

Article

Analyzing the Relationship between Digital Transformation Strategy and ESG Performance in Large Manufacturing Enterprises: The Mediating Role of Green Innovation

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Abstract: In the era of the digital economy, digital technology brings new opportunities for enterprises' development. The degree of enterprises' digital transformation determines their development level and potential. At present, China's "double carbon" policy is having a profound impact on the industry. The relationship between digital transformation strategy and environmental, social, and governance (ESG) performance is analyzed based on the digitalization and sustainable development goals of enterprises, and on the basis of positioning enterprise digital transformation level through the strategic alignment model (SAM). Data are collected by questionnaire survey from 224 large manufacturing enterprises in China as a sample for empirical testing by the hierarchical regression method. The empirical results show the following. (1) Digital transformation strategy has a direct positive and significant impact on enterprise ESG performance. Specifically, it is reflected in the two dimensions of digital transformation strategy, namely business digitalization and platform digitalization, which have a significant direct positive impact on enterprise ESG performance. (2) Enterprise green innovation plays a significant intermediate role in promoting the relationship between digital transformation strategy and enterprise ESG performance. (3) The two dimensions of green innovation, namely green process innovation and green product innovation, both play a partial mediating role in promoting business digitalization and platform digitalization development level to enterprise ESG performance, respectively. It can be concluded that business digitalization and platform digitalization can improve enterprise ESG performance by promoting green process innovation and green product innovation. Therefore, enterprises should clarify the direction of development of their digital transformation strategy, emphasize green innovation, and continuously improve their ESG performance to create favorable conditions for achieving sustainable development.

Keywords: digital transformation strategy; green information technology; green innovation; ESG



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1. Introduction

Over the past two decades, China, as a manufacturing powerhouse, has experienced rapid economic growth and made important contributions to global economic stability and development [1,2]. Upholding the shared vision of a sustainable future for mankind, the Chinese government is dedicated to global climate governance through concrete actions, and has made a commitment to the world to achieve "carbon peaking" and "carbon neutrality" by 2030 and 2060, respectively [3]. With the continuous integration of digital technology and the real economy, networking, digitalization and intelligentization in the economic society has become the general trend [4]. The combination of digitalization and the "double carbon" policy is a new driving force for the high-quality development of manufacturing enterprises. Digital technologies can help reduce carbon emissions through

enabling technology supply, establishing carbon management and carbon reduction, and reducing contract costs. Green information technology innovation plays a certain role in promoting digitalization and reducing the impact of enterprise carbon emissions [5]. In the “Action Plan for Achieving Carbon Peaking by 2030” (2021) [6], it is proposed that green manufacturing projects should be further implemented, green design should be vigorously promoted, green manufacturing systems should be improved, and green factories and industrial parks should be built. The Chinese government promotes the integrated development of digital, intelligent, and green industries, and strengthens the technological upgrading of key industries and sectors. The development of a green economy under the “double-carbon” target has become a new engine to implement national key strategies, and has promoted the transformation of the economy from factor-driven to green technology-innovation-driven [7]. It requires that, as the main drivers of economic development, enterprises must establish a sustainable development model that is green-oriented, technology-supported, and innovation-driven.

The extent to which enterprises benefit or harm sustainable development has received increasing attention from many quarters. Enterprise actions in this arena are often referred to as environmental, social, and governance (ESG) factors, which are used to evaluate how enterprises are performing with regard to sustainability [8]. The environmental aspect is usually measured by whether the enterprise has adopted environmental protection measures in the course of its operations. It captures, for example, carbon footprint, energy efficiency, energy management, waste management, and water usage. The social aspect refers to the social responsibilities undertaken in the process of enterprise development. It includes, e.g., human and labor rights, employee well-being, health and safety, diversity and inclusion, equality and non-discrimination, privacy and data protection, and supply chain management. Governance mainly focuses on principal-agent issues. Good enterprise governance can balance the legitimate rights and interests of various stakeholders. It covers how enterprises manage the “E” and the “S”, e.g., their management systems, governance structures, public affairs, bribery, and corruption [9]. The focus on ESG is driven by growing demand across enterprises’ stakeholders and the drive for strong ESG ambition is increasing [10]. Enterprises’ new ESG ambitions are aimed at shaping the manufacturing industry, and should lead to long-term competitive advantages [11]. Furthermore, ESG ambitions will boost talent attraction and strengthen enterprises’ partnerships with customers as well as improve their brand reputation [12,13]. Scholars have indicated that improving enterprise ESG performance can establish a reasonable incentive and constraint mechanism to optimize the experience model, promote sustainable development of enterprises, and maximize enterprise benefits and social benefits [14,15]. Therefore, enterprises are increasingly engaged in ESG activities. The improvement of Chinese enterprises’ ESG performance is demonstrating to the world that the Chinese government can “walk the talk”.

Digital technologies play an important role in fighting COVID-19 and promoting economic recovery [16,17]. The digital economy has become an important driving force for economic transformation [18]. The globalization and informatization of economic development have brought unprecedented opportunities to the operation and development of enterprises [19]. In recent years, many scholars have studied the relationship between digital transformation and enterprise economic benefits. When it comes to the recovery and growth of the green economy [20], there are many existing studies on the relationship between digital transformation and enterprise green innovation. Some scholars believe that digital transformation promotes green innovation activities [21] and strengthens carbon emission reduction effect [22], thus improving enterprise ESG performance. However, there are also scholars who take controversial or diverging views. Some scholars argue that digital transformation is limited in its ability to meet the requirements of green innovation [23]. A study suggests that productivity-driven digital transformation ignores sustainability and could cause environmental problems [24]. Some scholars have proposed that the innovative development of renewable energy does not always decrease carbon emissions [25]. However, few scholars have studied the linear relationship between dig-

ital transformation strategy and enterprise ESG performance in the context of the new requirements of China's "double carbon" policy. The direction of action of the two variables is not quite clear. The analysis of the mediating effect of green innovation between the two variables is insufficient. The relevant research is in the initial stage, and the theoretical exploration has not yet formed a system.

Against the background of national carbon peaking, carbon neutrality strategy, and ESG concept practice in capital markets, large Chinese manufacturing enterprises are selected as research objects to analyze and test the impact of digital transformation strategy on ESG performance and to examine the intermediary mechanism of enterprise green innovation. The findings are expected to theoretically deepen the understanding of the role of green information technology in promoting sustainable development and enrich empirical research on how digital transformation strategy drives enterprise ESG performance. This study may contribute to the existing theoretical landscape on analysis of the links between digital transformation strategy and ESG performance in the following aspects. First, existing research mainly focuses on the impact of digital transformation strategy on enterprise economic value [26]. However, corporate social responsibility is increasingly becoming an important basis for enterprises to build sustainable competitive advantage [27], emphasizing the importance of digital transformation strategy in the performance of enterprise ESG. It broadens the theoretical understanding of non-economic value creation in enterprise digital transformation. Second, from the micro perspective, the correlation between green information technology and enterprise sustainable development is directly established, which is conducive to deepening the micro understanding of the complex relationship between digital transformation strategy and enterprise ESG performance. Third, a theoretical model of "digital transformation strategy–enterprise green innovation–enterprise ESG performance" is constructed from the perspective of the strategic alignment model; furthermore, the intermediate transmission mechanism of enterprise green innovation is deeply analyzed, so as to open the "black box" of how digitalization enables enterprises to improve ESG performance. The research conclusions provide a theoretical basis for clarifying the complex relationship between digital transformation strategy and enterprise ESG performance. From the perspective of focusing on digital transformation strategy, the practical implications inspire enterprises to achieve high-quality "double carbon" goals and actively respond to the trend of participation in ESG.

The overall structure of the study takes the form of six sections. The research background is explained in the Section 1. In Section 2, we briefly summarize the relevant studies regarding digital transformation strategy and its impact on ESG performance to put forward the research hypotheses. The survey design is introduced and issues concerning data collection are displayed in Section 3. The empirical results are presented in Section 4. The findings are discussed in Section 5. The conclusions, the practical implications and the limitation of the study are presented in Section 6.

2. Literature Review and Hypotheses Development

2.1. Digital Level Analysis Based on Strategic Alignment Model

Enterprise digitalization refers to the application of digital technology and intelligent technology to the entire operation management and business process, as well as to the reliance on these technologies to improve research and development, production, sales, service, and other links. The aim is to promote the digitalization of the overall process of enterprise development enabling the enterprise value chain, the innovation chain and the supply chain [28]. With the rapid development of information technology, competition between enterprises is becoming increasingly fierce. Furthermore, the investment of enterprises in information technology increases year by year. Scholars have conducted research on strategic matching, and believe that the key through which enterprises can maintain their competitive advantages lies in their adaptation of their business plan (BP) and information systems planning (ISP) [29]. The most representative research is the strategic alignment model (SAM) proposed by Henderson and Venkatraman [30]. The

theoretical framework of SAM includes four fields: business strategy, IT/IS strategy, organizational processes and infrastructure, and IT/IS processes and infrastructure. Three types of matching relationships are formed: the first two are BP-ISP relationships in terms of the external environment, describing the enterprise's overall strategic planning in the face of market competition; the last two are the BP-ISP relationship in the internal environment, focusing on the specific management logic and structure design of the enterprise; and the cross-domain matching relationship, which reflects the matching of strategic planning and architectural processes [31]. In particular, four matching patterns are the most important and can better reflect the process of digital transformation. The first two matching paths are driven by business strategy, which can form the model of “strategy execution” and “technology potential”. The latter two paths are driven by IT/IS strategies, which can form “competitive potential” and “service level” models [32].

This study is aimed at large manufacturing enterprises with a basis for digital transformation. The objective is to examine whether they form digital strategy and reshape corporate strategy and organization based on it, so as to enable their sustainable development. Therefore, the latter two paths of the transformation process, driven by digital strategy are mainly considered, as shown in Figure 1: First, Competitive Potential: Path (1), from IT/IS digital strategy to business strategy, and to organizational processes and infrastructure. This mode focuses on how to make use of new information technology to enable enterprises to gain better or even new competitive advantages, stimulate novel needs of customers, and then formulate new business strategies on this basis, so as to influence or even change the organizational structure of enterprises in order to adapt to and support the business strategy [33]. Its formulation and implementation process must involve systematic analysis of the degree of enterprise digital transformation, mainly represented by the level of business digitalization. Second, Service Level: Path (2), from IT/IS digital strategy to IT/IS digital processes and infrastructure, and to organizational processes and infrastructure. This mode is aimed at optimizing the positioning of IT/IS digitalization in the external environment, and maximizing IT/IS digitalization ability by using first-class information technology, so as to meet the high requirements of the information system users; furthermore, through rapid and efficient user response, the business process and organizational service functions of the enterprise can play a full role [30]. The infrastructure and application of IT/IS digitalization is key to realizing the service level path, which is mainly characterized by platform digitalization.

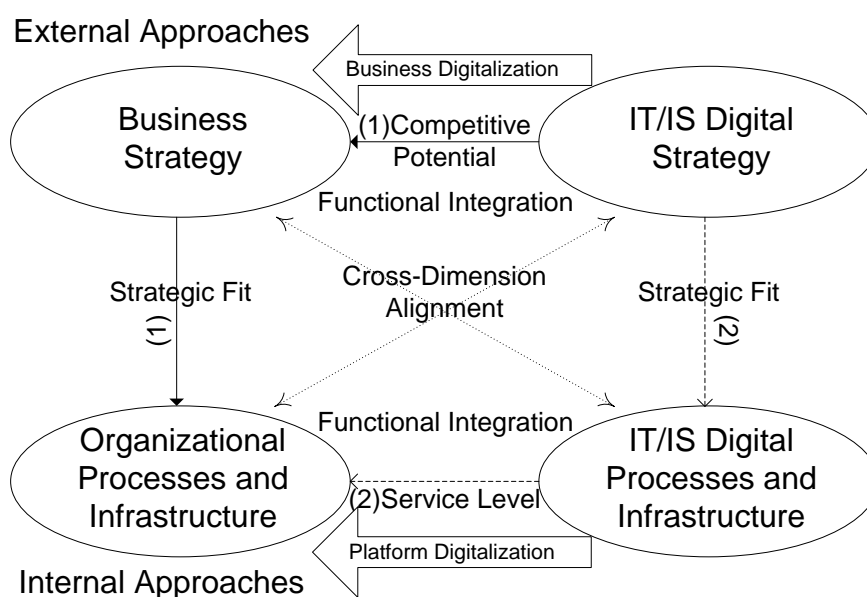


Figure 1. Strategic path of digital transformation based on SAM.

Based on the existing research on the dimensions of digital transformation and combined with the characteristics of green information technology, the complementarity, symbiosis, and openness of green information technology indicate that participants in digital transformation are synergistic and symbiotic. Their value co-creation can be achieved through business interaction. Therefore, digital transformation is moving in the direction of business digitalization. Meanwhile, the characteristics of green information technology indicate that participants need to realize online integration and sharing of resources through the platform in order to create value. It suggests that digital transformation is moving towards platform digitalization as well. Green information technology not only promotes the integration of business and the coordination of information flow among participants in digital transformation, but also supports the construction of more complex and dynamic platforms, allowing resources to flow quickly and be shared among participants [34]. To sum up, this study divides digital transformation strategy into two dimensions: business digitalization and platform digitalization.

In other words, the enterprise digital transformation strategy reflects the effective promotion of the application of digital technology, intelligent technology, and automation technology to the enterprise's overall operating performance and value presentation [35]. Furthermore, in practice, the application of digital strategy to enhance the sustainable development of enterprises has highlighted the importance of green information technology.

2.2. The Impact of Digital Transformation Strategy on ESG Performance

In 2006, the United Nations Principles for Socially Responsible Investment Organization (UN-PRI) adopted ESG factors as important indicators to measure sustainable development, and put forward the concept of ESG for the first time. The UN also encourages member institutions to obtain the double dividends of economic value and social value by incorporating ESG factors into their corporate operations [36]. The concept of ESG is very much in line with China's requirements for high-quality and sustainable development under the guidance of the "double carbon" goal. In order to achieve ecological progress and green sustainable development at the micro level, enterprises must take the initiative to take responsibility, actively incorporate ESG factors into their business and development, and promote their ESG performance through digital transformation strategy.

The impact of enterprises' digital transformation strategy on their ESG performance is evident in the following aspects: First, enterprises with good performance in environmental responsibility are committed to capturing and solving public environmental problems, thus increasing the capital investment in undertaking environmental responsibility. The core significance of enterprise digital transformation to ESG performance is that digital technology and intelligent technology can quickly capture environmental problems and provide corresponding green information technology services to help enterprises clearly identify and understand environmental responsibility issues [37]. Second, enterprises that perform well in ESG have a strong sense of social responsibility, which is reflected in the organization's willingness to make strategic decisions on social responsibility. They are willing to actively carry out green integration inside and outside the supply chain, and invest in the digital community with mutual benefit as the principle. The focus of enterprise digital transformation strategy is exactly in line with this, emphasizing green integration inside and outside the supply chain [38]. Finally, enterprises with good performance regarding corporate governance provide a stronger capital base to promote enterprise digitalization. This is because good corporate governance reduces the principal-agent problem, effectively alleviates financing constraints, and increases enterprises' capital investment in digitalization [39]. In the above three aspects, enterprise digital transformation has a positive impact on enterprise ESG performance. Hence, the following hypothesis is formed:

Hypothesis 1 (H1). *Digital transformation strategy has a positive impact on enterprise ESG performance.*

The existing literature mainly discusses the impact of digital transformation on enterprise economic value, namely business performance [40]. There are few studies on non-economic value and even fewer on directly establishing the correlation between digitalization and corporate social responsibility. Therefore, it is of great practical significance to explore the complex relationship between enterprise digital transformation strategy and ESG performance. In fact, against the background of China's vigorous implementation of digital transformation, social and environmental values are becoming increasingly important for enterprises to build sustainable competitive advantages. The reason is that digitalization has greatly improved the social transparency of enterprises and significantly alleviated the problem of information asymmetry; furthermore, stakeholders have higher expectations of enterprises to fulfill their environmental responsibilities, which will drive enterprises to actively construct and implement ESG [41]. To some extent, whether enterprises can achieve sustainable development goals depends on the governance effectiveness of digital technology penetration in all areas and levels of their business [42]. According to the theory of innovation value chain [43], digital transformation is a comprehensive digital innovation activity for the entire ecological network, including all stages of enterprise business activities. Therefore, business digitalization can be seen as the process from creative generation to commercial application carried out by enterprises in collaboration with green supply chain partners through digital technology. In the digital age, business processes have been changed from traditional commercialization processes to innovative ecosystem dynamic interactive processes composed of green supply chain partners [44]. Business digitalization can improve the way green supply chain partners communicate and connect with each other and each department within the enterprise, thereby facilitating real-time business interactions and steady improvement in enterprise ESG performance. Based on previous analysis of digitalization level via the strategic alignment model, the following hypothesis on business digitalization is proposed:

Hypothesis 1a (H1a). *Business digitalization has a positive impact on enterprise ESG performance.*

In order to adhere to carbon emissions reduction, capital investment must be regulated and screened adequately [45]. In essence, enterprise digital transformation strategy aims to introduce and apply digital technology by investing a large amount of capital, talents, and other resources to cope with the dynamic process of technological change and market fluctuation [46]. With the rapid growth of the global digital economy, in order to seize development opportunities, enterprises are rapidly advancing their digital strategy through cloud computing, big data, artificial intelligence, blockchain, and other technologies. Through the use of digital technologies, enterprises are reshaping their development planning and organizational structure, enabling themselves to adapt to the rapidly changing competitive environment [47]. Digital platforms are increasingly becoming the dominant organizational form in industrial practices. Enterprises can benefit significantly from different types of digital platforms [48]. According to the dynamic capability theory [49], platform digitalization plays an important role in promoting the entire digital transformation of the enterprise. It can be regarded as the construction of digital innovation network platform to realize the digitalization of resources and the network interconnection between green supply chain partners and each department within the enterprise. Platform digitalization can realize the integration of knowledge, data, and technology, thus promoting collaborative development in the green supply chain and the steady improvement in enterprise ESG performance. Based on previous analysis of digitalization level via the strategic alignment model, the following hypothesis on platform digitalization is proposed:

Hypothesis 1b (H1b). *Platform digitalization has a positive impact on enterprise ESG performance.*

2.3. The Impact of Green Innovation on ESG Performance

Green innovation, as is evident from the term, helps enterprises reduce their emissions based on scientific concepts. It specifically refers to the development of new renewable or non-toxic materials and products to improve energy efficiency and protect the environment, enhance production processes to reduce consumption of natural resources, and promote the capitalization of renewable resources [50]. Green innovation is an important measure by which enterprises can achieve sustainable development goals, and has been widely recognized by all sectors of society. Actively carrying out green innovation can help enterprises build their green image and enhance their competitive advantages [51]. In particular, under the “double carbon” policy, climate action based on green innovation will quickly become the key to how enterprises do business.

For enterprises in the digital era, the promoting effect of digital transformation strategy on ESG performance is largely achieved through enterprise green innovation. Specifically, first, from the perspective of environmental responsibility performance, many actions taken by enterprises to undertake environmental responsibility, such as improving technology, strengthening environmental governance, and pollution reduction, all rely on digital technology and intelligent technology. Furthermore, investment in digitalization can promote the green innovation of enterprises [52]. Second, from the perspective of ESG performance, corporate social responsibility is reflected in meeting the needs of stakeholders and establishing a good relationship with them, which will promote multi-party resource sharing, promote the green integration of the supply chain emphasized by digital theory, and further enhance green innovation [53]. Third, from the perspective of corporate governance, while enterprise management focuses on digital transformation, green innovation in enterprises' operations supports the target of being carbon neutral before 2060. It requires enterprises to strengthen investment in green innovation in order to implement the policy. Green innovation is considered “science-based” if it is in line with the latest actions that climate science deems necessary to meet the “double carbon” goals. It provides a clearly defined pathway for enterprises to reduce greenhouse gas emissions, helping prevent the worst impacts of climate change and future-proof business growth [54].

2.4. The Mediating Role of Enterprise Green Innovation

The “double carbon” policy emphasizes that enterprises should increase green and low-carbon investment and should actively carry out research and development and application of low-carbon, zero-carbon, and negative-carbon technologies [3]. Influenced by policies and institutions, enterprises will increase investment in information, capital, talent, and other aspects, and have more willingness and ability to lead digital strategy and green innovation. Therefore, as an important content of enterprise digitalization, green information technology is not only a new engine to promote Chinese economic development, but also a strategic choice to bring about enterprise green innovation under the goal of “double carbon” [55].

Green innovation of enterprises can be achieved through digital strategy, so that manufacturing enterprises can improve their ESG performance, and thus have a stronger corporate reputation and social recognition [56]. Because ESG can effectively weaken the factors that inhibit innovation, the support of government and investors for various elements of green innovation should be strengthened, forming a virtuous cycle, which helps enterprises to obtain strategic resources with environmental orientation and build sustainable competitive advantages [57]. Green innovation is the key link to achieve coordinated development of economic growth and environmental protection [58]. It will provide important support for China to accelerate the green transformation of its development mode and achieve the strategic goal of “double carbon”.

Furthermore, with the continuous advancement of digital economy and green development strategy, the relationship between enterprise digital strategy and green innovation has received increasing attention in academic circles. Relevant research on industrial 4.0 green information technologies, which includes big data, the Internet of Things, and

blockchain, has significantly improved the green innovation performance of enterprises by strengthening cooperation between enterprises and external stakeholders [59]. The large-scale increase in digital applications strengthens the exchange of internal and external information, improves the efficiency of resource allocation, may accelerate the integration of resource- and environment-related information with R&D resources, and encourages enterprises to carry out more green innovation activities. This new production mode, driven by digital technology, may bring new opportunities for enterprises to enhance their green innovation capability.

In short, digitalization and green innovation are both important strategic choices for enterprises. Digitalization itself is highly innovation-oriented, and enterprises are faced with continuous challenges in terms of resources, capabilities, technology, management, and other aspects during the implementation of their digitalization strategy [60]. Enterprises' investment in digitalization covers the investment in green innovation, and the implementation of digitalization strategy has a direct promoting effect on enterprises' green innovation. Green innovation thus forms a transmission chain connecting digital strategy and enterprise ESG performance. In view of this, the following hypothesis is proposed:

Hypothesis 2 (H2). *Green innovation has a mediating effect on the relationship between digital transformation strategy and enterprise ESG performance.*

Based on the existing research, the impact of enterprise green innovation on regional carbon emissions has a double effect of positive or negative [61]. Scholars have divided the dimensions of green innovation based on different theoretical backgrounds and research perspectives. It is generally accepted that it can be divided into green process innovation and green product innovation [21,62,63]. Green process innovation involves changes or adjustments to manufacturing processes that help reduce negative environmental impacts at production stages such as material procurement, manufacturing, or delivery, including clean technologies and end-treatment [64]. Green product innovation is the design of products that use fewer resources, have a lower environmental impact and risk, and prevent waste from being generated at the conception stage in the first place [65]. This study analyzes the mediating role of green innovation in the above two dimensions. Specifically, enterprises can integrate digital technology into the original production process [66]. Digitalization can improve the ability of information sharing and processing within enterprises to facilitate cross-department cooperation and coordination, in order to promote the quality of green process innovation. Business digitalization can empower enterprise business practices, enhance business flexibility, adjust and optimize the existing process and architecture with the help of digital technology, and promote enterprise innovation [45]. At the same time, enterprises can use digital technology to optimize resource allocation and create new products with competitive advantages through combination with original products [67]. Business digitalization can integrate a green supply chain to facilitate upstream and downstream business processes [68]. It is conducive to green product innovation, which affects the enterprise ESG performance. In conclusion, green process innovation and green product innovation mediate the relationship between business digitalization and enterprise ESG performance, respectively. The following hypotheses are proposed:

Hypothesis 2a (H2a). *Green process innovation has a mediating effect on the relationship between business digitalization and enterprise ESG performance.*

Hypothesis 2b (H2b). *Green product innovation has mediating effect on the relationship between business digitalization and enterprise ESG performance.*

Green innovation is often related to reducing product, process, or organizational changes that may create environmental burdens in the course of business operations, with the aim of designing products that use less energy, require fewer raw materials to manufacture, have less adverse impact on the environment, and are easy to recycle [69]. In order to

improve ESG performance, enterprises can strengthen resource exchanges with suppliers on green materials and environmental protection technologies via platform digitalization to promote green process innovation and green product innovation. On the one hand, the wide application of digital technology makes it possible for enterprises to use the Internet of Things, big data, and other ways to obtain information such as customers' consumption habits and preferences, so that enterprises can accurately identify market demand and the process of corporate institutional innovation can be optimized [70]. Platform digitalization effectively promotes enterprise green process innovation [71], thereby enhancing the customer satisfaction and building a good enterprise reputation, which affects the enterprise ESG performance. On the other hand, digital platforms provide reliable information knowledge for the decision-making process of enterprises, and the enterprise resource management system supported by cloud computing and big data analysis can show strong management potential [21]. Platform digitalization enables product developers to acquire and leverage tacit innovation knowledge through advanced technologies such as neural algorithms and machine learning [72]. It makes the tacit knowledge widely existing in the enterprise gradually become apparent, and expands the knowledge base of enterprise green innovation [73]. Green product innovation needs high-quality employees and rich knowledge reserves as support. Platform digitalization facilitates the introduction of green product innovation and improves access to external knowledge to enhance the level of green product innovation. Thus, enterprise green innovation has changed from being experience-driven to data-driven. Platform digitalization is laying an intellectual foundation for improving the quality of green product innovation, which affects enterprise ESG performance. In conclusion, green process innovation and green product innovation mediate the relationship between platform digitalization and enterprise ESG performance, respectively. The following hypotheses are proposed:

Hypothesis 2c (H2c). *Green process innovation has a mediating effect on the relationship between platform digitalization and enterprise ESG performance.*

Hypothesis 2d (H2d). *Green product innovation has a mediating effect on the relationship between platform digitalization and enterprise ESG performance.*

Moreover, the promoting effect of digital transformation on green innovation will be amplified with the increase in the number of users applying digital technology in an enterprise [74]. When enterprises are in the early stages of digitalization, they need to invest extensive funds in digital infrastructure construction, platform construction, and technical talent introduction. At this time, economies of scale have not yet formed, information sharing among users is difficult to achieve, and the effect of digital transformation in promoting green innovation is not completely evident. As the number of users using digital technology increases and reaches a critical value, the marginal cost of linkage between these users continues to decrease, and the cost of information release, retrieval, and acquisition drops significantly. Enterprises can obtain new technologies, new industry standards, and new market demand information more quickly and easily, and the promoting effect of green innovation is thus amplified [75].

In fact, enterprise ESG performance will be affected by many factors. Referring to relevant literature on enterprise ESG performance: (1) Enterprise size may be related to the degree of digitalization and industry status of an enterprise, thus likely influencing the ESG performance of an enterprise; (2) Industry style may predict the future trends and innovation potential of enterprises in economic development [51]; (3) In addition, the longer an enterprise is established (Enterprise Age), the more it accumulates the ability to undertake green supply chain integration and green innovation [76].

To sum up, the theoretical model of this study is as shown in Figure 2.

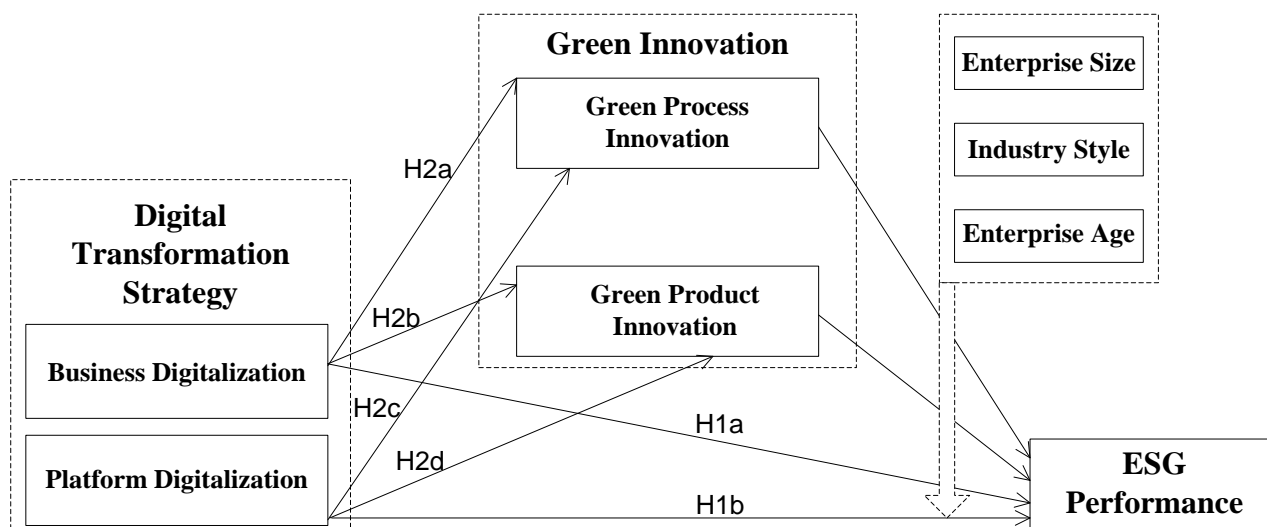


Figure 2. Research framework.

3. Research Methodology

3.1. Research Sample and Data Collection

In this study, large manufacturing enterprises in China were taken as samples. Snow-ball sampling was adopted through channels of alumni association and entrepreneur association. Questionnaires were distributed online via the www.wjx.cn platform through the e-questionnaire link of WeChat to relevant personnel of the surveyed enterprises. The questionnaire survey started from the beginning of February 2023 and lasted nearly 1.5 months. In order to effectively reduce common method bias, the investigation was carried out in three core stages: In the first stage, variable data such as basic information and perceived ESG performance of relevant enterprises were collected. In the second stage, variable data such as business digitalization and platform digitalization were collected. In the third stage, variable data such as green process innovation and green product innovation were collected. The data collection work was completed in mid-April 2023. A total of 300 questionnaires were issued, and 263 were recovered. Recovered questionnaires were excluded as invalid if any of the following were observed: (1) The basic information part of the answer was incomplete; (2) The data in the measurement part of the scale were missing; (3) The time spent on online questionnaire was less than 1 min. Finally, 224 effective questionnaires were collected in this study, with effective recovery of 74.67%. Other information in this article was obtained from XINHUA.net, State Intellectual Property Office, China Securities Index, enterprise annual reports, and the enterprise website.

Statistics show that in terms of enterprise scale, 75 enterprises had fewer than 1000 employees, accounting for 33.48%; 95 enterprises had 1000 to 10,000 employees, accounting for 42.41%; 31 enterprises had 10,000 to 20,000 employees, accounting for 13.84%; 12 enterprises had 20,000 to 30,000 employees, accounting for 5.36%, and 11 enterprises had more than 30,000 employees, accounting for 4.91%. In terms of industry types, there are 42 petroleum, coal, and other fuels processing enterprises, accounting for 18.75%; 33 enterprises related to basic chemicals, chemical raw materials, and chemical products manufacturing, accounting for 14.73%; 46 enterprises related to mechanical equipment and other special equipment manufacturing, accounting for 20.54%; 10 enterprises related to medical equipment, biomedicine, and medicine manufacturing, accounting for 4.46%; 26 enterprises related to steel and metal products, accounting for 11.61%; 28 enterprises that were computer, communication and other electronic equipment manufacturers, accounting for 12.5%; 12 enterprises were automobile, railway, ship, aerospace and other transportation equipment manufacturers, accounting for 5.36%; 14 enterprises of electrical machinery and equipment manufacturers, accounting for 6.25%; five enterprises related to non-metallic mineral products and building materials, accounting for 2.23%; and eight enterprises re-

lated to food, beverage, tobacco, textile, clothing and other light industrial manufacturing, accounting for 3.57%. In terms of the enterprise age, 68 enterprises were established in 1991 or before, accounting for 30.36%; 67 enterprises were established in 1992 to 1996, accounting for 29.91%; 19 enterprises were established in 1997 to 2001, accounting for 8.48%; 24 enterprises were established in 2002 to 2006, accounting for 10.71%; 15 enterprises were established in 2007 to 2011, accounting for 6.70%, and 30 enterprises were established in 2012 or later, accounting for 13.39%.

3.2. Variable Selection and Questionnaire Development

The variables involved in this study were all measured by the Likert's five-point measurement method, with 1 indicating complete nonconformity and 5 indicating complete conformity. All variables were received from the questionnaire as shown in Appendix A. Literature analysis was adopted in the conceptualization process and the selection of scales. By searching and consulting a large number of literatures in related fields, the corresponding analysis of literatures which were similar to the research framework of this study was carried out. The scales used for specific measurements were all mature scales tested in previous studies which had a similar causal mechanism to that of this study. The two-way back-translation procedure was followed [77], in order to ensure that the scale items were adapted to the study in the Chinese enterprise context. Specific variable selection and theoretical literature support are as follows:

- (1) Explanatory variable: Digital transformation strategy. Digitalization is a complex dynamic process, which is extremely difficult to quantify; therefore, the digitalization degree is introduced to measure the implementation level of enterprise digitalization relative to static [78]. Based on Wu et al. [41], in which the degree of enterprise digitalization was evaluated through text analysis, two measurement dimensions were selected for this index: The dimension of business digitalization (BD) was measured by reference to the six items developed by Aral and Weill [79]; the dimension of platform digitalization (PD) was measured by reference to the four items developed by Kim [80].
- (2) Explained variable: Enterprise ESG performance (ESG), in which the dimension of corporate environmental responsibility was chosen according to Rahman and Post [81], six items of enterprise environmental responsibility were selected and measured with reference to China's national conditions. In addition, the China Securities ESG rating system is selected as a supplement, which is based on the core connotation and development experience of ESG, combined with the actual situation of the Chinese market [82]. They are supplemented by the Chinese characteristics of the ESG evaluation system. Seven items were selected to measure Social and Governance in this study.
- (3) Intermediary variable: Green innovation is rich in connotation and involves multiple dimensions [83]. In this study, dimensions directly related to manufacturing were selected for measurement. Among them, the dimension of green process innovation (GPC) was measured by reference to the four items developed by Wu [84]. The dimension of green product innovation (GPD) was measured by reference to the four items developed by Delgado-Verde et al. [85].
- (4) Control variable: Based on existing research results, Enterprise Size, Industry Style, and Enterprise Age were selected as the main control variables. This is because enterprise size is closely related to the ability of enterprises to implement digital transformation strategy, and enterprises belonging to different industries often experience different impacts on their ESG performance [51]. Moreover, the longer an enterprise has been established, the more experiences and effectiveness it will have accumulated in digital transformation [74,76].

3.3. Reliability and Validity

Confirmatory factor analysis was performed in this study, and the KMO value was 0.959 ($p < 0.001$); KMO > 0.9 confirms that factor analysis was effective and the correlation between variables was strong, which is very suitable for factor analysis. The cumulative sum of squares of rotating loads explained by the first factor was 20.924%, which was less than 40% of the critical standard, proving that there was no common method bias. The Cronbach's α value of each variable in Table 1 was above 0.6, which met the reliability requirements.

Table 1. The reliability of variables.

Variables	Number of Items	Cronbach's Alpha
ESG	13	0.952
BD	6	0.933
PD	4	0.938
GPC	4	0.931
GPD	4	0.931

4. Empirical Results

4.1. Descriptive Statistics

The values for mean, standard deviation, and correlation coefficient of the five variables of business digitalization, platform digitalization, green process innovation, green product innovation, and enterprise ESG performance are shown in Table 2. All correlations between pairs of variables were positive and significant at the 0.1% level.

Table 2. Pearson correlation analysis.

Variables	Mean	Std. Deviation	BD	PD	GPC	GPD	ESG
BD	4.2894	0.72240	—				
PD	4.2299	0.74655	0.790 ***	—			
GPC	4.3025	0.75968	0.752 ***	0.739 ***	—		
GPD	4.2533	0.78290	0.756 ***	0.776 ***	0.835 ***	—	
ESG	4.3386	0.70184	0.785 ***	0.738 ***	0.833 ***	0.724 ***	—

Note: *** $p < 0.001$.

4.2. Hypothesis Testing and Analysis

In this study, SPSS 26 statistical software was used, with BD, PD, GPC, and GPD as independent variables and ESG as the dependent variable, to verify the research hypothesis through hierarchical regression. This method was applicable in this study, because the advantage of hierarchical regression method was that the degree of influence of each factor at each layer on the result was quantified, very clear and definite [86]. By providing not only an appropriate theoretical basis in the literature review, but also logical reasoning for the sequence of predictor variables during variable selection, the scientific validity of applying this method was guaranteed [87]. The results of regression analysis are shown in Table 3. Model 1, Model 2, and Model 3 were used to verify H1 (direct effect). Model 4 and Model 5 were used to test H2 (mediation effect). From Model 1 to Model 2, R^2 increased by 0.532, and the explanatory power of the model increased. Similarly, from Model 2 to Model 5, the explanatory power of the model gradually increased.

In Model 1, the direct relationship between business digitalization and enterprise ESG performance was tested. For the regression analysis, enterprise ESG performance was adopted as the dependent variable, and enterprise size, industry style, and enterprise age as independent variables. The regression results showed that their R^2 values of goodness of fit were too small, indicating that they were insufficient to explain enterprise ESG performance. On the basis of model 1, business digitalization was added to model 2 as an independent variable, and the regression results showed that BD had a significant

positive effect on ESG ($\beta = 0.743$, $p < 0.001$); therefore, Hypothesis 1a was supported. Similarly, Model 3 tests the direct effect between platform digitalization and enterprise ESG performance, and it can be seen that PD has a significant positive effect on ESG ($\beta = 0.287$, $p < 0.001$). Hypothesis 1b is thus supported.

Table 3. Hierarchical regression analysis.

Variables	Dependent Variables: Enterprise ESG Performance (ESG)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	4.131 ***	1.091 **	0.877 ***	0.527 **	0.526 **
Control Variables					
ES	0.065 ***	0.014	0.008	0.012	0.011
IS	0.054 *	0.016	0.009	0.010	0.009
EA	−0.039 *	−0.008	−0.005	0.002	0.003
Independent Variables					
BD		0.743 ***	0.517 ***	0.289 ***	0.306 ***
PD			0.287 ***	0.094	0.124 *
Intermediary Variable					
GPC				0.487 ***	0.540 ***
GPD					−0.100
R ²	0.088	0.620	0.654	0.759	0.762
ΔR^2	0.088	0.532	0.034	0.104	0.003
ΔF	7.072	306.795	21.611	93.823	2.650

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

In Model 4, the mediating effect of green process innovation was tested, with enterprise ESG performance as the dependent variable and green process innovation as the independent variable. The regression results showed that GPC had a significant positive effect on ESG ($\beta = 0.487$, $p < 0.001$). The regression results of Model 4 and model 3 were compared. The significance level of the regression coefficients of business digitalization and platform digitalization decreased, and the coefficient value became smaller. Therefore, the influence of business digitalization and platform digitalization on enterprise ESG performance was partly mediated by green process innovation—that is, green process innovation had a mediating effect on the relationship between business digitalization and enterprise ESG performance as well as on the relationship between platform digitalization and enterprise ESG performance. Therefore, Hypotheses 2a,c were preliminarily verified.

Similarly, Model 5 tested the mediating effect of green product innovation. Although the regression results of Model 5 and Model 3 showed that the significance level of the regression coefficients of business digitalization and platform digitalization decreased, and the coefficient value became smaller, GPD was not found to have a significant positive effect on ESG ($\beta = -0.100$, $p = 0.105$). Therefore, Hypotheses 2b,d need to be tested.

This study used PROCESS 2.16 software, the bootstrap method [88], and templates mode4, with GPC, GPD, and ESG as dependent variables. The regression results are shown in Table 4.

Table 4 shows that, based on the control variables ES, IS, and EA, when the dependent variable was GPC, the 95% confidence interval for BD was [0.6834, 0.8762], and so the confidence interval value did not include 0. Therefore, BD ($\beta = 0.7798$, $p < 0.001$) had a significant effect on GPC. Similarly, PD had a significant impact on GPC. When the dependent variable was GPD, BD had a significant impact on GPD, and PD had a significant impact on GPD. When the dependent variable was ESG, the 95% confidence interval for GPC was [0.3949, 0.6298], and so the confidence interval did not include 0. Therefore, GPC had a significant effect on ESG. Meanwhile, the 95% confidence interval for BD was [0.2187, 0.4747], and so the confidence interval value did not include 0. Therefore, BD had a significant impact on ESG through GPC. Similarly, when the dependent variable

was ESG, GPD had a significant impact on ESG, and BD had a significant impact on ESG through GPD. GPC had a significant effect on ESG, and PD had a significant effect on ESG through GPC; GPD had a significant impact on ESG, and PD had a significant impact on ESG through GPD.

Table 4. The results of bootstrap regression analysis.

DV	IV	Coeff	SE	LLCI	ULCI
GPC	ES	0.0000	0.0130	−0.0255	0.0256
	IS	0.0073	0.0184	−0.0289	0.0435
	EA	−0.189	0.0135	−0.0455	0.0077
	BD	0.7798	0.0489	0.6834	0.8762
	ES	−0.0018	0.0152	−0.0310	0.0292
	IS	−0.0027	0.0200	−0.0428	0.0359
	EA	−0.0195	0.0129	−0.0457	0.0055
	PD	0.7457	0.0667	0.6167	0.8752
GPD	ES	−0.0085	0.0135	−0.0345	0.0182
	IS	0.0028	0.0164	−0.0292	0.0360
	EA	−0.0050	0.0127	−0.0302	0.0195
	BD	0.8245	0.0506	0.7137	0.9126
	ES	−0.0133	0.0155	−0.0427	0.0173
	IS	−0.0104	0.0161	−0.0425	0.0209
	EA	−0.0040	0.0139	−0.0310	0.0230
	PD	0.8270	0.0534	0.7176	0.9267
ESG	ES	0.0141	0.0085	−0.0023	0.0315
	IS	0.0124	0.0129	−0.0135	0.0373
	EA	0.0020	0.0096	−0.0177	0.0199
	BD	0.3393	0.0650	0.2187	0.4747
	GPC	0.5177	0.0603	0.3949	0.6298
	ES	0.0165	0.0115	−0.0061	0.0388
	IS	0.0154	0.0162	−0.0171	0.0476
	EA	−0.0064	0.0118	−0.0300	0.0160
ESG	BD	0.5154	0.0807	0.3586	0.6771
	GPD	0.2761	0.0670	0.1448	0.4090
	ES	0.0162	0.0086	−0.0001	0.0336
	IS	0.0107	0.0133	−0.0154	0.0369
	EA	0.0015	0.0096	−0.0176	0.0204
	PD	0.2345	0.0662	0.1131	0.3741
	GPC	0.5886	0.0726	0.4364	0.7199
	ES	0.0198	0.0105	−0.0004	0.0413
ESG	IS	0.0127	0.0172	−0.0210	0.0454
	EA	−0.0085	0.0115	−0.0317	0.0135
	PD	0.3852	0.0912	0.2093	0.5698
	GPD	0.3485	0.0926	0.1715	0.5340

Notes: DV = dependent variable; IV = independent variable; Coeff = coefficient; SE = standard error; LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.

In addition, it can be seen from Table 5 that the 95% confidence interval with 5000 bootstraps for BD → GPC → ESG was [0.6594, 0.8266], and so the confidence interval value did not include 0. Therefore, GPC had a significant mediating effect on BD to ESG ($\beta = 0.7430$, $p < 0.001$). Hypothesis 2a was verified. Similarly, Hypotheses 2b–d were verified.

Table 5. The results of the mediating effect test.

Hypothesis	Path	5000 Bootstraps						Result
		Coeff	SE	t	p	LLCI	ULCI	
H2a	BD → GPC → ESG	0.7430	0.0424	17.5156	0.0000	0.6594	0.8266	Supported
H2b	BD → GPD → ESG	0.5154	0.0601	8.5784	0.0000	0.3970	0.6338	Supported
H2c	PD → GPC → ESG	0.6734	0.0450	14.9546	0.0000	0.5847	0.7622	Supported
H2d	PD → GPD → ESG	0.3852	0.0653	5.8947	0.0000	0.2564	0.5140	Supported

Notes: Coeff = coefficient; SE = standard error; LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.

5. Discussion

5.1. Summary of the Findings

Based on the actual situation of sustainable development of large manufacturing enterprises in China, this study reveals the mechanism by which digital transformation strategy influences enterprise ESG performance. Results show that digital transformation strategy has a significant positive impact on enterprise ESG performance. Specifically, the two dimensions that characterize the level of digital transformation strategy, namely business digitalization and platform digitalization, both contribute to improving enterprise ESG performance. Furthermore, enterprise green innovation plays an intermediary role between digital transformation strategy and enterprise ESG performance. The experimental results could be interpreted as follows: (1) Digital transformation strategy can improve ESG performance by promoting green innovation. (2) Business digitalization can improve ESG performance by promoting green process innovation. (3) Business digitalization can improve ESG performance by promoting green product innovation. (4) Platform digitalization can improve ESG performance by promoting green process innovation. (5) Platform digitalization can improve ESG performance by promoting green product innovation.

5.2. Discussion of the Findings

Enterprise digital transformation and ESG performance are both hot issues at present. However, the existing research on the relationship between digitalization and ESG and the mechanism of action between them is insufficient. For example, one study identified two paths through which digitalization affects ESG, increasing “G” scores by lowering agency costs and increasing “S” scores by increasing goodwill, but no path for increasing “E” scores was found [89]. One study analyzed the mediating effect of green innovation between digital transformation and ESG performance, but selected the number of green invention patents as only one indicator [90]. It can be seen that previous studies on the dimensions of green innovation and digital transformation strategy are insufficient and inadequate, and these subjects need to be further explored. Based on previous studies, this study selected several variables for empirical analysis, and opened up the path of the relationship between digital transformation strategy and ESG performance in large manufacturing enterprises. To a certain extent, it fills the scientific gap in this field and enriches the existing landscape of relevant theories.

5.3. Theoretical Significance

Macroscopically, through empirical research on related behaviors of large manufacturing enterprises in China, this study makes clear the role of digital transformation strategy in promoting ESG performance under the “double carbon” strategy, which is an important basic content for enterprises to build sustainable competitive advantages. Previous studies mainly focus on the impact of digital transformation strategy on enterprise economic value [91]. At the present stage, there are few studies on the pathway between digital transformation and ESG performance. This study expands the application boundaries of the strategic alignment model. As a result, with a new theoretical model established and verified in this study, it broadens the theoretical understanding on how digital transformation helps enterprises create non-economic value.

Microscopically, the correlation between green information technology and sustainability is established in the process of proposing and verifying research hypotheses, which is conducive to deepening the micro understanding of the complex relationship between digital transformation strategy and enterprise ESG. Further, this study takes a positive view of the “double-edged sword” effect of digital transformation on enterprises from the perspective of ESG performance, and verifies its promoting effect in multiple dimensions. It is a very useful supplement and extension to recent relevant studies, and is conducive to making relevant policy recommendations.

In general, in terms of theoretical innovation, a theoretical model is constructed of “digital transformation strategy–enterprise green innovation–enterprise ESG performance”

based on the perspective of the strategic alignment model. Through the two dimensions of business digitalization and platform digitalization in digital transformation strategy, the intermediate transmission mechanism of “green process innovation” and “green product innovation” in enterprise green innovation is deeply analyzed. Specifically, this study is helpful to combine the external and internal factors of the enterprise and put forward the managerial implications.

6. Conclusions and Implications

In conclusion, the higher the degree of implementation of digital transformation strategy, the better the enterprise ESG performance—this is also consistent with the conclusion reached by scholars using other methods in recent studies [89,90]. It proves the importance of and need for enterprise digital transformation strategy in large manufacturing enterprises. Many factors from inside and outside enterprises promote their digital transformation and create strong prerequisites for the improvement of enterprise ESG performance. In this process, the promotional role of enterprise green innovation is crucial. Enterprise digital strategy could integrate “process” and “product” innovation to achieve “quality enhancement” of green innovation, and promote the steady growth of enterprise ESG performance.

6.1. Policy Implications

For government departments, the following measures should be implemented in actively promoting “double carbon” policies and guiding enterprises to focus on improving their ESG performance: First, they should promote high-quality development of the manufacturing sector and support high-quality investment by manufacturing enterprises, in order to promote intelligent, high-end, green, digital, low-carbon production increase and expansion of a new round of industrial technological transformation. Government departments should strengthen specific policy support for manufacturing industries such as information systems, integrated circuits, automobiles and new energy, biomedicine, and green petrochemicals. Second, government departments should improve the industrial level, support the sustained development and growth of manufacturing enterprises, increase the scale of enterprises, and support industrial cluster development. Third, government departments should promote the transformation and upgrading of the manufacturing sector and vigorously promote the digital transformation of enterprises. They should build intelligent digital application scenarios and promote the transformation of industries into green and service-oriented industries. They should build manufacturing innovation platforms to enhance industrial technology innovation, as well as promotion and application ability of new products.

6.2. Managerial Implications

The findings have the following implications for enterprises seeking to improve ESG performance through digital transformation strategy and enhance their green innovation behavior: First, enterprises should actively carry out business digitalization and digital platform construction, apply the theory of strategic consistency, adopt platform digitalization as an important basis to form the digital strategy of the enterprise ecosystem, use digital strategy to lead the enterprise strategy to diversification, and develop “digital architecture and process” to promote business digitalization. Thus, digital transformation strategy can realize the competitive potential route from “digital strategy” to “business strategy” and then to “organizational processes and infrastructure”, or the service level route from “digital strategy” to “digital processes and infrastructure” and then to “organizational processes and infrastructure”.

Second, in implementing the digital transformation strategy, enterprises should effectively play the positive role of promoting green innovation through digital technology. They should enhance the cultural atmosphere of innovation and attach importance to green innovation as an important guarantee of their sustainable development. Under

the guidance of digital transformation strategy, practical and effective green information technology is introduced to improve the green innovation ability of enterprises, and green process innovation and green product innovation are promoted by creating a good internal and external environment so as to create favorable conditions for the implementation of enterprise ESG.

Third, ESG should cut across everything enterprises in China do, internally and externally. It should start at the very top level of management, and from the very beginning of product innovation, all the way through to business development, manufacturing, communications, and talent attraction and retention. For enterprises' external stakeholders and customers, ESG is increasingly linked to their position in the market, and sustainability will be fundamental to their future competitiveness. As a result, enterprises' ESG targets should be a clear part of their core strategy, and should be integrated into their daily practices and activities.

6.3. Limitations and Future Research

Although the conclusions of this study provide theoretical and practical reference for enterprises seeking to improve ESG performance through digital transformation strategy, there are still the following limitations and areas for improvement: (1) In order to ensure the consistency of multi-dimensional measurement, the questionnaire method adopted in this study has its limitations. The measurement is mainly based on subjective perception, so certain subjective biases may be unavoidable. Moreover, compared to the collection of secondary data, it is more difficult to collect first-hand data from enterprises. The concession of multi-dimensional survey is the higher research cost and the relatively smaller sample size; (2) The samples of this study are all from Chinese enterprises. The digital transformation strategy and enterprise ESG performance based on the Chinese context are different from those of other countries in the world. It is suggested to expand the study boundary in future research, measure the relevant situation of enterprises in more countries, further validate and develop the conclusions, and improve the universality of the relevant study; (3) When discussing the relationship between digital transformation strategy and enterprise green innovation, the focus is on the analysis of different strategic routes of digital transformation. However, the analysis of the mechanisms by which enterprise green innovation may be promoted is relatively scarce. Studies on the promoting effect of strengthening digital transformation strategy on green innovation, through internal and external integration of green supply chain, are also a key part of our future research; (4) Although all the hypotheses proposed have been proven through empirical analysis, how to make enterprises attach great importance to their own ESG performance and achieve effective methods of improvement has not been fully explored. Subsequent studies will propose and analyze several possible moderating variables based on a large number of references and case experiences. How to improve the performance of enterprise ESG is also a problem that needs to be discussed from multiple perspectives in the future.

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Appendix A. Questionnaire

Appendix A.1. Basic Information

1. The current number of employees of your enterprise: (ES)

A. fewer than 1000 B. 1001 to 3000 C. 3001 to 5000 D. 5001 to 7000 E. 7001 to 10,000 F. 10,001 to 15,000. G. 15,001 to 20,000 H. 20,001 to 30,000 I. 30,001 to 50,000 J. 50,001 to 70,000 K. 70,001 to 100,000 L. more than 100,000.

2. The main fields of your enterprise: (IS)

A. petroleum, coal, and other fuels processing enterprises B. basic chemicals, chemical raw materials, and chemical products manufacturing C. mechanical equipment and other special equipment manufacturing D. medical equipment, biomedicine, and medicine manufacturing E. steel and metal products F. computer, communication and other electronic equipment manufacturers G. automobile, railway, ship, aerospace and other transportation equipment manufacturers H. electrical machinery and equipment manufacturers I. non-metallic mineral products and building materials J. food, beverage, tobacco, textile, clothing and other light industrial manufacturing.

3. Year of establishment of your enterprise: (EA)

A. in 1991 or before B. 1992 to 1996 C. 1997 to 2001 D. 2002 to 2006 E. 2007 to 2011 F. 2012 to 2016 G. in 2017 or later.

Appendix A.2. Scale Items

Please answer the following questions according to the actual situation of your enterprise.

Items	Complete Nonconformity → Complete Conformity				
Explained Variable: Enterprise ESG Performance (Rahman and Post, 2012; Huazheng ESG Ratings Methodology, 2023) [81,82]					
1. The company has an environmental report (ER), a corporate social responsibility report (CSR) report, or a CSR with a section on environmental responsibility.	1	2	3	4	5
2. The stakeholder is involved in setting corporate environmental policies.	1	2	3	4	5
3. A Department of pollution and/or senior management position for environment exists.	1	2	3	4	5
4. ISO 14001 has been implemented at the plant and/or firm level.	1	2	3	4	5
5. The company provides information about environmental audits.	1	2	3	4	5
6. The company discloses its Energy/Water/Electricity use and/or Greenhouse Gas Emissions (in reduction or absolute numbers).	1	2	3	4	5
7. The company attaches importance to employee safety and health, pay attention to employee motivation and development.	1	2	3	4	5
8. The company performs quality certification, recall, complaints and other product responsibilities?	1	2	3	4	5
9. The company attaches importance to risk management, has a good supply chain relationship, and maintains data security and privacy?	1	2	3	4	5
10. The company is committed to providing social services, employment opportunities, scientific and technological progress and other social contributions?	1	2	3	4	5
11. The company protects shareholders’ rights and interests, has reasonable governance structure and high stability of management.	1	2	3	4	5
12. Corporate information disclosure credibility, solvency, high tax transparency.	1	2	3	4	5
13. The company pays attention to business ethics and opposes corruption and bribery.	1	2	3	4	5

Items	Complete Nonconformity → Complete Conformity				
Explanatory Variable: Digital Transformation Strategy—Business Digital (BD) (Aral and Weill, 2007) [79]					
1. Setting up digital transformation governance structures.	1	2	3	4	5
2. Meeting regularly across functional boundaries and holding workshops involving multiple organizational levels.	1	2	3	4	5
3. Outlining and communicating the DTS, using a variety of media and channels.	1	2	3	4	5
4. Working business and customer to centric as well as agile and innovation to oriented.	1	2	3	4	5
5. Networking, collaborating, and exchanging knowledge on digital transformation.	1	2	3	4	5
6. Our company is driving new business processes built on technologies such as big data, analytics, cloud, mobile and social media platform.	1	2	3	4	5
Explanatory Variable: Digital Transformation Strategy—Platform Digital (PD) (Kim, 2020) [80]					
1. Communicate and coordinate product/price/delivery/payment information with foreign customers.	1	2	3	4	5
2. Disseminate product/service information.	1	2	3	4	5
3. Understand product and market preference.	1	2	3	4	5
4. Use platform’s match service to match with customers or aggregate more customers.	1	2	3	4	5
Intermediary Variable: Green Innovation—Green Process Innovation (GPC) (Wu, 2013) [84]					
1. Using cleaner technology to reduce hazardous substance emissions and/or waste.	1	2	3	4	5
2. Recycling and reusing waste and/or emissions.	1	2	3	4	5
3. Reducing the consumption of water, electricity, gas, or oil.	1	2	3	4	5
4. Reducing the use of raw materials.	1	2	3	4	5
Intermediary Variable: Green Innovation—Green Product Innovation (GPD) (Delgado-Verde et al., 2014) [85]					
1. We have modified the product design in order to not use toxic compounds within their production process.	1	2	3	4	5
2. We have modified the product packaging in order to use biodegradable materials.	1	2	3	4	5
3. We have modified the product design in order to obtain an efficient charge of energy and water when they are used.	1	2	3	4	5
4. We have modified the product design in order to extend its useful life.	1	2	3	4	5

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