

The Impact of Supply Chain Digitization on Corporate Environmental Performance: the case of Weiming Environment

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Abstract. This study explores the impact of supply chain digitization on corporate environmental performance, taking Weiming Environment Protection as a case study to analyze the path and impact of its digitization process on green supply chain management. It is found that the application of digital technology not only improves the collaborative innovation ability and resource allocation efficiency of the supply chain, but also effectively reduces environmental pollution and resource waste. In green supply chain management, Weiming Environment realized the digital supervision of the whole process of garbage removal, waste treatment and resource recycling through the intelligent management system, which improved the environmental performance of the enterprise. The study further suggests that digital technology plays an important role in promoting green transformation and can provide strong support for enterprises to cope with eco-standards and market competition. This study provides useful experiences and lessons for other enterprises in digital transformation and environmental performance improvement.

1 Introduction

China is vigorously promoting the strategy of sustainable development and actively promoting the green transformation of the economy and society. In this context, optimizing energy structure and developing green and low-carbon industries have become important tasks for enterprise development, which requires enterprises to fulfill more social responsibilities while pursuing economic benefits, especially in the construction of green supply chains. Accompanied by the swift advancement of the digital economy, the resilience and effectiveness of the supply chain have markedly improved. The implementation of digital technology not only fosters collaborative innovation within the supply chain but also significantly enhances production and management efficiency, optimizes resource allocation, and mitigates environmental pollution and resource waste. Therefore, how to effectively apply digital technology to green supply chain management has become a key issue that enterprises need to address.

The goal of this research is to investigate the impact of the digital supply chain on the company's environmental performance using a case study technique. This study will evaluate

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the environmental performance of the case company to determine the impact of digital technology on green supply chain management. It will summarize the company's successful practices, offering viable lessons and references for other enterprises. This study discusses the potential of digital technology in facilitating green transformation and offers critical insights for firms to navigate increasingly strict ecological standards and fierce competitors in the future.

2 Literature review

Diverse experts possess varying perspectives on the contributing elements of supply chain digitization. Khan discovered integration and operational models are significant drivers for supply chain digitalization [1]. Choudhury identifies sales and operations planning, strategic sourcing, intelligent manufacturing, and warehouse management as useful techniques to enhance supply chain digitization success through MICMAC [2]. Vitsentatou, based on Grey-Denmatel research, deems that technology, consumers, and industry are the three primary drivers of digital transformation in the food service supply chain [3]. In terms of enabling mechanisms for supply chain digitization, Wang claims that the digitization of the supply chain depends on processes like value-added efficiency enhancements and the integration of sustainability and digitalization [4]. Ho demonstrates through case studies that digitization of the manufacturing supply chain can be accomplished using three frameworks: top-down, bottom-up, and hybrid, facilitating digital transformation both upstream and downstream of the supply chain [5]. On the impact of supply chain digitization, Lerman's regression analysis shows that digital supply chains are directly associated with elevated levels of green supply chain management [6]. Xu contends that supply chain digitization plays a crucial role in enhancing the internationalization performance of enterprises [7].

Research on elements affecting environmental performance has concentrated on both the firm's internal management and the external environment. From internal management, Awawdeh believes that technological innovation positively influences the enhancement of enterprises' sustainability initiatives and advocates for firms to advance their performance via green innovation [8]. Wang points out that green innovation is not only cost-effective and efficient, but it also significantly influences the financial health of the enterprise; it is predicated on the provision of adequate financial support [9]. On the management side, Sarfraz perceived that cognitive CEOs could drive corporate environmental responsibility and encourage superior environmental performance [10]. Li states that organizations can significantly diminish resource waste with green training and environmental awareness publicity [11].

From the external environment, Wang proves through empirical study that raised penalties for corporate pollution and central government regulation of localities can improve regional environmental performance [12]. Yu holds that the implementation of environmental protection policies and the reform of the green tax system can stimulate business environmental investment and augment green innovation capacities [13]. Ning discovered that commercial banks limit financial access for environmentally harmful firms through green credit regulations and encourage corporate transparency regarding environmental data and green innovation [14].

In conclusion, while researchers have extensively examined the motivations, mechanisms, and impacts of supply chain digitization, studies about its impact on enterprises' environmental performance are limited. This paper takes Weiming Environment Protection Co., Ltd as a case study to explore the relationship between supply chain digitalization and environmental performance. It reveals its influence path, aiming to provide theoretical support and practical guidance for enterprises to pursue digital transformation in their supply guidance.

3 Case study

Through data collation and analysis of current events, this study selects Weiming Environment as a case study, focusing on the path and impact of its digitization process on environmental performance post-2018. This case offers factual evidence for the analysis and assists other firms in improving their environmental performance through supply chain digitalization. Weiming Environment has three main divisions: Weiming Environment invests and operates waste incineration and environmental protection projects, Weiming Environment protection equipment and new materials, and Zhejiang Jiawei New Energy Group Co. invests and operates new energy projects. Intelligent sanitation and urban-rural integration have been Weiming's digital initiatives since 2018. The comprehensive data collecting and monitoring system was launched in 2019, the high-end environmental protection industrial park was operated in 2020, and the new energy all-industry chain was fully implemented in 2022.

3.1 Green supply chain management

In terms of supplier selection, Weiming Environment Protection Company adheres to the principle of sunshine procurement to ensure the openness and transparency of the bidding and purchasing process. Before entering into cooperation, the company carries out sufficient background investigation on suppliers, comprehensively considers product quality and industry competitiveness, and finally selects the most cost-effective enterprise. For suppliers that have already cooperated, the company implements hierarchical management, dividing them into core suppliers, formal suppliers, and potential suppliers. For potential suppliers, the quality of their products is tested and controlled by way of trial. If unqualified products are found, subsequent cooperation will be terminated in a timely manner.

Weiming Environment is dedicated to establishing a dual primary industry chain encompassing environmental protection and renewable energy. The environmental protection industry chain, centered on waste incineration, is predominantly located in Zhejiang Province and intends to expand its operation to the central and western regions. By the end of March 2024, the number of waste incineration projects controlled by the company had reached 52, with a daily operating scale of 35400 tons. Moreover, Weiming has carried out horizontal and vertical extensions in the industrial chain and has developed businesses that deal with food waste treatment, medical waste disposal, and landfill leachate treatment. Among them, there are 17 food waste treatment and operation projects, with a daily processing capacity of 1925 tons. The equipment required by the company is provided by its subsidiaries, such as Environmental Protection Equipment Company Limited, Wenzhou Jiawei Environmental Protection Technology Company Limited, and Shanghai Jiawei Environmental Protection Technology Company Limited.

In the emerging energy sector, Weiming has invested in three high-ice nickel projects in Indonesia in collaboration with MERIT, Xinwanda, and Greenmax to facilitate the manufacture of new energy materials. In the midstream sector, a joint venture with Tsingshan Holdings, Shengtun Mining, and Xinwangda, Zhejiang Weiming Shengqing Energy New Materials Co., Ltd., to invest in the construction of lithium battery new material projects, using high-ice nickel as raw materials to produce high-nickel ternary cathode materials and electrolytic nickel. In the downstream, it cooperates with Yongqing Technology and GEM Co., Ltd. to build a green recycling and low-carbon demonstration park, focusing on the recycling of power batteries and battery fertilizers so as to build an integrated new energy industry chain.

Weiming Environment uses the thermal energy produced from waste incineration and the biogas derived from kitchen waste processing as the facility's power supply, thereby achieving energy recycling in the production process and minimizing resource wastage.

3.2 Applications of digital technology

The company has implemented a smart sanitation system in the garbage removal and transport process. Specifically, a GPS is installed on rubbish removal vehicles to track the vehicle's operating status, location, and speed in real time, transmitting the relevant data to the big data collection center. The information collection center summarises and stores the data, analyzing each segment of running data through a data model to calculate the ideal operating route. Based on the results of the analysis, supervisors in the data center use intercom terminals to dispatch operators and vehicles flexibly and cope with different situations. In addition, rear-pressure refuse collection vehicles are used on the transport equipment to replace the traditional covered refuse collection vehicles. Combined with the electromechanical-hydraulic integration technology, the hydraulic device is commanded by an electronic control system to achieve the automatic loading and unloading of refuse containers, thus reducing the need for manually hauling and transporting refuse containers. This electronic control system continuously checks the vehicle's status. In the event of an anomaly, emergency measures can automatically be initiated via the hydraulic system to maintain safe vehicle operation. In staff management, performance is associated with the execution and quality of sanitation activities, and the compensation evaluation criteria are visible to facilitate efficient management.

After the waste is transferred to the treatment plant, it goes through the receiving and storage system, incineration system, waste heat utilization system, flue gas purification system, and water treatment system. Each system is supervised by the SLS data collection and monitoring system, which summarizes and analyzes the production assessment indicators in real time and conducts scoring, grading, early warning, and problem diagnosis. During equipment operation, the DCS automatic control system independently developed by the company disperses the control function to each subsystem and equips different subsystems with appropriate algorithm modules. The operating process data of all subsystems is aggregated to the operating station, and the operating status of the equipment is monitored and controlled through the intelligent control panel. In addition, the company adopts the ACCS grate control system to regulate essential parameters in the waste incineration process automatically. It combines with the DCS system through the OPC protocol to collect and manage data such as combustion air volume, hearth speed, and steam output to ensure efficient incineration efficiency. The gas data generated during the incineration process is displayed on the large screen in the plant in real-time and is networked with the environmental protection supervision department to accept the external supervision of the public.

3.3 Impact of supply chain digitization on green supply chain management

In terms of logistics services, the company adopts rear-loading compaction trucks with fully automated processes to enable compression and loading operations of waste during transport. Mechatronic technology intelligently adjusts the pressure and flow of the hydraulic system according to the needs of the operation, thereby reducing fuel consumption and pollutant emissions. In addition, the rational planning of the removal route of the big data center improves the overall operational efficiency of the garbage truck, shortens the transport distance, and reduces carbon dioxide emissions.

In terms of information management, the company has introduced a data acquisition and monitoring system (SLS) to visualize the entire production process on a central control screen and realize the sharing of production data. This not only allows the government and the public to monitor the environmental behavior of enterprises better but also fosters adherence to environmental regulations. When the system detects data abnormalities, the automatic early warning system will notify the relevant person in charge in time to achieve early detection and early treatment of problems and reduce the impact of harmful substances on the environment. The DCS system used in the production process not only controls every step of the process but also ensures that the equipment operates in an optimal state, minimizing energy consumption and waste generation. The ACCS grate control system ensures that the waste is fully incinerated and energy efficiency is maximized.

3.4 Environmental performance

3.4.1 Energy consumption

As shown in Table 1, the consumption of raw coal resources showed a significant downward trend, and the consumption decreased significantly compared to 2021. In terms of water resource utilization, in addition to the use of surface water and groundwater, The company also puts the collected rainwater, purified recycled water, and reclaimed water into daily production so as to reduce the over-dependence on surface water and groundwater. The number of projects put into operation has increased significantly in the past three years, and transport vehicles are still dominated by fuel trucks, increasing the use of fuel, diesel, and gasoline.

Table 1. 2021-2023 Energy consumption and utilization.

Category	2021	2022	2023
Liquefied gas(tonne)	31	35	35
Raw coal(tonne)	38333	1496	2601
fuel oil(tonne)	3155	2588	4067
Diesel fuel(litre)	1799799	3596133	3502360
Gasoline(litre)	241209	300690	326815
Purchased electricity(kWh)	6730397	13996140	24379300
Municipal water purchases(m ³)	3946328	4397966	5944737
Surface usage(m ³)	1104	1341	2048
Groundwater use(m ³)	739421	694267	938282
Usage of rainwater harvesting(m ³)	1104	1341	2048
Total recycled/reclaimed water(m ³)	643360	685215	1205756

With regard to the use of electrical energy, although the enterprise has adopted thermal energy and biogas as alternatives to thermal power generation, initially reducing the use of raw coal, these two methods of power generation are still unable to meet the needs of multi-project operations, and the power of purchased electricity continues to grow.

3.4.2 Greenhouse gas and exhaust emissions

With the expansion of the enterprise's business segments and the increase in the number of projects put into operation, the emission of related waste is also growing slowly. For waste gas treatment, Weiming Environment mainly adopts an SIS system for real-time monitoring and combines selective non-catalytic reduction (SNCR) denitrification technology, semi-dry and dry deacidification treatment, activated carbon adsorption, cloth bag dedusting, as well

as selective catalytic reduction (SCR) denitrification and wet deacidification technology to form a comprehensive flue gas purification process. This suite of technologies efficiently eliminates the majority of pollutants in flue gas, including particulate matter, nitrogen oxides, and acid gases, thereby allowing pollutant emissions to be controlled within environmental standards.

3.4.3 Solid waste management

During the period 2021-2023, the total quantity of slag, sludge, fly ash curing blocks, raw ash, and hazardous waste cloth tape has increased. Additionally, the total volume of general solid waste utilized in the recycling process has significantly risen, surpassing the total amount of other solid waste produced. This trend is primarily attributable to the company's implementation of resource-oriented treatment and the establishment of partnerships with external slag processing facilities, where the outsourced unit processes the slag for subsequent reuse in production. Simultaneously, the corporation primarily employs a combination of cement chelating agent curing and landfill disposal to manage both the curable and non-curable fly ash produced from trash incineration. The corporation mostly employs landfills as the solution for the permanent disposal of other hazardous wastes.

4 Conclusions

The application of digital technology in the supply chain enables the transmission of information across production nodes, accurately represents the production status in real-time, and mitigates environmental pollution by hazardous substances at the source. By integrating and analyzing data through automated systems, enterprises can attain enhanced management, implement advanced environmental protection technologies, and create new equipment to efficiently address the exhaust gases, wastewater, and solid waste produced during the manufacturing process.

In addition, the environmental protection industry, especially in the field of waste incineration and power generation, is currently facing the problem of overcapacity, and companies need to expand other businesses to generate revenue while improving their operational capabilities. Weiming Environment Protection Co., Ltd. Has established a novel material industry chain utilizing high-ice nickel raw resources, mostly employed in the production of lithium batteries for new energy vehicles. Digital technology may enhance resource allocation across upstream, midstream, and downstream suppliers, boost synergistic efficiency, and facilitate the establishment of environmentally sustainable production lines in supply chain integration. All enterprises, not solely those focused on environmental protection, must embrace social responsibility, foster technological innovation, and collaborate with organizations experienced in green practices. They should leverage digital technology's advantages of information sharing and resource integration to attain sustainable development objectives.

This study mainly explores the environmental protection potential of digital technology in specific industries, but the applicability to other industries has not been thoroughly analyzed. In addition, the high cost of digital systems may hinder their adoption by small and medium-sized enterprises, and the study has not fully considered the compliance and data security issues faced by enterprises in the digitalization process. Future research could focus on the adaptability and cost-benefit analysis of different industries.

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