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A Review on the Incentive Mechanism for Green Innovation in Supply Chain

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Abstract: As economic development has shifted from high-speed development to high-quality development stage, environmental green development is closely related to the future of mankind, and the call of society to solve environmental problems and vigorously develop green economy is getting higher and higher. By combing and analyzing the current research progress on the incentive mechanism of green innovation in the supply chain, it is found that the current research direction mainly focuses on product pricing, strategy selection and performance evaluation in the green supply chain, and most of the research methods adopt game theory, but there are still diverse mathematical modeling details and specific research perspectives. On this basis, the research direction of supply chain green innovation incentive mechanism can be further expanded and extended.

Keywords: Green supply chain; Green innovation; Incentives; Government subsidies.

1. Introduction

Under the background of global economic integration and environmental globalization, modern enterprises pay more and more attention to the concept of green supply chain management with coordinated development of economy and environment. Supply chain as an important link to integrate and optimize resources, it is urgent to integrate green environmental protection into supply chain management.The government has introduced policies to promote the development of green supply chains, and has successively proposed carbon neutrality targets.In February 2021, The State Council issued the Guiding Opinions on Accelerating the Establishment and Improvement of the Green, Low-carbon and Circular Development Economic System, proposing to improve the circulation system of green, low-carbon and circular development and build green logistics [1]. In January 2022, the "14th Five-Year Plan for the Development of Modern Comprehensive Transportation System" made it clear that green and low-carbon transformation should be comprehensively promoted, efficient freight service systems should be built, and logistics costs should be continuously reduced [2].

The government has continuously introduced policies to not only strengthen the environmental education of people, but also make consumers more and more actively pay attention to the environmental properties of products, and this green preference is gradually and steadily increasing. As the key driving force to promote green consumption, green consumers are the backbone to ensure the sustainable development of green consumption. Only by fully understanding the purchasing preferences and behavioral factors of green consumers can we scientifically predict the preferences of consumers, thus providing important support for the long-term stable development of enterprises and the sustainable development of the environment.

Under the dual driving role of government regulations and consumer green demand, modern enterprises must pay attention to improving the environmental properties of products, and the supply chain will introduce more green products to the market. Many domestic and foreign scholars have studied the green innovation of supply chain from various perspectives. This paper mainly summarizes the green supply chain and the incentive mechanism of green innovation.

2. Reviews

2.1. Green supply chain management

Green supply chain management, also known as environmentally conscious supply chain management, comes from the idea of supply chain management and sustainable development. In 1994, Webb studied the impact of some products on the environment, suggested that appropriate raw materials should be selected through environmental criteria, and at the same time paid attention to recycling, and put forward the concept of green procurement [3]. The US National Science Foundation (NSF) funded 400,000 US dollars to conduct an "Environmentally responsible Manufacturing (ERM)" study at the Manufacturing Research Association (MRC) of Michigan State University, which proposed the concept of green supply chain in 1996 and took green supply chain as an important research content [4]. Islam (2017) divides green supply chain practices into reverse logistics, industrial symbiosis, green information technology and systems (GITS), green design, carbon management, supplier environmental collaboration, customer environmental collaboration, ISO14001 certification, internal management support, green procurement, green manufacturing, green packaging, green logistics, green outsourcing, and green warehousing [5] . Although scholars have different emphasis on understanding the meaning of green supply chain, they generally agree that green supply chain can improve enterprise performance and is an important means to improve the environment.

2.1.1. Green supply chain product pricing

The pricing of green products in the supply chain is one of the important decisions in the supply chain, which is involved in most of the literature on green supply chain innovation. Feng Yan and Li Xiaoshen (2023) took the manufacturer-led green supply chain consisting of one manufacturer and one retailer as the research object, constructed three supply chain models of manufacturer's equity concern, retailer's equity concern and supply chain member's equity concern based on

the reference price of consumers, and proposed the optimal pricing strategy under each model. It also analyzes the influence of the fairness concern coefficient and the reference price effect of consumers on the optimal strategy, and finds that the fairness concern coefficient and the reference price effect of consumers change the wholesale price, greenness level and retail price of products, and have an impact on each member of the supply chain and the whole supply chain system [6]. Sang Shengju and Zhang Qiang (2020) considered the optimal pricing strategy and optimal product greenness in the second-level green supply chain under the condition of uncertain production cost and market demand, and pointed out that taking into account the uncertainty of market environment can improve the income level of manufacturers and retailers [7]. Yang Haoxiong et al. (2022) built a two-level dual-channel green supply chain game model of "online sales of manufacturers - offline sales of retailers" based on two different strategies of R&D subsidies and price subsidies, and considered fairness concerns, to explore the effects of different subsidy levels and fairness concerns on product greeneness, optimal pricing and profit [8]. Jin Jiyao et al. (2020) assumed that consumers have a preference for environmental innovation. By establishing and comparing three models: no subsidies, subsidies for local production enterprises and subsidies for FDI production enterprises, they found that the impact of government subsidies on performance is not significantly different among different types of investors, and all of them increase the market demand for products [9]. Ling Yantao et al. (2021) found that consumers' willingness to pay green is the key to corporate profits, and there is no green product market when consumers' willingness is low [10]. Wang Wei et al. (2022) considered the choice of green supply chain strategy in the case of multiple manufacturers and found that the cost recovery coefficient and the increase of green input had a certain negative impact on the supply chain [11]. The results of Cao Yu et al. (2022) show that in terms of environmental label selection, manufacturers are more willing to self-label to achieve the highest profits, but retailers can gain more profits by using certified labels [12]. Jamali and Rasti-Barzoki (2018) studied the dual-channel green supply chain and the pricing of two alternative products, green products and non-green products [13]. Wang and Song (2020) [14] studied the pricing decision problem of dual-channel green supply chain with green R&D investment and sales effort under uncertain demand. Gao Xiaohong et al. (2015) [15] studied the impact of retailers' sales effort behavior on pricing decision and performance in the retailer-dominated supply chain. Jadidi et al. (2017) [16] studied the pricing problem when full-unit quantity discount scheme was adopted in the fast fashion supply chain. It was found that volume discounting can benefit suppliers and retailers by increasing their total profit, and in addition, end consumers can also benefit from the strategy. Shen et al. (2017) [17] studied the impact of brand value on the pricing decision of co-branded products of fast fashion enterprises, analyzed the impact of profit-sharing contract and fixed patent fee contract on brand performance, and pointed out that fast fashion brands should form alliances with well-known luxury fashion brands. Adhikari and Bisi (2020) [18] put forward a new cooperation mechanism of green clothing supply chain using green cost sharing contract and revenue sharing contract, and studied the influence of fair concern behavior of supply chain members on greenness and pricing decisions. Xiong Feng et al. (2022) focused on the influence of risk preference of supply chain members on dual-channel green supply chain, and based on the construction of a two-tier supply chain model dominated by suppliers, studied the influence of risk avoidance coefficient among members on product greenness, online and offline sales price [19].

2.1.2. Green supply chain strategy research

As for the game players in the green supply chain, such as enterprises, governments, consumers, etc., the strategy models made by them are also research hotspots. In the green supply chain composed of manufacturers and retailers, Han Mengyuan et al. (2022) built a product quality-retail price-service level decision model with optimal benefit based on game theory, and found that price competition between green products and alternative products is conducive to the improvement of service level [20]. Meng et al. (2020) took consumer groups' environmental preferences and changes in consumption levels into consideration, analyzed the impact of government subsidies on the price decisions of green supply chain members under four different circumstances, and concluded that subsidies to producers can effectively reduce the wholesale and retail prices of green commodities. Government subsidies to retailers will increase the wholesale price of green goods, while subsidies to green consumers will increase the wholesale price and retail price of green goods [21].Choi (2013) proposed a two-stage fast fashion supplier selection strategy [30]. Guo et al. (2020) consider the influence of the greenness level of fashion products on the supply chain decision-making, and study the product pricing strategy of multiple fashion retailers under the two conditions of greenness level competition and price and greenness level joint competition [31]. Shi et al. (2021) incorporated the feature of product fashion decreasing over time into the model, and studied the optimal pricing and production strategy under the condition of pre-sale period and regular sale period [32]. He Ju et al. (2021) studied the optimal order of fast fashion supply chain in the context of new retail and found that the faster the update frequency of goods, the higher the order quantity and the lower the selling price [33].

2.1.3. Green supply chain performance evaluation

Zhu and Sarkis (2006) took 186 Chinese manufacturing enterprises that have implemented green supply chain management as investigation subjects, and evaluated the relationship between green supply chain management practice and performance by using hierarchical regression analysis. Then, they focused on the driving factors of green supply chain management in three typical industries in China, namely automobile industry, thermal power plant and electronics. It is believed that WTO accession is conducive to promoting green supply chain management practices in manufacturing industries in China and other developing countries [34]. Wang Yongfu and Mu Jun (2022) combined the characteristics of green supply chain strategic alliance for forest products, and built a performance evaluation index system for green supply chain strategic alliance for forest products, including four dimensions, including financial status, customer service, internal process and green environmental protection level. They adopted analytic hierarchy process and fuzzy comprehensive evaluation methods to conduct empirical analysis on the performance of green supply chain strategic alliance for forest products. Provide reference basis for the construction and optimization of forest products green supply chain strategic alliance [35]. Afum et al. (2020) took manufacturing smes in Ghana as a sample and pointed out that green supply chain integration

has a significant positive impact on the sustainable performance of manufacturing smes in Ghana [36].Liu Haijian et al. (2023) regarded the pilot work of supply chain innovation and application as a quasi-natural experiment, took the data of listed companies from 2012 to 2020 as research samples, investigated the impact of supply chain digitalization on enterprise green innovation, and found that the green innovation effect of supply chain digitalization mainly existed in state-owned enterprises, both ends of the industrial chain, and areas with low marketization degree. Mechanism test shows that supply chain digitalization improves the level of green innovation of enterprises by promoting green supply chain integration and strengthening the effectiveness of external governance [37].

2.2. Green innovation incentive mechanism

The research on greeninnovation originated in the 1990s. Porter and vanderLinde (1995) first proposed greeninnovation, believing that greeninnovation is a kind of product design and means to improve environmental problems carried out by enterprises under environmental regulations [38]. Barbierietal. (2020) further points out that green innovation refers to the innovation that avoids and reduces the negative impact of enterprises on the environment by updating or improving products, technologies, processes and systems [39].

2.2.1. Incentive mechanism within the supply chain

As more and more enterprises realize that green innovation and production of green products can improve benefits and profits, occupy market advantages, establish an environmental image, and win the favor of consumers, more and more enterprises in the supply chain begin to carry out green innovation independently, and research on the green incentive mechanism within the chain begins to appear.

The incentive mechanism of green innovation in supply chain is an important means to promote green innovation and share innovation cost and risk. Sun Jianhui and Zhang Haibo (2020) considered the impact of the green reputation of the supply chain on the overall revenue, studied the collaborative innovation cooperation of the green supply chain consisting of a single core enterprise and a single supporting enterprise, and investigated the decision-making situation of each enterprise in the supply chain under different supply chain contracts. The effectiveness of collaborative innovation cooperation between core enterprises and supporting enterprises of green supply chain is verified from the theoretical level [40]. Wang Yingtong (2020), taking into account the heterogeneity of consumers and starting from the practical background of existing green innovation subsidy methods, analyzed the impact of different green innovation subsidy modes, the proportion of green consumers and consumers' environmental protection preferences on supply chain decision-making, and then discussed their impact on environmental benefits, economic benefits and social welfare. The equilibrium values obtained under different circumstances are compared and analyzed, and it is concluded that under certain circumstances, the intervention of the core enterprises of the supply chain in green innovation will be conducive to the improvement of social welfare and the reduction of retail prices [41].Yu Lijing et al. (2019) built an evolutionary game model of cooperative innovation between manufacturing enterprises and logistics enterprises from two perspectives of market mechanism and government regulation based on collaborative innovation theory and evolutionary game theory, and analyzed the stability of enterprise strategy selection. It is found that under the market mechanism, the alliance can reach a stable state of collaborative innovation only when the enterprise's collaborative innovation income is higher than the sum of "free rider" income and input, and the benefit distribution ratio, input cost coefficient and knowledge transfer efficiency all have an impact on the enterprise's strategy choice [42].

2.2.2. Incentive mechanism out the supply chain

Although most enterprises have self-driven innovation behavior within the chain, only a small number of enterprises have real production and innovation ability to achieve green innovation. Most enterprises are limited by their own conditions and high attribute requirements of green products, as well as the competitive market environment, so enterprises cannot achieve sustainable development on their own. Sometimes it is also necessary to rely on the power of the off-chain government to achieve win-win development, so the government has issued a series of incentive subsidy policies, subsidies are the most commonly used means for the government to encourage enterprises to innovate green. The literature research on this aspect is also relatively abundant. Wang Xu, Yang Youde and Wang LAN (2020) concluded that information disclosure may prompt the government to subsidize an enterprise. Among them, the higher the degree of information disclosure, the more green innovation subsidies an enterprise will receive. Its green innovation performance shows a linear upward trend under a certain amount of subsidies, and then gradually becomes smooth [43]. Ellie Hou (2018) studied the inherent complexity and coordination of the green supply chain under the government's green innovation subsidies by constructing a multi-phase dynamic game model for enterprises. Her research results showed that an appropriate stepped policy level would encourage enterprises to invest in energy conservation, while manufacturers could not be encouraged to increase investment in green innovation when the subsidy standard was too strict. In addition, government subsidies for companies to recycle waste can increase manufacturers' profits and stimulate an increase in the proportion of companies that recycle waste. The range of stability of this complex system will vary. With the increase of subsidies gradually decreased [44]. Li et al. (2018) considered three government financial subsidy strategies and studied the influence of various subsidy strategies on enterprise decision-making under the same subsidy object [45]. ManmanW et al. (2019) studied how to design the best subsidy scheme for regulators pursuing the maximization of social welfare, so as to stimulate enterprises' technological innovation while considering consumers' green preferences. Three models were discussed, namely, non-innovation by design enterprises, internal independent innovation and external imported innovation. Finally, the optimal selection strategy of enterprises, consumers and government is obtained [46]. Zhao (2020) et al. [47] constructed a profit distribution model of closed-loop supply chain members without financial subsidies and with different government subsidy objects, and compared and analyzed the optimal pricing and profit of closed-loop supply chain under different subsidy objects.To sum up, it is not difficult to see that in the existing green supply chain, the government has a decisive influence on its construction, and subsidies for different entities can bring certain promotion. Therefore, it is of great practical significance to consider government subsidy policy in the

study of green supply chain.

3. Summary

By summarizing the definitions of green innovation by scholars, it can be found that although various scholars have different descriptions of green innovation, the overall views of scholars on green innovation are the same. One is to improve the operating efficiency of enterprises, and improve the efficiency by innovating the process of product design, manufacturing, logistics, sales, recycling and reuse. Another purpose is to protect the environment while minimizing the loss of resources, improve the utilization rate of resources to reduce carbon emissions, minimize the damage caused by products to the ecological environment through ecological green design, and maximize the benefits of enterprises.

Green supply chain management can indeed bring about green innovation, and the relationship between green innovation and green supply chain should be considered from the perspective of system. The concept of green innovation in green supply chain should be accepted by all stakeholders in the supply chain. At present, the concept of green development is in its infancy, and many "green" products rely on energy saving and emission reduction of terminals. The purpose of green innovation is to solve the negative environmental effects from the source to the terminal. Green innovation in the green supply chain should seek green innovation at every node, so as to reduce the negative environmental effects and improve the overall competitive advantage and green performance of the green supply chain.Green supply chain management has achieved rich research results. More and more enterprises begin to incorporate environmental factors into supply chain operation management to achieve a win-win situation of economic and environmental benefits. In recent years, the research on green supply chain and its management is still evolving. This paper reviews the existing literature on green supply chain management and green innovation, and classifies them. It is found that there are specific research details such as green supply chain management strategy and empirical research. The vast majority of literatures related to quantitative research adopt the research methods of game theory, but the mathematical models show a diversified trend. However, the game subject of specific modeling is still the manufacturer and retailer as the main consideration, and there are few logistics providers as the main decision makers of green innovation in green supply chain. In the current era of independent green innovation of logistics providers, where Jingdong's "green Flow Plan" and SF Express's "box partner plan" prevail, it is also feasible to consider whether logistics providers need green innovation and what impact green innovation can bring to their own interests.

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