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Research on Green Logistics Management in the Context of Low-Carbon Economy

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Abstract

Against the backdrop of China's carbon peaking and carbon neutrality strategy, low-carbon development has become an important direction for the high-quality development of various industries. As a fundamental industry supporting commodity circulation, the logistics industry is confronted with increasingly prominent problems such as high energy consumption, high emissions, and packaging waste pollution, making its green logistics transformation extremely urgent. To remove practical obstacles in implementing green management in the logistics industry and promote the coordinated development of the logistics industry and the ecological environment, this paper adopts a literature review combined with an analysis of industry practices to investigate green logistics management in a low-carbon economy. It elaborates on the connotation and practical value of green logistics management and identifies the existing problems in the industry's development. The study finds that the development of green logistics in China is still constrained by multiple factors, including weak green and low-carbon awareness, outdated equipment and technologies, an imperfect policy and regulatory system, an insufficient supply of interdisciplinary talent, and a lack of benefit coordination mechanisms in the supply chain. Accordingly, this paper proposes comprehensive measures from five dimensions: awareness cultivation, technological upgrading, institutional improvement, talent development, and supply chain coordination. These measures aim to remove obstacles to the green transformation of the logistics industry, provide a reference for the logistics sector to advance low-carbon development, and achieve a win-win outcome between economic and ecological benefits.

Keywords

Low-Carbon Economic Environment; Green Logistics; Logistics Management

1. Introduction

Driven by the carbon peaking and carbon neutrality goals, the low-carbon economy serves as a key guideline for industrial transformation and upgrading. As a foundational sector underpinning commodity circulation, logistics features energy-intensive operations including transportation, warehousing and packaging. With the sustained expansion of e-commerce and logistics services, environmental

issues such as exhaust emissions and packaging waste have grown increasingly prominent. Many logistics enterprises still adhere to traditional operational models and show notable deficiencies in implementing green development concepts and deploying advanced technologies, which poses substantial practical barriers to the industry's green transition. Accordingly, this paper analyzes prevailing challenges in green logistics management in light of industrial realities, explores targeted improvement strategies, and provides references for the low-carbon and sustainable development of the logistics sector.

2. The Connotation and Significance of Green Logistics

2.1. The Connotation of Green Logistics

Green logistics is a management model proposed for the development of the logistics industry. In the processes of logistics warehousing, distribution, and transportation, it adopts management models, materials, and other means that can mitigate the environmental damage caused by traditional logistics transportation, so as to maximize the utilization efficiency of logistics resources and protect the logistics environment in an all-round and multi-level manner.Rather than one-sidedly seeking pollution reduction, this model pursues a balance between economic and ecological benefits. Through operational process optimization, adoption of eco-friendly equipment and supplies, and rational allocation of logistics resources, it lowers energy consumption, exhaust emissions and packaging waste across logistics links. It also prioritizes the recovery and recycling of waste materials to form a resource-conserving and eco-friendly logistics system.In contrast to traditional logistics that prioritizes circulation efficiency and cost control, green logistics takes environmental constraints into corporate operational considerations and seeks coordinated development of sound enterprise operation, industrial advancement and ecological conservation.

2.2. The Significance of Green Logistics

Developing green logistics is an inherent requirement for the logistics industry to achieve sustainable development in the era of the low-carbon economy. For logistics enterprises, green logistics emphasizes economies of scale. By formulating sound logistics plans, enterprises can make transportation and warehousing more scientific, pursue the goals of energy conservation, high efficiency, and pollution reduction, and substantially reduce logistics operational costs.Furthermore, while helping enterprises reduce costs, green logistics enables them to build a responsible green brand image, better align with green consumer demand, and enhance their overall competitiveness within the industry.

From an industry perspective, green logistics compels the logistics industry to abandon the energy-intensive extensive development model. It facilitates the

iterative upgrading of full-process operational processes such as transportation, warehousing, and recycling, thereby enabling the industry to enhance quality and efficiency in the direction of low-carbon and standardized development.

From a social and ecological perspective, green logistics effectively mitigates exhaust emissions and packaging waste pollution caused by logistics activities, improves the recycling and utilization of energy and materials, supports the implementation of the carbon peaking and carbon neutrality strategy, promotes coordinated development between industrial growth and ecological conservation, and provides robust support for green and sustainable socio-economic development.

From the perspective of national development strategy, the implementation of green logistics management can advance low-carbon development within the logistics sector, support national energy conservation and emission reduction efforts, spur green development across related sectors, accelerate the low-carbon transition of the socio-economic system, and advance national economic and social sustainability.

3. Main Problems in Green Logistics Management under the Low-Carbon Economy

3.1. Weak Awareness of Green and Low-carbon Development

Although the government has introduced a series of carbon peaking and carbon neutrality policies, the logistics industry as a whole still has an inadequate understanding of green logistics. Most enterprises focus more on short-term costs and benefits, regard green environmental measures as additional operational burdens, and lack the intrinsic motivation and enthusiasm to advance green logistics development. Among them, small and medium-sized logistics enterprises generally take operational benefits as their primary goal and attach relatively little importance to low-carbon transition. Some managers hold a one-sided view of green logistics, simply equating it with the replacement of packaging with eco-friendly materials. They fail to recognize that environmental management should run through the entire logistics business chain, and extensive operational practices persist in their operations.Green transformation is generally characterized by substantial upfront investment and a long payback period. Constrained by cost pressures, many enterprises only passively meet minimum compliance requirements and lack systematic and long-term low-carbon transition planning. In addition, the low-carbon literacy of frontline practitioners is uneven, and their awareness of energy consumption control in operational processes remains weak. Frequent problems such as empty running and overpacking further impede the effective implementation of green management measures.

3.2. Outdated Logistics Equipment and Technology

At present, the industry application of logistics equipment and digital technologies in China shows significant polarization. Leading logistics enterprises have already adopted new-energy transport vehicles and intelligent warehouse scheduling systems, whereas numerous small and medium-sized logistics enterprises, constrained by financial resources, are making slow progress in equipment upgrading and digital transformation.In the transportation segment, traditional fuel vehicles continue to account for a relatively high share. Constrained by high procurement costs and inadequate charging and battery-swapping infrastructure, the large-scale deployment of new-energy logistics vehicles remains difficult to achieve. In warehousing and handling operations, numerous small and medium-sized logistics enterprises still rely on manual operations, and the penetration rate of automated and energy-efficient warehousing equipment remains low.In terms of informatization, most small and medium-sized enterprises lack professional logistics scheduling and carbon accounting systems, making it difficult for them to apply big data algorithms to optimize transportation routes and effectively alleviate empty trips. Moreover, the absence of unified interface standards for information systems among market entities results in data silos and impedes information coordination and sharing across the supply chain.Meanwhile, green packaging and waste recycling technologies are not widely applied, and eco-friendly consumables remain costly to procure. Constrained by funding and technological bottlenecks, mature green operational models cannot yet be widely adopted across the industry.

3.3. Imperfect Policy Standards and Regulatory System

Currently, China's green logistics policy documents are mainly guiding plans and advisory opinions. Unified, detailed, and actionable industry implementation standards are lacking. Carbon accounting rules and green enterprise rating indicators for various logistics links remain unclear, leaving enterprises without clear references for green logistics management.Subsidies and tax incentives for enterprises purchasing new-energy equipment and using recyclable packaging are limited in scope, leaving most small and medium-sized logistics enterprises unable to benefit from policy support. Moreover, the large number and scattered distribution of market entities in the logistics industry complicate routine supervision, and the constraints on high-energy-consuming and high-polluting logistics practices remain weak.Some policies emphasize publicity and guidance but provide insufficient binding constraints. As a result, the green transition of enterprises depends largely on voluntary willingness, and the guiding and compelling effect of relevant institutional mechanisms has not been fully brought into play.

3.4. Insufficient Supply of Green Logistics Professionals

As an interdisciplinary field integrating logistics operations, low-carbon technologies, and environmental management, green logistics generates strong market demand for professionals with both practical experience and low-carbon expertise.China's logistics talent market is characterized by a significant structural mismatch: on the one hand, there is a surplus of frontline operational staff; on the other hand, there is a severe shortage of high-end and interdisciplinary professionals proficient in supply chain planning, data analytics algorithms, and the design and operation of intelligent logistics systems.In terms of talent training, logistics programs at some universities focus on traditional logistics modules, while green and low-carbon courses account for a relatively small proportion. As a result, there is a mismatch between the supply of graduates and the actual talent needs of enterprises. Enterprises also lack routine training mechanisms for green business operations, leaving managers and frontline staff without systematic training; this talent shortage directly hinders enterprise green transformation.

3.5. Uncoordinated Benefit Distribution Mechanisms among Supply Chain Participants

Green logistics transformation requires joint funding from upstream and downstream supply chain members for upgrading and transformation. However, at present, the supply chain has not yet established a sound mechanism for sharing costs, benefits, and risks.Updating green packaging, procuring new-energy equipment, and building low-carbon information systems all raise upfront costs. While the environmental benefits of green transition are public goods, logistics enterprises bear most of the transformation costs alone. Since upstream shippers and downstream consumers do not participate in cost sharing, small and medium-sized logistics enterprises find it difficult to bear such high expenditures on their own.Supply chain participants have divergent demands. Some market entities focus solely on short-term economic benefits and are unwilling to participate in green collaborative projects such as joint distribution and packaging recycling. The lack of motivation for upstream and downstream collaboration hinders the formation of a full-chain green logistics management pattern.

4. Optimization Strategies for Green Logistics Management in a Low-carbon Economy

4.1. Foster Green and Low-carbon Awareness to Consolidate the Ideological Foundation

To advance the implementation of green logistics, the primary task is to change entrenched business concepts in the industry. The government can promote knowledge of the low-carbon economy and green logistics through industry presentations and the dissemination of typical cases, correct the one-sided view that

green transformation only increases costs, and guide enterprises to formulate long-term low-carbon development plans in light of their actual conditions, rather than confining themselves to superficial changes such as merely switching to eco-friendly packaging.In addition, enterprises should convey green development concepts throughout the organization from top to bottom. Internal briefings can be conducted to emphasize the importance and necessity of green logistics. Enterprises may either establish a dedicated green logistics management department or rely on effective cross-departmental coordination to clarify individual performance assessment and division of responsibilities at different stages of logistics activities, thereby fostering a low-consumption logistics pattern. Regular green operations training should also be provided for managers and frontline staff to standardize operations across all stages of transportation, warehousing, and packaging. Such training helps reduce wasteful practices such as empty trips and overpacking, integrate low-carbon requirements into daily operations, and enhance employees' initiative in green operations.

4.2. Accelerating Logistics Equipment Upgrading and Promoting Digital Technology Application

To address the practical difficulties faced by small and medium-sized enterprises (SMEs), such as obsolete equipment and insufficient technical strength, coordinated efforts from multiple parties are needed to promote equipment upgrading and technology application. Enterprises should gradually phase out outdated, high-energy-consuming equipment in light of their operational capacity and moderately introduce new-energy transport vehicles, energy-efficient warehousing equipment, and automated loading and unloading equipment.Moreover, by relying on big data and artificial intelligence (AI), the application of intelligent logistics systems can be further promoted. Such systems help optimize delivery routes and transportation plans, reduce unnecessary travel and empty trips, lower empty-trip rates and fuel consumption, and provide strong support for logistics enterprises to reduce carbon emissions.The government should continue to improve supporting infrastructure such as charging and battery-swapping facilities, thereby lowering the threshold for using new-energy equipment. It is also necessary to promote information standardization in the logistics industry, remove data barriers between enterprises, eliminate data silos, and achieve coordinated information sharing across the supply chain.In addition, greater efforts should be made to promote circular packaging and waste material recycling technologies. It is also necessary to expand supply channels for green consumables, reduce the procurement costs of eco-friendly materials, and promote the application of advanced green technologies among small and medium-sized enterprises.

4.3. Improving Industry Policy Standards and Enhancing Supervision and Incentive Mechanisms

A comprehensive institutional system provides an important guarantee for the orderly development of green logistics. In light of the actual situation of China's logistics industry, relevant authorities should refine unified standards for carbon accounting across the entire logistics process and green enterprise rating, thereby providing clear references for green management in enterprises.The coverage of incentive policies should be expanded, and supportive measures such as equipment procurement subsidies and tax relief should be implemented. Resources should be appropriately channeled toward small and medium-sized logistics enterprises to alleviate the financial pressure they face in green transition.Given the scattered distribution of logistics market entities, regulatory authorities should innovate supervisory instruments and establish routine supervision mechanisms to strengthen constraints on high-energy-consuming and non-compliant operations while attaching equal importance to incentives and constraints. Such institutional arrangements can reduce sole reliance on enterprise self-discipline and, through institutional guidance, compel the industry to achieve green upgrading.

4.4. Building an Interdisciplinary Talent Training System to Remedy the Shortage of Professional Talent

To address the shortage of interdisciplinary green logistics talent, a two-way training channel should be established to connect university education with corporate practice. Universities offering logistics-related programs should optimize their curriculum systems by incorporating teaching content on carbon accounting, reverse logistics, and low-carbon operations, thereby better aligning with the actual talent needs of industry and narrowing the gap between education and industry.Logistics enterprises should establish systematic internal training mechanisms to regularly organize employees to acquire green logistics-related knowledge and skills, thereby enhancing their professional competence. Targeted school-enterprise cooperation should also be actively promoted to recruit industry professionals, strengthen the green logistics management team, and provide talent support for the implementation of various green management measures.

4.5. Coordinating Supply Chain Interests and Building a Full-Chain Collaborative Model

Green logistics development depends on coordination between upstream and downstream supply chain participants, which requires a sound mechanism for sharing costs, benefits, and risks.Responsibilities of all supply chain participants should be clearly defined to change the current situation in which logistics enterprises bear the costs of transformation alone. Shippers, logistics service providers, and distribution channel participants should jointly share the costs of green transition. Collaboration between upstream and downstream enterprises should be encouraged to implement collaborative projects such as joint distribution

and packaging recycling, thereby balancing short-term investment against long-term overall returns.All market entities should be guided to move beyond a short-term profit-driven mindset and value the competitive advantages brought by full-chain green upgrading. Connecting production, warehousing, transportation, and terminal recycling into a complete chain helps achieve low-carbon operations across the entire supply chain.

5. Conclusion

In the context of the low-carbon economy, green logistics is an inevitable choice for the high-quality transformation of the logistics industry. Rather than merely updating equipment and materials, this transition constitutes a systematic endeavor encompassing concepts, technologies, institutions, talent, and supply chain coordination.Constrained by practical factors such as the high proportion of small and medium-sized logistics enterprises and the considerable cost pressure of green transition, coordinated efforts are required. The government should provide effective guidance and regulation, enterprises should actively pursue innovation and reform, and supply chain participants should work together to address existing problems.The green transition of the logistics industry cannot be achieved overnight. Continuous optimization and adjustment based on industry practices remain necessary to balance business development and ecological protection, thereby promoting China's logistics industry toward sustainable development with synergistic economic and ecological benefits.

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