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Research on Green Logistics Based on Supply Chain Management

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Abstract: This study systematically analyzes the development status of green logistics, and points out that there are outstanding problems in resource utilization, environmental protection, cost benefit and concept technology in the current logistics indu stry. Based on the theory of supply chain management, this paper puts forward three core cou ntermeasures: one is to construct green supply chain, which realizes efficient coordination of logistics links and reduces resource waste and pollution by optimizing supplier selection, strengthening green supervision and establishing coordination mechanis m; The second is to promote green logistics technologies, including clean energy vehicles, intelligent route planning, degradable packaging and digital management systems, to improve operational efficiency and reduce environmental impact. The third is to strengthen the dissemination of green concepts, through the construction of green culture and green consumption guidance for consumers, to jointly promote green logistics practices from both sides of supply and demand. Future research can be further deepene d in terms of quantitative cost-benefit analysis, case coverage expansion, and cutting-edge technology tracking.

Keywords: Green Logistics; Supply Chain Management; Sustainable Development; Green Transportation; Green Packaging.

1. Introduction

1.1. Background

With the rapid development of global economy and prosperity of e-commerce, logistics industry, as one of the pillars of modern economy, shows strong growth trend. Express business volume continues to rise, freight turnover scale continues to expand, logistics system is increasingly perfect, which strongly promotes economic growth and social operation. These challenges not only threaten ecological security, but also restrict the long-term sustainability of the logistics industry, becoming a real dilemma that needs to be solved urgently. Against this background, the concept of green logistics emerges and gradually becomes the core direction of industry transformation. It emphasizes implementing environmental protection concepts in all aspects of logistics, realizing resource conservation and environmental friendliness, covering green transportation, warehousing, packaging and distribution. Among them, green transportation focuses on the adoption of clean energy vehicles, optimization of route design and implementation of common distribution; green storage focuses on energy-saving buildings, intelligent lighting and temperature control systems; green packaging is committed to source reduction, biodegradable material substitution and recycling system construction; green distribution focuses on low-carbon and intensive management of terminal links. Especially in China, with the in-depth implementation of sustainable development strategy, the clear proposal of "double carbon" goal and the continuous promotion of ecological civilization construction, green logistics has become the only way to promote the upgrading of the industry. Policies at all levels have been issued intensively, enterprises are actively seeking green transformation, and green logistics is moving from theory to practice, gradually leading the industry to high-quality development.

This paper aims to systematically sort out the background and core concept of green logistics development, analyze the challenges and opportunities currently faced, explore the key path and countermeasures to promote the transformation of green logistics, in order to provide theoretical and practical reference for the sustainable development of logistics industry. The fourth part puts forward countermeasures and suggestions to promote the development of green logistics; the fifth part summarizes the full text and looks forward to the future development direction.

1.2. Research Objectives

By using the theories and methods of logistics and supply chain management, this paper systematically analyzes the problems existing in the process of green logistics development, and puts forward targeted solutions to promote the sustainable development of logistics industry. Specifically, this study will discuss the key issues of green logistics development from the perspectives of resources and environment, cost and benefit, concept and technology, and put forward strategies such as building green supply chain, promoting green logistics technology and strengthening green concept propaganda. Through the above research, this study expects to provide practical guidance for logistics enterprises, and at the same time provide reference basis for the government to formulate relevant policies, and finally realize the extensive application and in-depth development of green logistics in logistics industry.

2. Literature Review

2.1. Theoretical Basis of Green Logistics

Green logistics focuses on reducing pollution and resource consumption. The concept and connotation of green logistics have been widely discussed in academic circles. Domestic scholars have formed different definitions from multiple perspectives. Yin Yanbo (2015) constructed the framework of green logistics system in Modern Logistics Management, decomposed it into green transportation, warehousing, loading and unloading, packaging and circulation processing modules, and clarified the meaning of each part. This division

has been generally recognized because of its strong systematicness. With the deepening of research, more scholars from different angles to further explore the inherent attributes and practical value of green logistics. Wang Guowen (2010) advocated integrating environmental protection concepts into the whole process of supply chain, emphasizing the promotion of overall efficiency and sustainability through upstream and downstream collaboration. Liu Zhijun et al. (2023) believed that the key to green logistics lies in green management and control of transportation links, technological innovation and implementation of energy conservation and emission reduction responsibilities. Tong Pengcheng (2023) regards green logistics as a composite category covering transportation activities, social low-carbon supervision and integrated management. On this basis, Liu Xinyi (2023) proposes that the fundamental goal of green logistics is to promote the unity of economic benefits and social and environmental benefits. The above theories jointly lay the scientific foundation for green logistics and provide direction for practical promotion.

2.2. Research on the Relationship between Supply Chain Management and Green Logistics

As an integrated model, supply chain management plays a key role in promoting the development of green logistics. Li Weifeng (2025) pointed out that supply chain management helps to improve environmental performance in the logistics process, thus promoting the achievement of green logistics objectives. Specifically, by optimizing resource allocation in each link and strengthening synergy between upstream and downstream enterprises, it can reduce energy consumption and emissions while improving the overall efficiency of logistics operations. Green logistics is not only reflected in the operational level, but also involves the strategic level of system planning. To build a green supply chain, sustainable concepts need to run through all links such as product design, raw material procurement, production and manufacturing, warehousing and transportation, packaging and distribution, and reverse logistics, forming a green closed loop covering the whole life cycle. This means that enterprises should not only promote their own green transformation, but also guide the upstream and downstream of the supply chain to participate in it together to create a green ecosystem for coordinated development. In this process, enterprises should strive for the dual unity of economic and environmental benefits, not only through green measures to reduce operating costs, prevent environmental risks, but also rely on green brand image to enhance market competitiveness and public recognition.

2.3. Research on the Present Situation and Problems of Green Logistics Development

In recent years, although green logistics has made significant progress in the world, its development still faces many challenges. Existing empirical studies reveal the status quo and challenges of green transformation in China's logistics industry from multiple dimensions. Based on typical case analysis, Wang Pengfei and Xing Wenjie (2022) point out that the pain points of current transformation mainly focus on the lagging environmental awareness of practitioners, insufficient professional talent reserves, lack of high-end equipment and imperfect policy support system, and propose corresponding countermeasures accordingly. Focusing on specific industries, Xu Ke et al. (2024) took tobacco logistics as the research object and constructed the performance evaluation system by using entropy weight method and factor analysis method. It was found that although the overall green level of the industry was at a high level, there were obvious shortcomings in the storage link and management mode. Therefore, it was proposed that the penetration and application of energy-saving and environmental protection technologies should be accelerated to drive the industry to advance to intelligence and specialization. In addition, Gong Shuanglei and Hu Shengqiang (2024) empirically tested the heterogeneous impact of environmental regulation and green technology innovation on sustainable development using data from A-share listed enterprises. The results show that the latter has a significant positive effect on shaping the green image of logistics enterprises. Existing research has gradually shifted from early conceptual theory to practical application and problem analysis, but there are still obvious deficiencies: The research on green logistics technology innovation, clean energy vehicles, degradable packaging and other green logistics technology innovation is less, and the discussion on policy incentives is also limited, which is difficult to support the actual application demand. Therefore, it is necessary to further analyze the development problems of green logistics in the future and propose more targeted solutions.

3. Analysis of Green Logistics Development

3.1. Resources and Environment

3.1.1. Waste of Resources

Xiao Huiying and Fei Kefan (2020) pointed out that the rapid development of e-commerce has led to a sharp increase in the consumption of non-degradable packaging materials, and the design of redundant packaging in some enterprises has further aggravated resource consumption; in the transportation link, due to asymmetric supply chain information and unreasonable planning, the phenomenon of vehicle return empty is common, which not only increases fuel consumption, but also reduces transportation efficiency. Ren Li (2023) proposed green innovation that can integrate goods through information platform, promote common distribution, promote multimodal transport and shared logistics, reduce empty driving and energy consumption, and realize resource utilization.

3.1.2. Environmental Pollution Manifestation

The impact of logistics activities on the environment is concentrated in two aspects: carbon emissions and waste. In the transportation link, the widespread use of fuel vehicles brings a large amount of greenhouse gas emissions, of which carbon dioxide emissions continue to grow, posing significant pressure on the global climate. Research shows that the transportation process accounts for the vast majority of the total carbon emissions of the logistics industry, and this proportion is difficult to effectively reduce under the traditional mode. At the same time, logistics operations will also produce a large number of wastes, such as packaging materials and waste equipment. If improperly disposed, these wastes will cause serious pollution to soil, water and the atmosphere. Take disposable plastic packaging as an example, its degradation cycle is long, ecological harm is great, and it has become one of the important sources of environmental pollution. Therefore, how to reduce carbon emissions and

reduce wastes by means of green logistics has become an environmental issue that needs to be solved urgently.

3.2. Cost and Benefit Question

3.2.1. Cost Composition of Green Logistics

In the actual process of promoting green logistics, enterprises are faced with multiple cost constraints, mainly reflected in green technology R & D and application, environmental protection facilities procurement and supporting management system construction. Although the introduction of green technology is an important prerequisite for achieving low-carbon transformation, its high R & D investment often discourages SMEs. At the same time, capital investment in environmental protection equipment is also an important part of green logistics costs. In order to achieve packaging lightweight or waste recycling, enterprises need to introduce specialized equipment and technical support, which further increases operating expenses. In addition, building a complete green supply chain management system also requires a lot of manpower and material resources, covering employee skills training, environmental data monitoring and other hidden expenses. The superposition effect of all kinds of costs makes enterprises face heavy capital pressure when implementing green logistics strategy.

3.2.2. Cost Versus Benefit Contradiction

Although the long-term benefits of green logistics are obvious, in the short term, enterprises often face prominent contradictions between costs and benefits. Specifically, green logistics requires a high degree of synergy among all links in the supply chain. However, due to factors such as complex environmental certification processes and high procurement costs of green materials, the stability of the supply chain is affected, and cost fluctuations are also aggravated, further increasing the uncertainty of operating costs. At the same time, consumers generally have high price sensitivity to green products and services, and are unwilling to bear additional expenses only for environmental protection attributes, which weakens the market competitiveness of enterprises to a certain extent. Therefore, how to effectively balance cost pressure and long-term sustainable development benefits in the short term has become a key challenge for enterprises to promote green logistics.

3.3. Conceptual and Technical Problems

3.3.1. Insufficient Recognition of Green Concepts

At present, logistics enterprises and consumers still have a low awareness of the concept of green logistics, which restricts the promotion and development of green logistics to a certain extent. Many enterprises still regard green logistics simply as an additional social responsibility burden, rather than a key path to build core competitive advantages. This deviation directly leads to obvious passivity and lack of innovation motivation in daily operations. At the same time, consumers 'awareness of green logistics is also obviously insufficient. Although environmental awareness has increased in recent years, most consumers still pay more attention to price and timeliness when choosing logistics services, while paying less attention to green attributes. This cognitive bias leads to insufficient demand in the green logistics market, which further affects the enthusiasm of enterprises. Strengthening the publicity and popularization of green concepts and improving the cognitive level of all parties are important prerequisites for promoting the green transformation of the logistics industry.

3.3.2. Green Technology Development Lags Behind

There is a significant gap between the technological development of green logistics and the actual demand. Technical bottlenecks are increasingly becoming a key factor restricting the development of the industry. In terms of clean energy, the application of electric vehicles and hydrogen vehicles in logistics transportation is still immature. Limited by endurance, supporting infrastructure and high use costs, it is still difficult to achieve large-scale promotion. At the same time, intelligent logistics technologies such as Internet of Things, big data and artificial intelligence are still in the initial stage of application, and enterprises have obviously insufficient reserves in related technologies and talents, which makes it difficult to support efficient green management. In addition, the R & D progress of green packaging technology is relatively slow, the cost of degradable materials and recycling technologies is still high, and there are still many problems in the stability of materials and market acceptance. Therefore, accelerating the R & D and innovation of green logistics technology and striving to break through the bottleneck of core technologies have become the key to promoting the sustainable development of the logistics industry.

3.4. Lack of Technological Innovation

At present, the development of green logistics is generally faced with the outstanding problem of lagging technological innovation. Zhao Yinghui et al.(2023) pointed out that technological innovation is the core path to solve the environmental dilemma of logistics industry. Through continuous optimization and continuous improvement of applicability of technical solutions, it can effectively balance the improvement of logistics efficiency and environmental benefits. However, at present, the R & D investment of enterprises is generally low, the independent innovation ability is weak, and core technologies such as clean energy, intelligent scheduling, degradable materials and carbon footprint monitoring still mainly rely on external introduction. In addition, innovation activities are mostly concentrated in a single link, with insufficient coordination with the supply chain as a whole, and the integration of production, learning and research is not close enough. The conversion rate of achievements is relatively low. The integration depth of digital and intelligent technologies with green logistics is limited, and the endogenous power for continuous iterative upgrading has not yet been formed.

4. Green Logistics Strategy Based on Supply Chain Management

4.1. Green Supply Chain Construction

4.1.1. Supplier Selection and Management

The construction of green supply chain should start with supplier selection and management to ensure the green level of the whole supply chain. Enterprises should give priority to suppliers with environmental awareness and sustainable production methods, and regard them as long-term partners, focusing on evaluating their performance in renewable resource use, energy conservation and emission reduction effectiveness, and ISO14001 environmental management system certification. At the same time, it is necessary to establish a transparent supplier green monitoring mechanism to promote suppliers to continuously improve their environmental protection level by regularly reviewing their

environmental performance. This will not only help promote the green development of the supply chain, but also bring good social reputation and economic benefits to the enterprise.

4.1.2. Supply Chain Synergy Mechanism

Supply chain collaboration and integration is the key to achieving efficient operation and sustainable development of green supply chains. Information sharing and joint decision-making, as the core content of collaboration, can effectively reduce resource waste and improve logistics efficiency. By building a unified information platform, enterprises can grasp the data of transportation, warehousing, distribution and other links in real time, thus optimizing resource allocation and reducing energy consumption. Upstream and downstream enterprises jointly formulate transportation plans, which can effectively avoid empty vehicles and reduce carbon emissions. Zhang Bowei and Ma Fanhui (2024) pointed out that it is difficult for upstream and downstream entities of the supply chain to achieve accurate supply-demand coordination due to factors such as opaque information and poor connection mechanism. Based on this, they believe that only by effectively coordinating the interests of all parties and eliminating coordination obstacles can the long-term stable operation of the green supply chain be guaranteed.

4.2. Application of Green Logistics Technology

4.2.1. Green Transportation Technology

Green transportation technology is the core of driving the green transformation of logistics industry. Zhang Linqiang (2024) pointed out that some leading third-party logistics enterprises are actively introducing cutting-edge technologies such as new energy transportation vehicles and intelligent route planning to further reduce energy consumption and alleviate environmental pollution. On this basis, with the help of advanced route planning algorithms, logistics enterprises can accurately calculate the optimal distribution route, greatly reduce the empty rate and mileage redundancy, and thus reduce fuel consumption and carbon emission intensity. At the same time, vigorously promote clean energy vehicles such as electric trucks and hybrid vehicles, which can significantly reduce the industry's dependence on fossil fuels, effectively reduce total exhaust emissions, and help improve regional air quality. The application of green transportation technology can not only help enterprises reduce logistics operation costs, but also shape a good green development image, thus further enhancing the market competitiveness and industry influence of enterprises.

4.2.2. Green Packaging Technology

Yu Guang (2021) pointed out that with the development of logistics industry and the improvement of ecological environmental awareness, green packaging issues in logistics enterprises have received more and more attention. Therefore, degradable materials and packaging reduction are the two main directions of green packaging technology. For example, packaging made of bio-based materials or recyclable materials can reduce dependence on non-renewable resources and reduce waste generation. It can also reduce the use of unnecessary packaging materials by optimizing packaging design, which can also effectively reduce logistics costs and improve resource utilization efficiency. The development of intelligent packaging recycling systems has further promoted the popularization of green packaging technology. For example, by placing electronic packaging on packaging Tags can improve packaging recycling efficiency and help companies better track and manage reverse logistics, thereby achieving the goal of circular economy.

4.2.3. Green Logistics Technology Innovation

It is necessary to strengthen the independent innovation of green logistics core technologies, focus on breaking through key technologies such as clean energy vehicles, intelligent path optimization, degradable packaging, circular sharing system, carbon footprint accounting, etc. and form independent intellectual property rights; promote enterprises, universities and scientific research institutes to establish a collaborative innovation mechanism for production, learning and research, establish an integrated achievement transformation system for demand docking, pilot test, demonstration and promotion, and improve the efficiency of technology implementation; In addition, Chang Peipei et al.(2025) advocated that enterprises should rely on digital technology to build an intelligent management system covering the whole process of logistics, and realize double reduction of operation cost and environmental burden through efficient scheduling; At the same time, it is suggested to further improve the innovation guarantee mechanism by establishing innovation fund, implementing preferential tax policy and strengthening compound talent cultivation, so as to provide stable support for the continuous iteration of green logistics technology.

4.3. Green Concept Promotion

4.3.1. Enterprise Green Culture Construction

In modern enterprise management, establishing green logistics concept is the logical starting point of promoting sustainable development. Its essence lies in requiring enterprises to implement environmental protection principles in the whole process of production and operation, which constitutes the primary link of implementing green logistics strategy. Therefore, logistics enterprises should regard green culture construction as the cornerstone of concept landing, and gradually shape a value system with sustainable development as the core through systematic strengthening of environmental awareness training for employees. Specifically, enterprises can adopt diversified measures, such as carrying out environmental protection theme practice activities on a regular basis, or incorporating green indicators into performance appraisal, so as to effectively deepen employees 'recognition and execution of green concepts. At the same time, enterprises also need to formulate clear green development strategic plans, deeply embed green logistics practices into daily operation management, guide all departments to work together, balance demands of all parties, and jointly point to green goals. Ultimately, this highly environmentally conscious corporate culture not only significantly enhances internal cohesion, but also substantially enhances corporate social responsibility and public brand image.

4.3.2. Consumer Green Guide

The green consumption concept of consumers is the key driving force for the high-quality development of green logistics industry. Enterprises can guide consumers to establish green consumption awareness through diversified publicity and education activities, and lay a solid social foundation for the large-scale promotion of green logistics. For example, popularizing the ecological value of green logistics through social media, public service advertisements and other communication channels can significantly enhance consumers 'recognition and support for environmentally friendly logistics services. At the same time, logistics

enterprises can also take the initiative to add green logistics service options, such as providing recyclable packaging materials, launching low-carbon transportation solutions, etc., to further stimulate consumers 'enthusiasm for green logistics. Therefore, strengthening consumer green consumption education is an important measure to promote the green transformation of the logistics industry.

4.4. Policy Support and Regulatory System

4.4.1. Fiscal and Tax Incentives

In terms of fiscal and tax incentive policies, there has been in-depth research on government subsidy strategies for green logistics. Yi et al.(2021) discussed the subsidy effect for green transportation, Sun and Li (2021) analyzed the subsidy mechanism for green packaging and its impact, and Wang et al.(2018) examined the subsidy effect on logistics infrastructure construction. On this basis, it is recommended to further improve the fiscal and tax incentive system for green logistics: For enterprises that implement green logistics and meet the standards of energy conservation and emission reduction, VAT and enterprise income tax shall be reduced or deferred; at the same time, tax deduction shall be implemented for relevant links such as the use of clean energy and degradable packaging materials, so as to effectively improve the income expectation of green investment of enterprises and reduce their short-term cost pressure. In addition, banks, insurance and other financial institutions should be actively guided to develop diversified financial products such as green credit, green bonds and green insurance, give priority to supporting the construction of green supply chain-related projects, broaden financing channels for enterprises, help alleviate their long-term capital pressure in the process of green transformation, and form a coordinated power pattern of financial guidance and financial support.

4.4.2. Industry Standards and Specifications

In terms of the construction of industry standards and norms system, it is necessary to speed up the formulation and comprehensive implementation of national standards and industry norms covering green transportation, storage, packaging, distribution and other links, clarify specific quantitative indicators such as carbon emission intensity, waste recovery rate, packaging reduction ratio, proportion of new energy vehicles, etc., so as to provide clear measurement basis and operation guidance for green development of the industry. At the same time, we should establish an authoritative and unified green logistics enterprise certification and green supply chain certification system, and grant official certification marks to enterprises meeting the standards, so as to encourage them to actively practice green concepts and enhance market competitiveness and brand value. In addition, it is necessary to improve the statistical monitoring system for data such as energy consumption, carbon emissions, packaging waste generation and disposal in the logistics industry, promote standardized data collection, aggregation and analysis, provide solid and reliable data support for scientific formulation, accurate implementation and effect evaluation of relevant policies, and form a virtuous cycle mechanism of "standard leading-certification incentive-data driving".

4.4.3. Market Regulation and Law Enforcement Constraints

In terms of market supervision and law enforcement constraints, it is necessary to improve the environmental access and exit mechanism, raise the environmental protection access threshold of the logistics industry, restrict high-emission and high-pollution vehicles and facilities from entering core areas such as urban distribution and key parks, and implement rectification or retirement within a time limit for enterprises that fail to meet the standards for a long time. Sun Jianbo and Zhang Yongrui (2020) further emphasize that the government should establish a green logistics performance evaluation and information disclosure mechanism to regularly assess the progress and effectiveness of green transformation of enterprises. Specifically, public supervision should be introduced by forcing enterprises to disclose key environmental indicators such as carbon emission, energy consumption and packaging material use, and differentiated supervision strategies should be implemented according to the evaluation results-that is, enterprises with remarkable transformation achievements should be commended and rewarded, and enterprises failing to meet the standards should be rectified within a time limit or punished accordingly. In addition, green supervision should be extended to the upstream of the supply chain, bringing suppliers 'environmental performance, packaging compliance, transportation low carbon level, etc. into the scope of supervision, so as to realize green control in the whole process from production to terminal.

4.4.4. Public Services and Platform Support

In terms of public services and platform support, the government should play a leading role, take the lead in building a green logistics public information platform, integrate and provide multi-dimensional information docking services such as route optimization, joint distribution, transportation capacity sharing, packaging recycling and reuse, and break down information barriers., promote the efficient allocation and intensive use of resources, and effectively improve the resource utilization efficiency of the entire industry. At the same time, it is necessary to plan as a whole and increase the investment in the construction of public infrastructure such as charging and replacing power station, hydrogen refueling station, green sorting center, packaging recycling network, etc., and improve the infrastructure network layout of green logistics, so as to effectively reduce the external cost burden faced by enterprises in carrying out green operation. In addition, universities and scientific research institutes shall be actively guided and supported to carry out professional talent cultivation and key technology research and development in the field of green logistics, encourage in-depth integration of production, learning and research, provide diversified public services such as technical consultation, standard training and scheme diagnosis for enterprises, comprehensively improve the professional accomplishment of industry employees and green operation ability of enterprises, and lay a solid foundation for green transformation and sustainable development of logistics industry.

5. Conclusion and Prospect

5.1. Conclusion

This study systematically analyzes the development status of green logistics, and points out that there are outstanding problems in resource utilization, environmental protection, cost benefit and concept technology. Green logistics is not only an inevitable choice to deal with environmental pressure, but also a key path to promote sustainable development of the

industry. Based on supply chain management theory, this paper puts forward a series of countermeasures: Build green supply chain, realize efficient coordination of logistics links and reduce resource waste and pollution by optimizing supplier selection, strengthening green supervision and establishing coordination mechanism; Promote green logistics technologies, such as clean energy vehicles, optimizing transportation routes and degradable packaging, etc., to improve efficiency and reduce environmental impact; Strengthen green concept dissemination, promote green logistics practice from both sides of supply and demand through enterprise green culture construction and consumer green consumption guidance.

5.2. Outlook

Although this study has achieved certain results in theory and practice, there are still deficiencies. Due to the limitation of data acquisition, it has not been able to quantify the cost composition and long-term benefits of green logistics, which affects the accuracy of conclusions to a certain extent. At the same time, there are few cases selected, which makes it difficult to fully reflect the implementation effects of different enterprises. The discussion on the dynamics of green logistics frontier technologies is relatively lagging behind. The future research can be deepened from three aspects: First, use big data and models to strengthen quantitative analysis of green logistics cost benefits and accurately evaluate its economic and environmental benefits; second, expand case coverage and improve the universality of research conclusions; third, keep up with the development of green logistics technology and explore its innovative application in the supply chain to provide more forward-looking guidance for sustainable development of the industry.

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