

Examining Green Innovation and Digital Transformation as Essential Factors of Sustainable Performance

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Abstract. As digital transformation continues to advance at a rapid pace, the imperative for innovating and transforming business models becomes increasingly pronounced, underscoring the significance of business sustainability. Delving into the sustainable performance of enterprises holds the potential to not only identify underlying risks and foster robust operations but also bolster the trajectory of a company's sustainable development. This study scrutinizes the impact of sustainable technologies on enterprise sustainability performance, with a keen focus on the interplay between digital transformation and green innovation as delineated in the existing literature. Findings suggest that the relationship between digital transformation and sustainable performance is intricate, and influenced by a multitude of factors. Moreover, green innovation emerges not only as a direct driver of sustainable performance but also as a facilitator of digital transformation, thereby amplifying its role in fostering sustainable development within enterprises. By examining these dynamics, this research aims to provide insights that can inform strategic decision-making aimed at enhancing sustainability within organizations.

Keywords: Green Innovation; Digital Transformation; Sustainable Performance.

1. Introduction

In 1987, the WCED asserted the sustainable development idea that follows the UN. Next, the gap was filled at the corporate level. Today, the role of business is not only to function in an economic way as part of the economic realm, but it is also imperative to create sustainable development [1]. There is "environmental balance, economic prosperity, and social responsibility", forming the triple bottom line as a responsible business goal to Support sustainable development. Companies can now measure their sustainability level with the help of the sustainability indices technique, making a process easy and efficient. So, on a triple-bottom-line basis, businesses will assess a project's sustainability through sustainable performance when making decisions, including the economic, social, and environmental indicators.

Hence, the core of the strategy through which the triple bottom lines are embedded into the companies is new business models, which make it evident that sustainability is a crucial constituent of corporate value proposition and value creation. This means that sustainability can be achieved through short-term environmental and economic measures and longer-term societal improvement [1]. Given the circumstances that innovation in business models has emerged as a key strategy for establishing long-term competitiveness, the conversion from conventional to sustainable business models is increasingly essential, raising the bar for organizations' sustainability. In the meantime, as the digital economy evolves, companies are digitally transforming themselves - one step in the modern information revolution. Emerging technologies like artificial intelligence and big data are integrated by digital technology, which is vital in changing business paradigms and opening up new avenues for sustainable development. Simultaneously, digital technology can help businesses operate more efficiently, foster green innovation, improve market competitiveness, and achieve sustainable development.

As the concept of sustainable development is gaining ground, recycling, and recovery methods are becoming crucial. Green innovation (GI) uses green technologies to support the circular economy's sustainable performance. The relevance of green innovative behaviors is emphasized by this new approach to sustainability, which also benefits sustainable development.

To meet the trend of sustainable development, enterprises face the unavoidable challenge of improving their sustainability. Therefore, studying the factors that influence sustainable performance is of practical significance for enterprise sustainability.

2. Literature Review

Numerous studies have shown that technological change is the key to sustainability, as reflected in the digital technologies and green innovation technologies brought about by digital transformation (DX). In studies related to digital transformation and corporate sustainability, different literatures hold different views.

Some studies indicate that digitalization has a positive effect on business sustainability [2, 3]. Xu and Bhaumik point out that firms employing high technology can have an advantage in sustainability enhancement, and that firms that are more marketable benefit more [2]. Lee and Roh used a structural equation modeling study of 509 firms in central Chinese cities to demonstrate the beneficial effects of digital capabilities on sustainable performance [3]. Moreover, Dubey et al. focus on the linear relationship between corporate sustainability performance and DX, showing that business sustainability performance and digital transformation are positively correlated [4].

Correspondingly, some views suggest that DX does not always have a positive effect on the sustainable development of firms. Among them, Li argues that DX has a different influence on economic and environmental performance. According to his research, the degree of market volatility significantly influences the positive correlation between DX and economic success and the inverse U-shaped relationship between DX and environmental performance [5].

The majority of studies on GI and sustainable performance contend that GI improves organizations' sustainable performance [6, 7]. Shahzad et al. claim that GI is a major contributor to all three dimensions of sustainable performance [7]. They pointed out that green innovation can encourage firms to recognize the importance of the environment and make them more environmentally friendly. At the same time, it can drive firms to be economically sustainable by reducing costs through reduced energy losses and raw material use. In addition, companies that apply green innovations are more socially responsible, and the positive effects of green innovations on society have been shown [7]. Baeshen et al. provide SMEs with the opportunity to achieve green transformation and competitive advantage by exploring the green innovation determinants of achieving sustainable business performance [6].

Whereas, in the related literature exploring DX and sustainable performance, GI is typically thought to have a mediating function [8, 9]. In the related literature exploring the synergistic impact of DX and GI, Jia et al. analyzed the manufacturing industry through the variable second-order least squares method, and pointed out that digital transformation promotes the sustainable performance of firms both economically and environmentally, and that green technological innovations and green managerial innovations play a mediating role in it [8]. In addition, Yang et al.'s study also points out the mediating role of innovation type and explores the moderating role of environmental competitiveness [9].

Based on this, this paper will discuss the impact of DX and GI on sustainable performance and provide an outlook for future research.

3. Digital Transformation

3.1. Theoretical Studies

Digitization can be defined as a broad and deep process that involves the transformation of traditional, non-digital forms of information, operations, or processes into digital form for efficient processing, storage, transmission, and application through computers, the Internet, and other digital technologies. This process is not limited to changes at the technological and production levels but also involves a deeper restructuring of enterprises, industries, and the socio-economic structure of

society as a whole. At the enterprise level, digitization means that enterprises need to re-examine their business models, organizational structures, and management styles to adapt to the needs and challenges of the digital age. This includes efforts to build digital strategies, optimize business processes, and cultivate digital talent. Through digitalization, companies can better grasp market opportunities, improve competitiveness, and achieve sustainable development [10].

Digital transformation is an important strategy for companies to achieve the SDGs. Bican and Brem state that digitalization is not limited to industry and academia but is equally important in the sustainability and circularity of business models [10]. Digital transformation not only improves the operational efficiency and market competitiveness of companies but also gives rise to new business models. At the same time, digitalization has also had a profound impact on business models. New digital tools such as MOOCs, SPOCs, social media, etc. have brought innovative opportunities for enterprises.

3.2. Direct Effects

Recently, digital technologies have advanced by leaps and bounds, driving the DX of the company. DX not only improves enterprise performance and promotes green technological innovation, but also offers businesses new growth prospects to help them meet sustainable development objectives. In addition to fostering green technical innovation and enhancing organizational performance, DX offers businesses new growth prospects to help them meet sustainable development objectives. However, there is still a lot of space for research as the DX of the majority of Chinese businesses is currently only in the early stages. Therefore, the impact of DX on businesses' success in sustainable development deserves further exploration [11].

Based on data gathered from Shanghai and Shenzhen's A-share listed businesses between 2011 and 2020, Wang constructed enterprise digital transformation indicators using Python technology and integrated the environmental performance and financial performance of enterprises to comprehensively measure their sustainable development performance [11]. It is found that DX can significantly ameliorate the financial performance and environmental performance, and play a positive role in their sustainable development performance. In addition, digital transformation mainly enhances the sustainability performance of enterprises by promoting GI in the field of product, process, and management, which coincides with the role of GI mentioned above.

4. The Mediating Role: Business Models and Technological Innovation

Digital transformation has led to business model innovation, which has had a profound influence on consumer behavior, enabling consumers to access multimedia channels while also communicating with companies and other consumers in a predominantly digital way, a change that poses a threat to traditional industries while at the same time altering the market landscape [12]. Yang et al. pointed out that with the development of digital transformation, digitalization is profoundly changing the way companies operate and the competitive landscape of the market in terms of technological innovation and business model innovation [9]. Through digital transformation, enterprises can optimize business processes and improve efficiency with the help of advanced information technology, which enhances their ongoing effectiveness.

Based on the theories of sustainable development and technology availability, the research of Yang et al. empirically tested how the level of DX is influenced by the sustainable performance of enterprises [9]. Using text mining methods based on sustainable development and technology availability, using China's manufacturing industry as a sample, this study measured the digitalization level of enterprises. It explored the mediating role of technological innovation and business model innovation. Research has found that the application of digital technology provides more innovation opportunities and possibilities for enterprises, promotes their innovation activities, and thus enhances their competitiveness and sustainability. In addition, environmental competitiveness has a strong moderating influence that is averse to the connection digitalization level and technological innovation,

while the moderating effect between the digitalization level and business model innovation is not significant. This indicates that in a fiercely competitive market environment, enterprises may be more inclined to cope with competitive pressure through technological innovation, and the improvement of digitalization level has a positive promoting effect on technological innovation. However, the impact of environmental competitiveness on business model innovation is not significant, which may be because internal factors of enterprises and market demand influence business model innovation.

5. Green Innovation

Green innovation is now widely recognized by stakeholders, including governments and consumers, as an important strategy for achieving sustainable development.

In addition, since green innovation involves multiple dimensions such as process innovation and product innovation, when the type of green innovation is different, the impact on firms' sustainable performance is also different [13]. Green innovation can both have a direct impact on sustainable performance and play a mediating role in the process of enterprise DX affecting sustainable performance. Through green innovation, enterprises can break down information barriers, gather and integrate green knowledge, information, and technological resources, and enhance green innovation capabilities, thereby reducing pollution and improving environmental social responsibility performance while realizing economic benefits [8]. Green innovation contributes to the improvement of sustainable development performance by meeting environmental regulations and increasing social consensuses. At the same time, green innovation also helps to create a green image and build a network of relationships, thus further promoting sustainable development.

Imran et al. state that through the effective use of big data, organizations can drive green innovation to achieve higher sustainable performance [14]. This process not only helps to improve the core competitiveness of the organization and increase economic efficiency but also helps to reduce pollution and enhance the environmental and social responsibility performance of the organization [8].

Li delved into the challenges between environmental protection and economic development, particularly analyzing in detail the green innovation strategies of Chinese firms in the supply chain context [15]. It was found that factors such as supply chain environmental cooperation, managers' concern for the environment, and inter-firm interpersonal relationships all affect firms' GI. GI not only enhances firms' environmental performance but also strengthens competitive advantage indirectly through environmental performance. Li's study not only enriches the theoretical foundation of green innovation but also provides valuable guidance for corporate practice. Li suggests that policymakers should consider environmental protection and economic development in an integrated manner to promote green innovation among enterprises and foster sustainable development. In addition, enterprises should pay attention to environmental cooperation with supply chain partners, cultivate managers' environmental awareness, and focus on the role of interpersonal relationships in the cooperation, to promote green innovation more effectively and enhance enterprise competitiveness and environmental performance.

Another good example showing the role of green innovation is Ping Coal Co. According to Xu, through intelligent construction and green innovation, Ping Coal has significantly increased coal mine production efficiency, reduced employee labor intensity, and improved the operating environment [16]. In addition, Ping Coal has invested a cumulative total of RMB 3.47 billion in the past three years, built many intelligent demonstrations coal mines and intelligent working faces, significantly improved per capita work efficiency, and increased coal mine productivity by more than 15 percent. These initiatives not only promote the sustainable development of the company but also light up the green innovation road of Ping Coal.

6. Conclusion

Digital transformation brings unprecedented opportunities and challenges to enterprises. On the one hand, digital technology provides enterprises with more efficient means of operation and management, which helps to improve their economic performance. On the other hand, DX also encourages businesses to focus more on social responsibility and environmental preservation, driving them to make progress in environmental and social performance. However, the effects of DX on sustainable performance is not a simple linear relationship but is affected by a combination of factors, market turbulence, competitive environment, business models, and other factors may affect the effectiveness of digital transformation.

As a crucial tool for encouraging businesses to develop sustainably, the impact of green innovation cannot be ignored. Green innovation can not only reduce energy loss and raw material costs and improve the economic performance of enterprises, but also enhance their environmental awareness and sense of social responsibility, so as to promote enterprises to achieve better performance in environmental and social performance. In addition, green innovation can also be mutually reinforcing with DX, and promote business's sustainable development.

However, current studies on the effects of DX and GI on sustainable performance has some limitations. On the one hand, most of them focus on the single factor on sustainable performance, with less consideration given to the interactions and synergies between multiple factors. On the other hand, they are mostly based on a particular mega-field, and there are relatively few cross-field and cross-regional studies. Therefore, future research needs to further expand the research perspectives and methods, and deeply explore the mechanisms and paths of the effects of DX and GI on the sustainable performance of enterprises. With the continuous development of emerging technologies, DX and GI will become an important driving force for sustainable development of enterprises. To achieve a general enhancement in economic, environmental, and social performance, Enterprises need to seize the opportunity to strengthen technological innovation and management innovation, and promote the in-depth integration of DX and GI.

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