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Research on the sustainable development of supply chain digital enabling manufacturing enterprises

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Abstract: *This paper takes supply chain digitisation as the research background to explore its driving effect on ESG performance of enterprises in China. Through a review of relevant literature at home and abroad, the impact mechanism of supply chain digitisation on corporate ESG performance is systematically analysed. It is found that supply chain digitisation has a significant positive driving effect on corporate ESG performance through improving information transparency, optimising resource allocation and strengthening collaborative innovation. On this basis, this paper constructs a theoretical model of supply chain digitisation and corporate ESG performance, which provides a theoretical basis and practical guidance for Chinese enterprises to achieve sustainable development. It is finally concluded that supply chain digitisation is an important way for enterprises to improve their ESG performance, and enterprises should increase their investment in supply chain digitisation in order to promote the improvement of their own and the overall supply chain's ESG level.*

Keywords: *Supply chain digitisation; ESG performance; manufacturing*

1. Introduction

Against the background of global economic integration and the rapid development of information technology, supply chain management is no longer just a part of business operations, but has become a key strategy for enterprises to enhance their competitiveness and respond quickly to market changes. With the in-depth development of the fourth industrial revolution, the extensive application of digital technology is profoundly reshaping the traditional supply chain model. This wave of digital transformation involves not only the automation of production processes and the intelligence of logistics, but also data-driven decision-making and the optimisation of supply chain networks. This transformation has not only triggered a revolution in management styles and operation models within enterprises, but also a profound reconfiguration of the supply chain ecosystem in the external environment.

In recent years, it has been widely recognised by academics that supply chain digitisation not only improves operational efficiency and economic performance, but also has the potential to have far-reaching impacts on corporate social responsibility, environmental protection and corporate governance. Through a comprehensive review of the existing literature, this paper reveals how supply chain digitisation can positively drive corporate ESG performance through multiple paths, such as enhancing information sharing, improving supply chain agility, reducing transaction costs, and enhancing risk management capabilities. The expansion of the background part of this study not only takes into account the macro trend of technological advancement and economic globalisation, but also combines the micro needs of corporate social responsibility and sustainable development concepts, laying a solid foundation for the subsequent theoretical analysis and empirical research. Under this general environment, corporate environmental, social and governance (ESG) performance has increasingly become the focus of attention. Investors take ESG performance as an important indicator for assessing the long-term value and risk of companies, consumers are increasingly inclined to support companies with good ESG records when choosing products and services, and regulators take ESG as an important tool for promoting corporate social responsibility and green development. As a result, ESG performance has become an important criterion for evaluating the sustainability of enterprises, and even determines their survival and development to a certain extent. Based on this macro background, this study delves into the driving effect of supply chain digitisation on corporate ESG performance. Through a systematic analysis of how supply chain digitisation affects corporate performance in environmental protection, social responsibility fulfilment and corporate governance, it reveals the

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intrinsic mechanism of digital transformation and its far-reaching impact on corporate sustainable development. This not only helps to enrich the theoretical system in the field of supply chain management and ESG, but also provides a theoretical basis and practical guidance for how enterprises can improve their ESG performance through digitalisation in practice.

2. Literature review

In recent years, there has been a general consensus among academics that the digital transformation of supply chains not only significantly improves the operational efficiency and economic performance of enterprises, but also has an important and far-reaching impact on corporate social responsibility, environmental protection, and strengthening corporate governance. Existing academic literature elucidates how supply chain digitisation can positively contribute to firms' ESG performance through multi-dimensional pathways such as enhancing information sharing, improving supply chain resilience, reducing transaction costs, and enhancing risk management. This study integrates the macro context of technological innovation and economic globalisation with the micro perspective of CSR and sustainable development, which provides a solid theoretical foundation for subsequent theory building and empirical investigations.

2.1. Digitisation of the supply chain and its performance

In exploring the contribution of supply chain digitisation to economic efficiency, Zhang Zhe et al point out that enterprises should strengthen the integration of digital technology and supply chain systems, vigorously promote supply chain digital management methods, promote collaborative innovation among enterprises, and jointly explore and utilize the potential of data resources, so as to effectively enhance the total factor productivity of enterprises[1]. According to Lu Peng, through the use of digital tools to implement lean management, agile manufacturing and accurate supply chain collaboration, enterprises can eliminate information barriers, reduce non-essential labour inputs, optimize resource allocation, and thus reduce overall operating costs[2]. Yanjun Chen pointed out that the digitisation of the supply chain helps to promote the efficiency of the division of labour in enterprises[3]. Meanwhile, Zhang Keju et al suggested that digital transformation of enterprises can promote the optimisation of organisational structure as well as the improvement of production and operation processes[4]. Lai Xiaohua et al opened a number of key application services for digital manufacturing, including supply chain collaboration, supply chain traceability, supply chain empowerment, and so on, to supply chain enterprises by constructing a digital supply chain collaboration cloud platform for aerospace equipment, thus enhancing the collaborative operation capability of the supply chain[5].Zouari et al and Zhang Shushan et al found by means of questionnaires that digital transformation of supply chains helps to enhance the resilience and elasticity of the supply chain. In addition, existing studies have shown that supply chain digitisation can promote the improvement of enterprise performance[6], enhance the innovation ability of enterprises [7], and drive enterprises towards high-quality development[8].

At the same time, some studies have questioned the effectiveness of supply chain digitisation. Dolgui et al suggested that the high cost of technological investment required for supply chain digitisation may result in firms' revenues being insufficient to cover their inputs[10].Balakrishnan further pointed out that technological inputs for supply chain digitisation are easy to be imitated by competitors, and therefore it is difficult to build a lasting competitive advantage[11]. In addition, supply chain digitisation may cause ruptures between organisational structures and cultures, incoherence in organisational strategies, and reconstruction of benefit distribution patterns, which may lead to the creation of new conflicts[12][13][14].

2.2. Corporate ESG performance and its measurement

In supply chain networks, the close ties between customers and suppliers and their respective different status characteristics were brought to the attention of the study by Mengyu Shi and Jiamin Yan (2024). They found that the effectiveness of customer firms in improving ESG (environmental, social and governance) performance can significantly diffuse upstream of the supply chain, which in turn contributes to the improvement of suppliers' innovation capabilities. In contrast, researchers such as Li, Pu-ling et al. (2024) confirmed the supply chain transmission effect of customers‘ ESG performance from the perspective of the linguistic style of suppliers’ annual reports[16]. Their findings showed that the positive tone in suppliers‘ annual reports was enhanced as customers’ ESG performance improved.

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In addition, Xiao Hongjun et al. (2024) researchers used customers‘ digital transformation as the starting point of their study and concluded that customers’ digitalisation process significantly enhances supply chain resilience and promotes the sustainability of the entire supply chain by improving suppliers' ESG performance. [17]

With the rapid development of ESG, the attention of academics has gradually turned to exploring various internal and external factors that affect corporate ESG performance. In terms of the external environment, researchers have analysed how public concerns about the environment[18], analysts‘ concerns and media concerns affect firms’ ESG performance from a number of monitoring perspectives[19]. In terms of the internal management structure of firms, it was found that the governance of corporate party organisations has a positive effect on enhancing ESG performance. Meanwhile, factors such as digital transformation , the overseas educational background of independent directors, and the stability of the executive team have also been shown to be effective in improving firms' ESG performance. In addition, excellent ESG performance not only promotes firms‘ outbound investment, enhances M&A performance and financial performance, but also strengthens firms’ risk resilience [21]and innovation[22]. In addition, good ESG performance can also help to reduce the cost of debt financing [23]and agency costs of firms.

3. Pathways to supply chain digitisation for ESG performance in manufacturing companies

3.1. Transparency in digital supply chains breaks down information barriers

According to stakeholder theory, an enterprise is an association of interests composed of multiple stakeholders, which is actually a series of ‘contracts’ signed by a group of stakeholders, so the goal of an enterprise should be to maximise the value of stakeholders. Accompanied by the rapid development of mobile big data, cloud computing, blockchain, artificial intelligence, 3D printing and other technologies, digital technology is gradually integrated into the production process of the supply chain, which provides ‘empowerment’ for nodal enterprises to fulfil their social responsibility and improve their ESG performance.

In manufacturing enterprises, through the establishment of a unified data sharing platform, companies are able to seamlessly connect and share information in real time with all links in the supply chain, including raw material suppliers, manufacturers, distributors, retailers and end users. This transparency involves not only basic operational data such as inventory levels, production schedules, and order status, but also more complex strategic information such as market trend analyses, demand forecasts, and product design feedback. This comprehensive information sharing mechanism effectively breaks down the barriers caused by information asymmetry in the traditional supply chain, enabling each participant to make more reasonable decisions based on accurate and complete data.

Transparency in the digital supply chain provides manufacturing companies with the ability to gain deep insights into supply chain operations through advanced data analytics and processing technologies, such as big data, cloud computing and artificial intelligence. These technologies can quickly process massive amounts of data to identify potential risks and optimisation opportunities in the supply chain, thus helping companies to make early warnings and adjust their strategies. For example, by real-time monitoring of raw material market price fluctuations, enterprises can adjust their procurement strategies in time to avoid cost increases; by analysing real-time data from production lines, they can identify abnormalities in the production process and take measures to improve product quality and efficiency. Transparent digital supply chain also shows significant advantages in logistics management. Through IoT technology, companies can track the transportation status of products in real time, ensuring that the logistics process is visualised and controlled. This transparency not only reduces logistics delays and losses, but also improves customer satisfaction, as customers are also able to understand the dynamics of their orders in real time. At the same time, a transparent supply chain also optimises inventory management, reducing overstocking and out-of-stocks through accurate demand forecasting and inventory level monitoring, thereby reducing inventory costs and improving capital turnover. Transparency in the digital supply chain also promotes cross-departmental and cross-enterprise collaboration. In a transparent environment, different departments are no longer independent units, but can collaborate on decision-making and problem-solving based on common data and information. This kind of collaboration is not only limited to internal enterprises, but also includes collaboration with external partners, such as supplier collaborative planning, early supplier involvement in product development, etc., all of which help to shorten time-to-market and improve the competitiveness of the overall supply chain. Transparency in the digital supply chain brings

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improvements in ESG for manufacturing companies. Through transparent supply chain management, companies can better monitor and reduce the environmental impact of their operations, ensure social responsibility in the supply chain, and improve the transparency and efficiency of their governance structure. Not only is this an important way to achieve sustainable development, but it can also bring significant competitive advantage and long-term sustainability potential to companies.

3.2. Data-driven decision-making to optimise ESG practices

Data-driven decision-making to optimise ESG practices has become an important way for manufacturing companies to improve their competitiveness and sustainability. At the environmental level, companies collect real-time data on energy consumption, waste generation and emissions during the production process by installing sensors and utilising IoT technology. These data are fed into a big data analytics platform, and through complex algorithms and model analysis, they are able to identify inefficient links and high energy consumption points, so that targeted energy-saving measures and resource optimisation strategies can be developed. For example, through data analysis, an enterprise may find that the equipment of a certain production line still consumes a large amount of energy during off-peak hours, and thus adjust the operating hours without affecting productivity to reduce unnecessary energy waste.

In terms of social responsibility, data-driven decision optimisation helps companies better understand and respond to stakeholder needs. Companies analyse employee satisfaction surveys, community feedback and consumer research data to assess the effectiveness of their social responsibility activities and adjust corporate policies and practices accordingly. For example, an organisation may identify a growing need for work-life balance among employees and introduce more flexible working arrangements to increase employee satisfaction and reduce brain drain. At the same time, companies can use data analytics to monitor social responsibility risks in the supply chain and ensure that suppliers are complying with labour regulations and human rights standards, thereby safeguarding their brand image and market trust.

At the governance level, data-driven decision-making to optimise ESG practices is reflected in how companies can improve internal governance efficiency and transparency through data analytics. By establishing a data-driven internal monitoring system, enterprises can track financial indicators, compliance status and risk management in real time. Such monitoring helps companies identify potential violations, such as insider trading or improper connected transactions, and take measures to prevent them. In addition, through data analytics, companies can optimise the decision-making process of the board of directors and senior management to ensure that decisions are based on accurate and comprehensive information, thereby improving the quality and efficiency of decision-making.

Data-driven decision optimisation ESG practices not only help companies to improve resource efficiency, enhance social responsibility and improve governance, but also provide long-term strategic advantages, including increasing brand value, strengthening customer loyalty and attracting investment. Through this path, companies are better able to adapt to changing market and social demands, and realise harmonious integration of economic, environmental and social benefits.

3.3. Cross-sectoral collaboration to enhance ESG integration

Driven by global economic integration and information technology, enterprises are facing increasingly complex challenges, which require different departments to break down traditional silo thinking and work together to advance the integration of ESG issues through close collaboration. In this process, companies first need to establish a cross-departmental working group or committee comprising representatives from key departments such as finance, operations, human resources, marketing, legal and so on, to ensure that ESG issues are fully considered and implemented within the organisation. The role of this working group is to develop an overall plan for ESG integration, clarify the roles and responsibilities of each department in ESG practices, and develop specific implementation steps and timelines. On the environmental front, cross-departmental collaboration is reflected in the joint promotion of energy-saving, emission reduction and resource recycling projects. For example, the production department works with the finance department to invest in more energy-efficient equipment and processes through cost-benefit analyses, while the IT department provides technical support and monitors energy consumption data to ensure that the production process is green. At the social responsibility level, the human resources department joins forces with the marketing department to enhance employee satisfaction through training and improved employee benefits on the one hand, and

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to strengthen the brand image through socially responsible marketing campaigns on the other hand, to attract more consumers who are concerned about corporate social responsibility. At the governance level, cross-departmental collaboration is reflected in the establishment and improvement of internal control systems. The legal department works with the audit department to ensure that the company's operations are in compliance with laws and regulations, while all departments need to be involved in anti-corruption and compliance training to enhance the overall level of governance.

In addition, cross-departmental collaboration is reflected in the continuous monitoring and evaluation of the ESG performance of the enterprise. Departments need to report regularly on ESG-related KPIs and identify areas for improvement through data analysis. Through this cross-departmental collaboration, companies can integrate resources more effectively and leverage the expertise of each department to address ESG issues. This not only helps to improve the overall performance of the organisation, but also enhances the positive image of the organisation in the eyes of investors, customers and employees. Communication and transparency are key to success in this process. Companies need to establish an open information-sharing platform that encourages communication and co-operation between departments to ensure that ESG objectives and measures are effectively communicated and implemented. Ultimately, cross-departmental collaboration to enhance ESG integration will bring long-term competitive advantage to the organisation, helping it to stay ahead of the curve in the ever-changing market environment and achieve its long-term goal of sustainable development.

4. Conclusions

This paper comprehensively analyses the role of supply chain digitization in driving ESG performance improvement in manufacturing enterprises from three dimensions: transparency, data-driven decision-making and cross-sector collaboration, which provides useful reference and inspiration for enterprises to achieve high-quality development. In future development, enterprises should further deepen supply chain digital transformation to better meet ESG challenges and achieve sustainable development. An in-depth discussion on how supply chain digitisation can drive the ESG performance of manufacturing enterprises is presented, detailing the key paths in the process. The article reveals the role of digital supply chain transparency in breaking down information barriers. In traditional supply chains, there are often obstacles to information transfer, while digital means make the flow of information smoother and effectively improve supply chain transparency, providing a strong guarantee for enterprises to monitor and manage ESG risks. Second, this paper highlights the importance of data-driven decision-making in optimising ESG practices. By collecting, analysing and utilising big data, companies are able to more accurately grasp the current situation and trends in the ESG field, and thus develop more targeted strategies. This data-driven decision-making approach helps companies to continuously optimise their ESG practices and improve performance. The article also points out the critical role of cross-functional collaboration in enhancing ESG integration. In the process of supply chain digital transformation, all departments of an organisation need to work together to form a synergy. Through cross-departmental collaboration, enterprises can better integrate resources, promote ESG concepts throughout all aspects of enterprise operations, and achieve overall improvement of ESG performance.

After in-depth analysis, this paper finally concludes that the digital transformation of the supply chain not only provides enterprises with tools to monitor and effectively manage environmental, social and governance risks in real time, but also plays an important role in improving the accuracy of decision-making, the efficiency of resource use and the level of responsibility fulfilment. This transformation process has laid a solid foundation for enterprises to achieve overall improvement in ESG performance. In the fierce market competition, supply chain digital transformation has become a key factor for enterprises to maintain their advantageous position and promote sustainable development, providing strong support for enterprises.

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