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Optimization Strategy and Environmental Impact Analysis of Green Supply Chain

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Abstract: With the increasingly severe global environmental problems and the enhancement of public awareness of environmental protection, Green Supply Chain Management (GSCM) has become an essential strategy for enterprises to achieve sustainable development and enhance competitiveness. Green supply chain management not only focuses on economic benefits, but also emphasizes reducing environmental pollution and improving resource utilization efficiency in the whole process of the supply chain, to promote the harmonious coexistence between enterprises and the environment. Through literature review and case analysis, the current situation and trend of global supply chain carbon emissions are analyzed, and the research focus and direction are clarified. Through the effective use of PLCs automation, ERP can make the supply chain information transparent and strengthen the management of the supply chain. At the same time, LCA's carbon footprint tracking improves the efficiency and accuracy of tracking, and promotes the digital and decentralized development of the carbon market.

Keywords: Green supply chain, Economic benefits, Reducing environmental pollution.

1. Introduction

As global supply chains become increasingly complex and globalized, they are boosting economic growth while also causing a surge in carbon emissions. During the past decade, carbon emissions and pollution associated with economic development have caused severe issues such as the greenhouse effect, abnormal climate, and environmental degradation [1]. In response to this challenge, governments, international organizations and the business community have put forward the goal of decarbonization, and strive to reduce the carbon emission intensity of all links of the supply chain through technological innovation, policy guidance and other means to achieve green transformation of the supply chain. Many progressive companies, such as Walmart, Tesco, Hewlett Packard, and Patagonia, have capitalized on the opportunities of green supply chain management and are therefore very concerned with the environmental burden of their supply chain processes [2] .

The low-carbon economy and the global supply chain are mutually reinforcing and interdependent in promoting sustainable development, facing challenges such as climate change and energy security, and ushering in development opportunities such as the advancement of clean energy technologies and the continuous advancement of environmental protection policies.

From the current situation, Chinese enterprises in the supply chain development. It is in its infancy, and some large-scale enterprises are established a relatively perfect supply chain system, but in the

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fierce market competition, it still maintains independent operation state [3]. Such as: the application of enterprise green supply chain management is not enough, the cost of green supply chain management being unbearable for enterprises, the lack of green technology support, the relevant policies are not perfect [4].

This study aims to deeply analyze the internal logic and implementation path of global supply chain decarbonization strategy, and provide a scientific basis for relevant enterprises to formulate emission reduction strategies and optimize supply chain management. At the same time, by evaluating the effects and costs of different decarbonization measures, it provides a reference for government departments to formulate relevant policies and promote the development of green supply chains.

2. Literature review

2.1. Historical evolution of environmental issues

Before the 1940s, because the industry was not developed, the emission of pollutants did not exceed the environmental capacity, so the problem of environmental pollution was not prominent. The pollutants produced by industry are basically discharged directly into the atmosphere, water and other environmental media without any treatment [5]. From the perspective of carbon emission industry, industry is the largest industry of carbon emission in China. Therefore, reducing the carbon emissions of industrial enterprises is of great significance for reducing the overall level of China's carbon emissions and achieving the goal of energy conservation and emission reduction [6]. In 1974, The State Council established the Leading Group on Environmental Protection, which was the first specialized environmental protection agency in China. Since then, a number of regulations and systems have been promulgated to control environmental pollution [7].Later, several "storms" such as "regional approval limit" and "watershed approval limit" were adopted to deal with some illegal acts in violation of the Environmental impact assessment Law, which caused a shock throughout the country [8].

The state began to attach great importance to environmental issues, the Chinese government issued a plan on how to develop the new energy automobile industry in the future. The document clearly states that China will increase the proportion of new energy vehicles in public sector vehicles in 2021, and this proportion is required to be no less than 80%[9]. Among them, the double integration policy issued by automobile enterprises can promote the development of new energy and strengthen environmental protection. The policy encourages enterprises to increase investment in research and development, improve production efficiency and technical level, promote the development of the automotive industry to a greener and smarter direction, and make the supply chain sustainable. With the intensive introduction of the state's support policies for the new energy industry, Great Wall Motor's new energy vehicle sales have been in a leading position. According to the development strategy of Great Wall Motor, the development of new energy vehicles, green innovation, to achieve low-carbon transformation and upgrading trend [10].

2.2. History and Evolution of supply chain

In the early 1990s, Ford Group adopted the way of assembly line and vertical integration approach to bring the individual parts of the car together, and integrated these plants together to break the production of the car into many steps. This supply chain is usually divided into four levels: raw material suppliers, parts manufacturers, vehicle manufacturers and dealers [11]. Each worker was responsible for one of these steps, this means that Ford relies heavily on internal manufacturing for its production process, rather than external sourcing. However, due to limited information exchange and insufficient supply chain management technology, Ford Motor may have difficulty in achieving efficient coordination and optimization in the supply chain. In 1929, Toyota adopted the just-in-time

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(JIT) production mode. Due to the scarcity of resources, Toyota was committed to achieving the goal of "zero inventory" and reducing inventory overstock and waste through accurate production planning and efficient logistics management. This concept requires suppliers to deliver parts to the production line in a timely and accurate manner when Toyota vehicles need them, while greatly improving the efficiency of the supply chain. Combining the JIT production mode with the requirements of logistics assembly management in the construction of large cruise ships in China, and from the actual situation of the production site, the group technology can be flexibly used to improve the assembly efficiency, shorten the distribution cycle and reduce the cost [12]. In addition, Toyota has established a long-term, stable and interdependent cooperative relationship with its suppliers. For core suppliers, Toyota adopts the way of shares, so that Toyota will enjoy priority treatment, saving time, and like the ordinary supply chain, it will find several more, so that they compete with each other to reduce prices.

In general, the supply chain model still needs to be improved according to the flow between production and demand. The main purpose of inventory models is to determine appropriate stock levels to meet customer demand while minimizing inventory costs, providing effectiveness, efficiency and improved allocation of available resources [13]. For example, the clothing store purchases clothes, it needs to take into account the inventory cycle, how long these clothes can be sold, the shorter the time, the lower the management costs, if the clothes can not be sold for a long time, the store will use discount promotion, arouse the interest of customers, so as to sell the clothes.

3. Environmental impact analysis of green supply chain

3.1. Impact of Automation on Supply Chain Efficiency

The third industrial revolution has accelerated the development of factory automation, and factories have begun to use machines to replace manual labor in some aspects, during unexpected circumstances, when automated systems are most likely to behave unreliably, an operator is still expected to act as a backup to detect failure events and act appropriately to avoid a system error [14] . For example, there is an error on the assembly line: faulty operation, equipment failure, and so on. This will reduce efficiency, but also bring some unnecessary losses.

With the continuous development of science and technology, in order to solve the problems that may occur in the assembly line, people think of using programmable logic controllers (PCLs)to solve them, and control each assembly line through programming to fully realize automation, PLCs are usually a main part of automatic systems in industry [15], so as to greatly improve the automation efficiency of the factory.

3.2. Technological Advances on Supply Chain Management

The next step is how to effectively manage the goods, pass the information flow from the consumer to the producer, and allow the manufacturer to prevent other problems such as overstocking. The Apple Computer Company has evolved into one of the most innovative technology-based firms in the last three decades [16] .Apple has built an efficient supply chain system, covering multiple processes such as design, purchasing, manufacturing, logistics and sales. The original management model was the same as Toyota, which found multiple suppliers to produce parts, but due to the rapid replacement of electronic products, long information transmission time and errors, which led to the bullwhip effect. In order to solve this problem, Apple began to adopt an Enterprise resource planning system (ERP), ERP system centrally manages all kinds of resources and information of enterprises, enterprises can track orders, inventory, transportation and other information in real time, and obtain the latest supply chain dynamics in time. Facilitate communication and collaboration between enterprises and suppliers. All interested parties can view real-time data and exchange information in the system, increasing the transparency of the supply chain. ERP systems can generate real-time

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monitoring reports, provide key data for each link of the supply chain, identify potential problems, and take appropriate measures. Suppliers can also be comprehensively evaluated and managed to record their performance to ensure supply chain compliance and reliability.

Due to the dynamism in the current borderless world market, companies are confronting new markets as well as new competition. Decision-making processes are requiring different time horizons and geographical dispersions [17] . Clothing enterprises need to respond quickly to market demand. The whole process of clothing from design to production to shelves needs a very short time. This speed enables brands to quickly capture market trends and meet the changing fashion needs of consumers. The first generation is represented by ZARA, H&M, etc., which combines fashion trends, price and timeliness to create a new era of fast fashion. The second generation is represented by ASOS, BOOHOO, etc., which further develops the characteristics of the first generation and uses the Internet to achieve DTC (Direct to Consumer). The third generation is represented by Shein, Temu, etc., which achieve the ultimate in delivery factors and subvert the competitive landscape through ultra-low prices and ultra-fast response speed. These clothing brands need very fast information transmission speed, and have higher requirements for ERP.

The progress in information and communication technologies (ICTs) has promoted the development of manufacturing greatly [18] . With the continuous development of technologies such as the Internet of Things, big data, cloud computing and artificial intelligence, digital twin technology will usher in new development opportunities. In the manufacturing industry, such as automobiles, sensors and other devices collect various data of physical entities, such as geometry, structure, materials, operating status, environmental parameters, etc., through simulation can achieve remote monitoring of equipment, fault prediction and optimization maintenance, improve production efficiency and product quality, while reducing operating costs.

4. Carbon Footprint and Sustainable Supply Chain Practices

While the globalization of production in complex, interconnected supply chains has brought employment and economic growth to many developing economies, particularly in Asia, it is also associated with exploitative employment relations, environmental irresponsibility and recurrent ethical dilemmas [19]. Low-carbon economy, as a new direction of global economic development in the 21st century, is gradually becoming the focus of governments, enterprises and all sectors of society. The core of low-carbon economy is to reduce the negative impact of economic activities on the environment by improving energy efficiency, optimizing the energy structure, promoting clean energy, etc., and realize the decoupling of economic growth and greenhouse gas emissions, so as to build a sustainable economic system. In fact, most current sustainable strategies are intrinsically associated with the intention of reducing our overall carbon footprint [20]. For the carbon dioxide generated by enterprises, big data and Internet of Things technology can be used to monitor and record energy consumption and emissions data in real time to achieve dynamic tracking and analysis of carbon emissions. This method has the characteristics of high efficiency and accuracy, and can provide real-time carbon emission data support for enterprises. Carbon emissions are calculated by analyzing the entire life cycle of a product or service from raw material collection, production, transportation, use to disposal. The basic method of product carbon footprint accounting is life cycle assessment (LCA), and the key is to establish carbon footprint background database [21]. This is a common way to assess the carbon footprint of a product and gives a comprehensive picture of the carbon emissions of a product at all stages. Taking the textile industry as an example, Zhejiang Province urgently needs to find ways to effectively control the carbon footprint of textile industry, promote the sustainable development of textile industry and effectively promote the construction of low-carbon society [22]. Through a detailed investigation of the carbon emissions generated by textile enterprises in each production link, and obtain the carbon emissions related data of upstream and

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downstream enterprises, the textile products are issued a "carbon label" certification. This not only helps companies understand the carbon footprint of their products, but also promotes energy conservation and green development throughout the supply chain.

Blockchain technology has the characteristics of decentralization, transparency, immutability and security. Blockchain technology ensures the credibility and integrity of data by recording the flow process of data, thus providing traceability and tracking of data [23]. By linking carbon footprint data, data integrity and authenticity verification can be achieved to ensure the credibility of data. The decentralized and immutable characteristics of blockchain make it difficult for data to be tampered with once on the chain, thus improving the accuracy and credibility of carbon footprint data. Carbon trading using blockchain technology can ensure the safety of each transaction [24].

At present, Life Cycle Assessment (LCA) is mainly used at home and abroad to carry out product carbon footprint assessment research, through the analysis of the entire life cycle of products [25]. The system relies on the self-developed shared storage LCA data base platform and adopts the whole life cycle evaluation method to conduct digital dynamic assessment of carbon emissions. And combined with blockchain technology to achieve upstream and downstream data collaboration and cross-chain sharing of the industrial chain. The system can be widely used in various production scenarios such as agriculture and industry, and provides strong support for the accurate measurement and management of carbon footprint.

5. Measures and challenges

In the global wave of sustainable supply chain management, promoting supply chain decarbonization has become an industry consensus and urgent need. In order to achieve this goal, it is necessary to take multi-dimensional comprehensive measures from technological innovation, policy system improvement, international cooperation strengthening and green environmental protection culture cultivation.

The development of efficient and environmentally friendly supply chain technologies, such as green packaging materials, low-carbon logistics solutions and intelligent management systems, can significantly improve supply chain efficiency and reduce resource consumption and carbon emissions. Enterprises should increase investment in research and development, explore the application of new technologies, such as through the Internet of things, big data and other technologies to optimize inventory management, transportation route planning, to achieve energy saving and emission reduction of the entire supply chain.

The government should introduce more targeted and operable policies related to supply chain carbon emissions, and clarify emission reduction targets, responsibility subjects, and reward and punishment mechanisms. Establish a unified product carbon footprint standard system to cover the whole life cycle of products and provide a quantitative basis for supply chain decarbonization.

Although carbon trading and carbon tax policies are relatively effective incentives for carbon emission reduction, how to formulate more effective policies to promote the development of low-carbon supply chain management is still an important issue facing the government. In addition, uncertain market factors in the process of policy implementation may also affect the effect of carbon reduction.

Currently, there is a lack of uniformity in the international carbon label measurement standard, leading to questions about the reliability of carbon emission information. At the same time, members of the low-carbon supply chain attach different importance to low-carbon, and the degree of carbon emission information sharing is not high, so it is difficult to establish an effective collaborative mechanism to promote the realization of carbon emission reduction objectives of the supply chain.

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6. Conclusion

Supply chains employ a variety of technologies to optimize the efficiency and effectiveness of their operations, including digitalization, artificial intelligence, connectivity and identification, real-time location and remote management, security, and green and circular. The application of these technologies will help improve the flexibility, resilience and sustainability of the supply chain, creating greater value for enterprises.

With the global emphasis on environmental protection and sustainable development, green supply chain will become an important trend of supply chain management in the future. At present, the implementation of green supply chain still faces many challenges, such as technical bottlenecks, cost problems, and the improvement of laws and regulations. However, with the continuous progress of science and technology and the continuous improvement of policies, these challenges will gradually be solved. Although green supply chain has many advantages, it also faces many limitations in the implementation process. In order to overcome these limitations, governments, enterprises and consumers need to work together, strengthen cooperation and communication, and promote the continuous improvement and development of green supply chain management.

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