

Green Supply Chain Driven by Digital Intelligence: The Case of Schneider

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Abstract. Digital intelligence strengthens the green supply chain in an environment where businesses steadily strive environmental and eco-friendliness. It helps the environment achieve its goals of low energy use and zero carbon emissions. With Schneider Electric's digital intelligence transformation as an example, this study attempts to analyze the effects of digital intelligence transformation on businesses' green supply chains. This study uses the case study method as the primary research method, analyzes several papers in this direction and the official information released by Schneider Electric, and finally concludes that the digital intelligence transformation of the supply chain has had a positive impact on four aspects of the enterprise's green supply chain: design services, production management, transportation optimization, and energy saving, which will provide a reference for the digital intelligence transformation of enterprises in this industry.

Keywords: Digital intelligence; Green supply chain; Schneider Electric.

1. Introduction

With society's continuous progress and development, the new era has put forward higher requirements for the social benefits of enterprises. At the same time, to pursue high efficiency and profit, they have further integrated and developed digital supply chains by combining them with artificial intelligence after creating lean and digital supply chains.

The green supply chain is a modern management model that integrates environmental impact and resource efficiency in the whole supply chain. It is based on green manufacturing theory and supply chain management technology, involving suppliers, production plants, sellers, and users, and it aims to make the whole process of the product from material acquisition, processing, packaging, storage, transportation, use to end-of-life disposal have the most negligible impact (negative effect) on the environment and the highest resource efficiency. The highest resource efficiency. Unlike digital or intelligent supply chains, the digital supply chain is a combination of both, based on a lean supply chain, combined with new hardware and software technologies such as industrial Internet, big data, cloud computing, 5G mobile wireless network, artificial intelligence, robotics, intelligent logistics technology, etc., using a systematic and platform-based promotion path of intelligent services and intelligent decision making to link enterprises, users, goods and facilities. The supply chain connection becomes more diversified, efficient, and valuable by closely linking processes, data, and orders. Among them, a green supply chain requires enterprises to incorporate environmental protection principles into their supply chain management. It requires them to use less energy and the greenest materials to make the most environmentally friendly products. In contrast, digital supply chain transformation helps enterprises maximize resource use and optimize the supply chain management process. Therefore, this study argues that the digital intelligence transformation of the supply chain impacts achieving the enterprise's green supply chain goals.

Based on this context, this study asks the following two questions: How does the digital transformation of supply chains affect the achievement of green supply chain goals; Whether these effects are positive or negative? In this study, Schneider Electric, a company with rich experience in green supply chain and digitalization, is selected as the research target. This study will fill the gap of

the impact of the digital supply chain on the green supply chain, which will be essential guidance for more companies in this area.

2. Literature review

With the rapid diffusion and development of digital and intelligent technologies, the strategic importance of digital intelligence has been highlighted. It has become one of the most valuable assets of many companies [1,2]. And the green supply chain (GSC) is considered an organizational element that supports the circular economy and is one of the essential directions for companies' future development [3,4]. Currently, companies are seeking green supply chain innovation (GSCI) using emerging digital technology applications such as artificial intelligence, blockchain, automation and robotics, data analytics, cloud/quantum computing, 3D printing, and the Internet of Things to improve cost and service efficiency and improve the supply chain performance of companies and industry development [5,6].

Many scholars have also studied digital intelligence's impact on green supply chains. For example, Li et al. investigated the contribution and impact of rapid response technology on green supply chain development [7,8]. Congenital empirically tested the concept of collaborative innovation in green supply chains and the linkage with firms' absorptive capacity and innovation performance [9]. Sustainable supply chain management in the digital era: issues and challenges were studied by Zhang et al. They explored the opportunities and challenges of sustainable supply chain development in globalization and discussed the solutions [10]. Cui et al. proposed reconstructing a green supply chain path based on data intelligence. They argued that building a new digital intelligence green supply chain system from the dual perspective of external environmental support and internal information management of enterprises is essential for social development [11]. In addition, Jiang wrote an interview based on an interview with Zhang Kaipeng, Vice President of Schneider Electric China, in which Zhang Kaipeng systematically talked about Schneider Electric's efforts to connect inter-enterprise information platforms and build an IoT platform throughout the supply chain, to create a digital operating system. Schneider Electric implements digitalization through artificial intelligence and other intelligent technologies, implements the concept of lean production, and creates [12]. Schneider Electric implements digitalization through artificial intelligence and other intelligent technologies, implements the concept of lean production, creates zero-carbon factories, and helps carbon neutrality, which provides a reference for other enterprises.

However, studies exploring the impact of digital intelligence on green supply chains still have much to be improved. Therefore, in this study, the researchers have selected Schneider as an example of a manufacturing company that has made changes in recent years with the continuous penetration of digital intelligence and summarized and studied the impact of the application of digital intelligence on green supply chains in such manufacturing companies, using green supply chain-related indicators as benchmarks.

3. Case Background

With its headquarters in France, Schneider Electric SA is a multinational electrical corporation with a wealth of automation and energy efficiency expertise. The Schneider brothers established their business in Rueil, France, in 1836. Today, the Fortune 500 company, with 28.9 billion euros in revenue in 2021, employs more than 160,000 people across 180 facilities globally.

Schneider launched its EcoStruxure industrial architecture at the end of 2016, which marked the beginning of Schneider's transformation into a digital intelligence firm. The "Lighthouse Factory" list, devoted to selecting "digital manufacturing" leaders from thousands of companies globally, was released by the World Economic Forum in 2018. Its list included Schneider's Le Vaudeuil factory in France, and this designation represents Schneider's early successes in digital transformation. Four Schneider facilities have so far been listed on this list.

Schneider Electric, a business with a strong sense of social responsibility, has produced numerous accomplishments while increasing its annual income. It is dedicated to environmental conservation, ethics, and equality. Schneider was recognized as one of the most ethical businesses for the 11th year in March 2022 and was included on Fortune magazine's list of the world's most reputable corporations for the fifth time in February 2022.

Schneider is dedicated to achieving global carbon neutrality and has issued quarterly sustainability reports since 2015. Every three years in the past, Schneider has created sustainability plans; the first two three-year plans were completed in 2017 and 2020, respectively. In the first quarter of 2021, a brand-new five-year sustainability strategy will also be released. Schneider has started an environmental program dubbed "Net Zero through Zero Carbon" to assist its suppliers and customers in reaching their carbon neutrality goals as part of its ambition to be carbon neutral in its operations by 2025. Schneider will collaborate with 1,000 upstream suppliers in its supply chain, which account for 70% of the total carbon emissions of its upstream suppliers, to achieve the goal of reducing carbon emissions by 50% by 2025, helping to transition the world to a low-carbon future, as stated in Schneider's 2021 Sustainability Report.

Schneider Electric has offered green and intelligent manufacturing with the "5S" value proposition in response to the problems given by the dual transformation of energy and automation and the deconstruction and restructuring of traditional manufacturing industries by digital technology. Smart, Software, Sustainable, Stepwise, and Security/Safety are part of the so-called "5S" methodology. The company first began by digitizing the underlying machinery and hardware items, gradually realizing the connectedness of the underlying hardware, before moving up to open progressively up OT and IT technologies to make them integrate and work together. Before innovating product technologies, use cases, and business models, Schneider Electric concentrated on software research and development. Later, the company built an innovation ecosystem and focused on developing complete lifecycle solutions. The corporation ultimately achieved a role change in the digital era thanks to these three strategic reforms.

Schneider Electric is continuing to restructure itself at the same time. To maximize its active driving role in the green and intelligent manufacturing system, it attempts to perform horizontal integration, including end-to-end integration and consolidation. Schneider Electric is eager to share current resources and gradually begin digital transformation with a small budget for small and medium-sized businesses unsure of how to get started. Using "5S" as a model, Schneider Electric maintains that intelligence is a trend consistently applied in a green and intelligent manufacturing system. Through a "first cure + first soft and hard + tiny steps" method, researchers will secure the security of data and processes and finally realize the dual sustainable development of electrification and innovative transformation connected to multi-technology synergy.

Schneider Electric has assisted businesses in achieving a 65% increase in overall energy efficiency, a 50% increase in productivity, and a 50% increase in production safety and reliability through comprehensive digital energy efficiency management and industrial automation solution practices, as well as the development and application of various intelligent technologies. The increase in overall energy efficiency has shown the study team the critical role digital intelligence has played in creating a green supply chain. In recent years, the Shanghai Logistics Center of Schneider Electric (China) Co., Ltd. has also finished the Smart Logistics Center's digital transformation, increasing its investment in digital intelligence technology. Delivery quality and inventory correctness have achieved over 99.99% thanks to the steady use of intelligent logistics application solutions, and efficiency has grown by over 30%. The logistics center has had substantial success in various green supply chain-related KPIs. It has achieved 5% to 8% annual savings through energy monitoring experts and power consultants to improve additional energy management capabilities.

4. Case Analysis

4.1 Specific Measures

In its nearly 200 years of existence, Schneider Electric has developed into a global leader in digital intelligence transformation in energy management and automation. Schneider Electric offers connected products, controls, software, and services from the terminal to the cloud throughout the entire life cycle of enterprise business, integrating the top process and energy management technologies in the world to help customers achieve effective and sustainable development. By concentrating on the four aspects of "short-chain synergy, cooperation and symbiosis, digital empowerment, and green sustainability," Schneider Electric has also developed significant resilience.

Schneider Electric, a manufacturer, participates in the supply chain in a variety of capacities, including those of a manufacturer, warehouse worker, transporter-distributor, and so forth. Together, the upstream supply chain for raw materials and the downstream supply chains for retailers and end users make up the entire supply chain.

First, lean production is the foundation of it all, regardless of the link. To achieve process improvement and establish the groundwork for the transformation of digital intelligence, Schneider Electric applies it throughout each link. Schneider then establishes a specialized team for digital intelligence transformation, laying the groundwork for experience through point-to-point pilot on-site digital intelligence application projects and steadily growing the group of digital intelligence specialists to create an enterprise digital intelligence culture.

To break down the internal information "silos" of the company, Schneider also focuses on creating informationization platforms, such as data platforms, supplier management platforms, internal lean digital manufacturing platforms, transportation control towers, etc. Last but not least, Schneider created an IoT platform that runs upstream and downstream of the supply chain, widely adopted digital applications, opened up the closed manufacturing system among businesses, and allowed for the unified planning and integration of the supply chain into an end-to-end digital operation system, thereby increasing the supply chain's overall efficiency.

Schneider Electric also pledged to achieve carbon neutrality in the supply chain by 2040 and net-zero carbon emissions at the supply chain operation level by 2050. Schneider Electric has included green supply chains in its carbon neutrality target as part of this commitment. To achieve this, Schneider Electric has incorporated sustainability goals into every aspect of its supply chain operations, from product design and raw material selection to manufacturing, waste disposal, and product lifecycle management. Additionally, Schneider Electric has a set of management systems to promote green upgrades in all aspects of the supply chain. Combined with the transformation above of digital intelligence, it enables the construction of a green supply chain more effectively.

Schneider has developed a variety of eco-friendly initiatives since completing its digital transition, including the "Carbon Reduction Master" program. With its extensive knowledge and cutting-edge technologies in sustainable development, Schneider, the founder, has urged more businesses, organizations, and people to get involved. To achieve a win-win situation of both economic rewards and sustainable growth, it will share its successful experience of merging digital intelligence with a green supply chain with more people through joint promotion and entice additional "masters" to join. The "masters" who sign up will receive various services and solutions from Schneider, including top-tier design consulting services for digital transformation, lean production management, intelligent factory operation optimization, and intelligent supply chain management. He has, in a way, taking the lead in advancing the conversion of businesses to digital intelligence and green intelligent manufacturing.

4.2 Data Analysis

To investigate the impact of Schneider Electric's digital intelligence transformation measures on its green supply chain, this study referred to a large amount of literature in this direction and selected three indicators that are more representative and reflect the state of the green supply chain, namely,

the number of waste-free output plants, carbon dioxide emissions, and energy savings as a percentage of initial energy, from the indicators related to the impact of digital intelligence application, and extracted the corresponding indicators from Schneider’s official Quarterly Sustainable Development Report. The corresponding indicators were extracted from Schneider’s official Quarterly Sustainability Report, and finally, a line graph was constructed to visualize these data’s impact further.

4.2.1 Number of plants with no waste output

Figure 1 shows the number of plants with no waste output in the horizontal coordinate and the corresponding quarter in the vertical coordinate. This means that the waste from the production process can be fully recycled. As can be seen from the line graph, the number of Schneider’s waste-free factories has been increasing year by year since 2015 and has made rapid development from 2016 to mid-2018, finally exceeding the 200 mark in the fourth quarter of 2020.

In 2016, Schneider Electric started its digital intelligence transformation, implementing the concept of lean production and designing a whole management system to be applied to waste treatment, helping the development of cleaner production and waste resourcefulness. In this study, Schneider’s Le Vaudeuil plant in France was awarded the title of "Lighthouse Factory" in 2018, the first milestone of Schneider’s digital intelligence transformation. Since then, Schneider has gradually completed the digital intelligence transformation projects in the rest of its plants, of which four plants have been awarded the title of "Lighthouse Factory". A total of four factories were awarded the title of "Lighthouse Factory". At the same time, the data in the chart shows that the growth trend of the number of factories with no waste output has slowed down since 2018, which also indicates that Schneider’s Digital Intelligence transformation is gradually coming to an end. The Digital Intelligence transformation has successfully reduced waste generation (By 2020, Schneider Electric will have 13 national "green factories", accounting for 57% of the 23 factories in China).

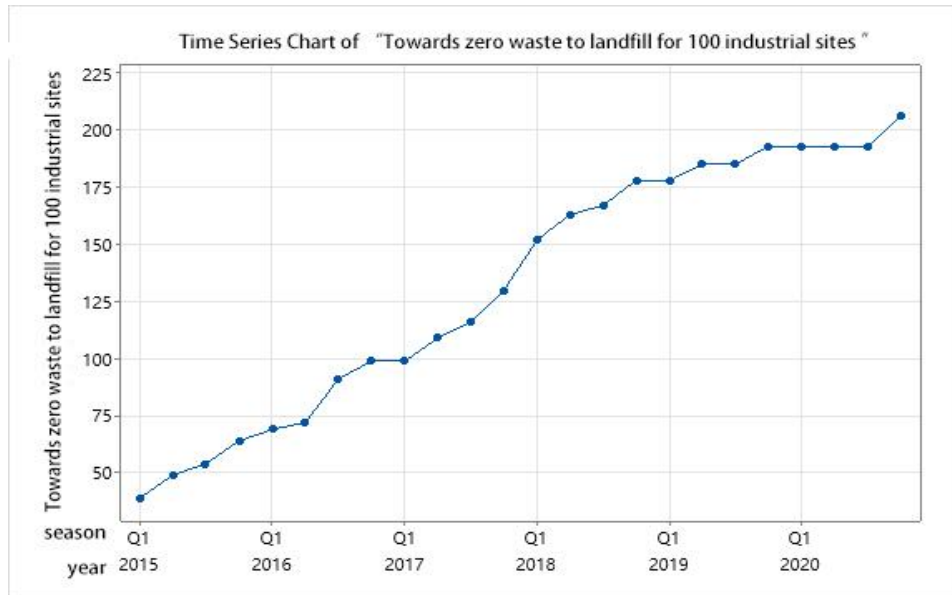


Fig. 1 Towards zero waste to landfill for 100 industrial sites

4.2.2 Carbon dioxide emissions

In Schneider’s Carbon Neutral and Sustainability Executive Insights, published in 2022, it is stated that nearly 94% of leading companies explicitly state that they are ready or are establishing a digitally driven approach to carbon governance. Therefore, this study examines the impact of Schneider’s digital transformation process on CO

- (1) Avoided CO2 emissions through maintenance, retrofit, and end-of-life approaches

Figure 2 shows the annual and quarterly CO2 emissions avoided through maintenance, retrofit, and obsolescence in the horizontal axis and the CO2 emissions avoided through maintenance, retrofit,

and obsolescence in the vertical axis, which is a measure of the reduction achieved through maintenance, retrofit, and obsolescence during Schneider’s digital transformation.

As with the lean process, the Digital Intelligence transformation requires Schneider to invest dedicated resources and teams of experts, and CO2 emissions are inevitable. In an interview with Mr. Zhang Kaipeng, Senior Vice President of Schneider Electric Global Supply Chain China, it is mentioned that Schneider has made the original fixed production line into a building block type and customized the production system for different product models and different capacity loads, and integrated 5G technology in the process, thus ensuring rapid switching of operation scenarios. In this process, Schneider carried out maintenance and renovation of the original equipment to reduce the CO2 emissions generated by the renovation, and a small number of equipment that did not meet the requirements were scrapped. The steady growth trend of the data in the figure from nearly 10,000 tons at the beginning of 2015 to almost 170,000 tons at the end of 2017 is also soundproof of the effectiveness of this work.

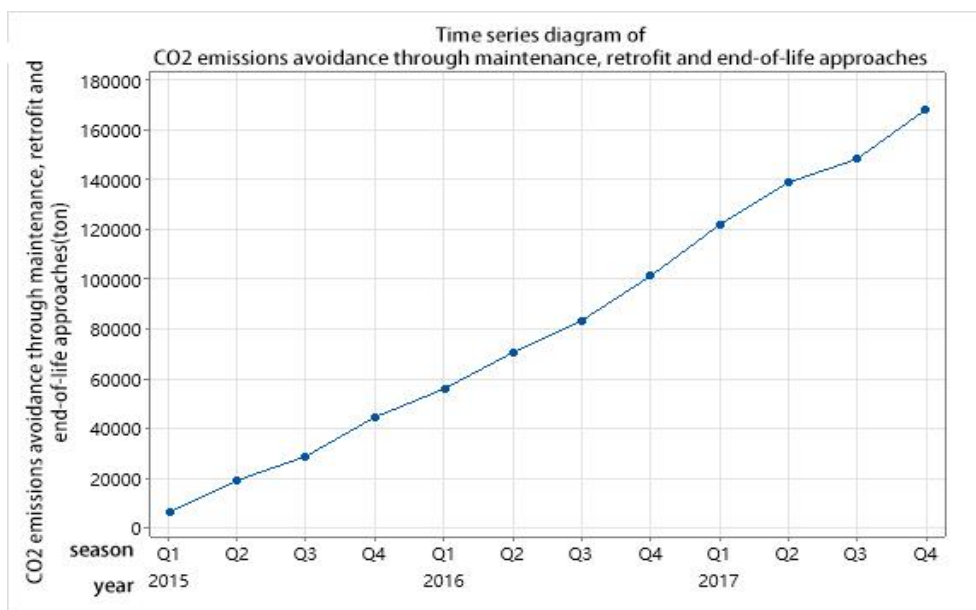


Fig. 2 Time series of avoided CO2 emissions through maintenance, retrofit, and end-of-life approaches

(2) Reduction of CO2 from the transportation process

The horizontal coordinate of Figure 3 is the year and the corresponding quarter, and the vertical coordinate is the percentage reduction of carbon dioxide from the transportation process. This indicator measures the reduction effect of digital intelligence in the transportation process. As can be seen from Figure 3, the reduction of CO2 in the transport process was significant between the first and second quarters of 2015 and has remained stable and fluctuating since then. Since 2016, the rate has increased rapidly, reaching a peak of about 17 %, then gradually decreasing in the middle of 2017.

In the digital transformation of enterprises, Schneider Electric uses big data algorithms to plan the best delivery routes for electric vehicles for logistics and transportation, significantly reducing energy consumption, reducing the negative impact on the environment during transport, and promoting the decarbonization of energy. Schneider Electric plans to reduce CO2 emissions from transportation by 15 percent by 2025.

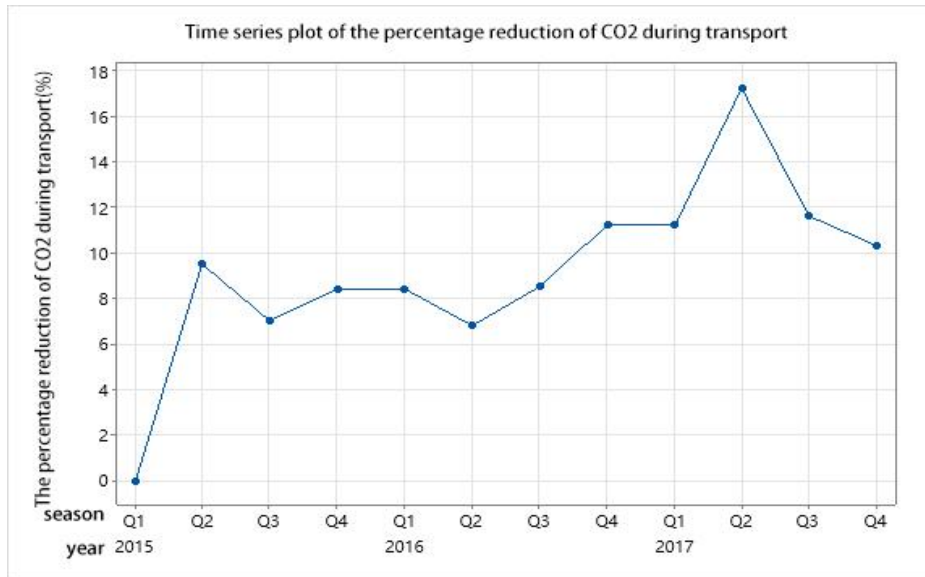


Fig. 3 Time series of percentage reduction of CO2 during transportation

4.2.3 Proportion of energy savings to initial energy consumption

The horizontal coordinate of Figure 4 shows the year and the corresponding quarter, and the vertical coordinate shows the ratio of energy savings to initial energy volume, which is used to measure the effectiveness of energy solutions brought to Schneider by the digital intelligence transformation. As seen from Figure 4, the proportion of energy savings to initial energy volume has been on a stepped-up trend since 2015, rising from 2 % at the beginning of 2015 to 10.5 % at the end of 2017.

Faced with the requirements of the digital economy era, Schneider Electric has actively launched the digital intelligence upgrade. Schneider Electric has built fully automated packaging and assembly lines and deployed LSD digital systems in assembly workshops to reduce the man-machine ratio. At the same time, Schneider Electric has created an energy management system that integrates solar photovoltaic, energy storage, and building control energy consumption to increase the penetration rate of new energy and reduce electricity consumption. In addition, Schneider Electric also uses IoT technology to open up the entire production and manufacturing process, reducing energy consumption while shortening delivery time, fully realizing energy saving and efficiency, enabling the industry chain to collaborate, and promoting overall efficient operation.

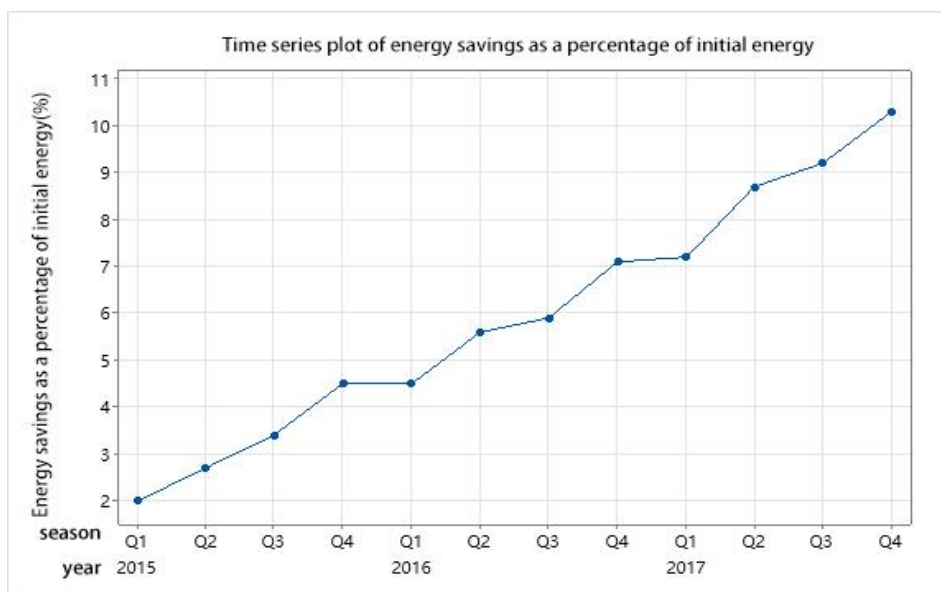


Fig. 4 Time series of energy savings as a percentage of initial energy

4.3 Summary and Expansion

China has entered the era of a digital economy and a new low-carbon era oriented by the "3060 dual carbon target". China's manufacturing industry is facing two major trends: low-carbon transformation and digital transformation, and digital intelligence is the best tool for the industry to realize these two transformations.

As a leading global expert in digital transformation, Schneider Electric not only actively practices green and intelligent manufacturing itself but also fully empowers its partners in the supply chain to move towards green transformation. Based on its long-accumulated leading experience and methodology, this study proposes four paths for the supply chain of manufacturing enterprises to realize digital intelligence upgrade based on the four value propositions of departure, focus, path, and integration.

First, planning. The transformation and reconstruction of the whole chain, system, and platform of digital intelligence transformation is not a one-day effort, and there is also a considerable risk of conversion. And the planning of the system is undoubtedly a kind of pre-rehearsal, not only to identify problems early but also from the best practices to gain experience.

Second, scene focus. The design and management of each scene as a relatively independent unit can become a crucial grip to achieve the effect of digital transformation of the local. With the realization of a series of essential digitalization scenarios and business value formation, enterprises' determination to promote transformation is strengthened.

Third, agile resilience. Agile resilience requires enterprises not only to be good at making changes themselves but also to be good at responding to environmental changes and finding the right balance among them. Therefore, under a clear goal, flexibility on the path is an effective model to ensure that the input and output of enterprises can be relatively balanced.

Fourth, ecological win-win. The digital transformation process requires internal cross-departmental collaboration and the integration of external resources to make up for their shortcomings. From this point of view, whether internal or external, building an ecosystem to promote the transformation of digital intelligence is essential.

5. Conclusion

By analyzing the impact of Schneider Electric's digital intelligence transformation on its green supply chain from three types of indicators: the number of waste-free output plants, CO2 emissions, and energy savings as a percentage of the initial energy volume, it is easy to find that the company has actively built an independent digital platform for the whole supply chain process since 2016, and then used artificial intelligence and other technologies to open up each platform, which ultimately has a positive impact on design services, production management, transportation optimization, and energy savings. The positive effect has been achieved in four areas: design services, production management, transportation optimization, and energy savings.

The main contribution of this paper is to link supply chain digitization with green supply chain and explore how digitization has impacted green supply chain, which fills the gap of related research. It is helpful to provide data support for other researchers and provide theoretical references for the transformation of enterprises into digital intelligence in the context of carbon neutrality.

Admittedly, there are still shortcomings in the current study. For example, fewer years of data are available in data collection, resulting in less significant data trends when analyzed. Future research should collect information through a broader range of channels, screen the data, and analyze them rationally to draw more accurate conclusions.

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