	**(5)** ***ESG***
AI	0.078 ***				
	(3.352)				
Blockchain		0.116 *			
		(1.737)			
Cloud			0.105 ***		
			(6.690)		
BigData				0.100 ***	
				(3.502)	
DigitalApp					0.076 ***
					(3.334)
_cons	1.706 ***	−1.519 ***	−1.146 ***	−1.422 ***	−1.311 ***
	(4.213)	(−4.136)	(−3.135)	(−3.843)	(−3.520)
Controls	Yes	Yes	Yes	Yes	Yes
Cid/Year FE	Yes	Yes	Yes	Yes	Yes
N	5,634	5,634	5,634	5,634	5,634
adj. R^2	0.282	0.142	0.155	0.147	0.146

Notes: T-statistics are presented below the coefficient estimates and are calculated based on robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5.4. Treatment of Endogeneity Problems

We addressed potential endogeneity problems such as mutual causation and omitted variables in relation to the benchmark regression results by introducing lag terms for the independent variable and instrumental variables. First, there is a time lag between R&D and the application of digital technology, and thus, we introduced lag terms for digital transformation in periods 1 (*L.Digital*) and 2 (*L2.Digital*) into the benchmark model. The regression results presented in columns (1) and (2) of Table 6 show that the coefficients of digital transformation in periods 1 and 2 are both positive at the 1% level of significance. Secondly, regarding the selection of instrumental variables, the condition of being related to independent variables rather than random disturbance terms needs to be satisfied, and thus, we used the logarithmic values of the volume of Internet business per capita in a city (*Internet*) and the number of mobile phone subscribers per 100 people in the same city (*Phone*) as the instrumental variables to regress each of the three indicators of digital transformation. These instrumental variables were chosen because the amount of Internet business per capita and the number of mobile phone subscribers per 100 people are positively correlated in a given city, and neither variable affects corporate ESG performance. The regression results are shown in columns (3), (4), and (5) in Table 6. After adding the instrumental variables, the coefficients of overall digital transformation (*Digital*), exploitative transformation (*Exploit*), and the square of explorative transformation ($Explor^2$) were all positive at the 5% level of significance, confirming that our benchmark regression results were robust.

Table 6. Results of endogeneity problem treatments.

	(1) ***ESG***	**(2)** ***ESG***	**(3)** ***ESG***	**(4)** ***ESG***	**(5)** ***ESG***
L.Digital	0.530 ***				
	(11.942)				
L2.Digital		0.456 ***			
		(9.960)			
Digital			0.715 **		
			(2.196)		
Exploit				0.717 **	
				(2.190)	
$Explor^2$					0.547 **
					(2.170)
_cons	−0.703 **	−0.848 ***			
	(−2.466)	(−2.660)			
Controls	Yes	Yes	Yes	Yes	Yes
Cid/Year FE	Yes	Yes	Yes	Yes	Yes
N	9146	7980	10143	10143	10143
adj. R^2	0.144	0.107	0.135	0.121	0.072

Notes: T-statistics are presented below the coefficient estimates and are calculated based on robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5.5. Mediation Path Analysis

The results of the benchmark regressions, robustness tests, and endogeneity problem treatments all provided support for our research hypotheses. However, they only confirmed the existence of a positive correlation between digital transformation and ESG performance through causal inference without identifying the underlying mechanism. Thus, we empirically examined the mechanism by which digital transformation affects ESG performance. As mentioned earlier, digital transformation can affect ESG performance via three dynamic capabilities: green innovation capability, social responsibility capability, and operational management capability. To test hypothesis H2a, because we considered that the stepwise regression method was less efficient and might not identify a mediating

effect even though it existed, we developed a mediating factor model (Model 4) and a Sobel model (Model 5) to empirically test the mediating mechanism [55]:

$$Mediator_{ij} = \beta_0 + \beta_1 Digital_{ij} + \lambda Controls_{ij} + Cid + Year + Ind + Prov + \varepsilon_{ij} \quad (4)$$

$$ESG_{ij} = \beta_0 + \beta_1 Digital_{ij} + \beta_2 Mediator_{ij} + \lambda Controls_{ij} + Cid + Year + Ind + Prov + \varepsilon_{ij} \quad (5)$$

The mediating variables (*Mediator*) in Model 4 represent the three dimensions of dynamic capabilities. In this study, the logarithm of the total number of green invention and utility model patent applications by enterprises (*GP*) was used as a proxy for green innovation capability; the social responsibility index published by Hexun.com (accessed on 20 March 2023) was used as a proxy for corporate social responsibility (*CSR*) capability; and total factor productivity (*TFP*), calculated using the Levinsohn and Petrin method, was used as a proxy for operational management capability [56]. In Model 5, the three sub-indicators of Bloomberg's ESG rating system, namely, the E, S, and G scores, which correspond to the three dimensions of dynamic capabilities, were used as a proxy for ESG. The other variables were the same as those used in the benchmark model.

The regression results using Models 4 and 5 are shown in Table 7. The coefficients of GP and TFP, presented in columns (1) and (5), were 0.656 and 0.357, respectively, at the 1% level of significance, and the coefficient of CSR shown in column (3) was 0.271 at the 5% level of significance. These results indicate that the digital transformation of enterprises contributes to increases in green patent applications (*GP*), corporate social responsibility index (*CSR*) scores, and total factor productivity (*TFP*), and thus, dynamic capabilities act as a mediating mechanism between digital transformation and ESG performance, providing support for hypothesis H2a. Columns (2), (4), and (6) show the results of regression using the Sobel model. It can be seen that the coefficients of digital transformation (*Digital*) and the mediating variables (*GP*, *CSR*, and *TFP*) were all positive at the 1% level of significance. These results indicate that digital transformation can improve enterprises' E, S, and G scores by enhancing their green innovation capability, social responsibility capability, and operational management capability, suggesting that dynamic capabilities have a significant positive mediating effect on the impact of digital transformation on enterprises' ESG performance, and thus hypotheses H2b, H2c, and H2d are supported.

Table 7. Results of mediation path analysis.

	(1) ***GP***	**(2)** ***E score***	**(3)** ***CSR***	**(4)** ***S score***	**(5)** ***TFP***	**(6)** ***G score***
Digital	0.656 ***	0.264 ***	0.271 **	0.260 ***	0.357 ***	0.078 ***
	(5.748)	(2.658)	(2.508)	(4.568)	(6.826)	(6.147)
GP		0.044 ***				
		(7.786)				
CSR				0.169 ***		
				(22.352)		
TFP						0.033 ***
						(18.701)
_cons	1.659 **	−0.113	4.260 ***	2.228 ***	−0.425	3.627 ***
	(2.063)	(−0.183)	(7.841)	(6.176)	(−1.120)	(34.516)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Cid/Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	9201	7939	8960	8764	9139	9139
adj. R^2	0.589	0.230	0.191	0.222	0.641	0.141

Notes: T-statistics are presented below the coefficient estimates and are calculated based on robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

6. Conclusions

6.1. Findings

Digital transformation has become an important means for enterprises to improve their ESG performance, which is necessary if they are to be considered high-quality organizations. In this study, we used a sample of A-share listed companies in China from 2011 to 2020 to analyze the mechanism via which digital transformation affects ESG performance; the following are the findings of this study. (1) First, according to ambidexterity theory, we constructively categorized digital transformation into exploitative transformation and exploitative transformation based on their technological attributes. Moreover, through textual analysis and keyword frequency statistics, we measured the level of corporate digital transformation, thereby enriching the existing evaluation framework for corporate digitalization. (2) Secondly, we not only examined whether overall digital transformation can effectively enhance ESG performance, but we also divided digital transformation into exploitative transformation and explorative transformation. The results showed that exploitative transformation has a positive effect on ESG performance, while explorative transformation has a U-shaped effect on ESG performance, and these regressions have all passed robustness tests. (3) Finally, we deconstructed the dynamic capabilities of enterprises into green innovation capability, social responsibility capability, and operational management capability in an effort to identify the mechanism by which enterprises' dynamic capabilities mediate the effect of digital transformation on their ESG performance. Our empirical tests confirmed that digital transformation indeed effectively enhances ESG performance, with dynamic capabilities as the mediation pathway.

To make the findings more intuitive, Table 8 summarizes the research hypotheses and their empirical results.

Table 8. Research hypotheses and empirical results.

S.N.	Research Hypotheses	Supporting Theories	Empirical Results
H1a	The digital transformation of enterprises has a significant positive effect on ESG performance.	Digital-driven theory	Significant
H1b	Exploitative digital transformation has a significant positive effect on ESG performance.	Ambidexterity theory	Significant
H1c	Explorative digital transformation has a U-shaped relationship with ESG performance.	Ambidexterity theory	Significant
H2a	Dynamic capabilities mediate the effect of enterprises' digital transformation on ESG performance.	Dynamic capabilities theory	Significant
H2b	Digital transformation can enhance enterprises' green innovation capability, which, in turn, improves their environmental score in relation to their ESG performance.	Natural resource-based theory	Significant
H2c	Digital transformation can enhance enterprises' social responsibility capability, which, in turn, improves their social score in relation to their ESG performance.	Symbiosis theory	Significant
H2d	Digital transformation can enhance enterprises' operational management capability, which, in turn, improves their governance score in relation to ESG performance.	Data-driven theory	Significant

6.2. Suggestions

To promote the use of digital technology in improving enterprises' ESG performance, we put forward the following suggestions.

From the national perspective, the nation should introduce policies and regulations that promote the application of digital technology, guide enterprises in pursuing the SDG strategy, and gradually incorporate ESG indicators into performance assessments. The government should promptly establish a policy framework for digital transformation in areas such as the environment and business. It should strengthen the development of next-generation digital infrastructure, build intelligent blockchain platforms, and promote data

integration and technological convergence among different industries. The government needs to provide special funding to support enterprises' technological R&D and help them incorporate digital technology in their production and management processes in an effort to improve their innovations and operational efficiency. Additionally, the regulatory authorities need to strengthen ESG disclosure standards and supervision and encourage more enterprises to undertake voluntary performance disclosure.

From the social perspective, society should embrace the idea that digital transformation can improve ESG performance. Industry associations should prioritize the protection of intellectual property rights related to digital technologies and guide different industries in achieving ESG strategy through digitalization. Digital technology suppliers and research institutions need to actively engage in the ecosystem of digital technology innovation, accelerating industry–research collaboration to drive digital transformation. Bloomberg, FTSE Russell, and other index providers need to establish comprehensive ESG rating systems to enable public disclosure of enterprises' ESG performance, thereby motivating enterprises to pay attention to ESG indices. The majority of investors should choose to invest in companies that pay more attention to digitalization and ESG development. Therefore, it is important for enterprises to focus on digital technologies and the ESG sector in order to obtain more investors.

From the enterprises' perspective, enterprises should adopt a long-term development strategy focused on digital transformation and improved ESG performance and introduce appropriate measures to assist them in achieving their goals. Enterprises should encourage the development of digital technology experts by introducing training and evaluation programs aligned with technological developments, thereby ensuring that the necessary scientific and technological skills are available to enable enterprises to move rapidly toward their ESG goals through digital transformation. Enterprises should embrace the benefits offered by the digital economy, actively develop digital technology, and introduce advanced technology into their decision-making and management processes, thereby enhancing their technological innovation and operational efficiency, enabling them to achieve the ultimate goal of sustainable development.

6.3. Limitations and Prospects

This study reveals the mechanism of digital change driving corporate ESG performance based on the mediating effect of dynamic capabilities; however, limitations still exist. First, digital technologies represented by blockchain and ChatGPT are evolving rapidly, giving rise to more cutting-edge digital technologies within a relatively short period of time. Therefore, to measure the digitalization level of companies more accurately, it is essential to continuously enrich the latest digital feature words in the bags of words and employ other methods such as questionnaire surveys or simulation simulations for assessment. Moreover, as ESG indices gain growing prominence among governments and investors globally, leading index providers, such as MSCI and FTSE Russell, have initiated the disclosure of ESG performance data. Nevertheless, the current ESG evaluation system remains insufficiently developed to accurately capture a company's sustainable development level. Future improvements in the ESG framework are necessary to bolster the credibility of the results. To address the aforementioned issues, researchers will continue to track cutting-edge theories and deepen the practicality of the findings.

Author Contributions: Conceptualization, X.S.; methodology, X.S.; software, S.W.; formal analysis, X.S., S.W. and F.L.; data collection, S.W. and F.L.; writing—original draft preparation, X.S. and S.W.; writing—review and editing, S.W. and F.L.; supervision, S.W. and F.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the National Social Science Fund of China (19BGL150), Natural Science Foundation of Shandong Province (ZR2020MG046), and Social Science Foundation of Jilin Province (2022J10).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data sets generated and analyzed during the current study are available in the github.com repository, https://github.com/sw8258/digital.git (accessed on 24 July 2023), and are available from the corresponding author on reasonable request.

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

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