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Research on the Low-Carbon Transformation Path of Logistics Enterprises Driven by Carbon Trading Policies

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Abstract: Against the backdrop of the global active response to climate change and China's all-out pursuit of the "Dual Carbon" goals, the logistics industry, due to its significant carbon emission scale, has become a crucial area for carbon emission reduction. This study focuses on the driving influence of carbon trading policies on logistics enterprises. It systematically expounds the relevant theoretical foundations, deeply analyzes the policy mechanisms, comprehensively reveals the challenges that enterprises face during their transformation, and innovatively proposes transformation paths such as the collaborative research and development of green logistics technologies, the multi-party sharing of equipment renewal costs, the construction of a low-carbon logistics talent echelon, and the dual adaptability strategy towards policies and the market. The aim is to provide theoretical support and practical guidance for the low-carbon transformation of logistics enterprises, and contribute to the vigorous development of China's low-carbon economy.

1. Research Background

As the situation of global climate change deteriorates increasingly, extreme weather events occur frequently, posing great challenges to human survival and development.[1] The international community has responded one after another by formulating strict carbon emission reduction targets. China, in particular, has bravely taken on the heavy responsibility and clearly proposed the grand "Dual Carbon" goals of striving to peak carbon dioxide emissions before 2030 and achieving carbon neutrality before 2060[2].

The logistics industry, as a fundamental industry supporting economic operation, has witnessed explosive growth in business volume driven by the vigorous development of the e-commerce economy. However, behind this prosperity lies a heavy environmental cost. Its large-scale energy consumption and carbon emissions have made it a key focus for carbon emission reduction. In this context, carbon trading policies have emerged as the times require. With market mechanisms as the core driving force, these policies endow economic value to carbon emission rights, prompting logistics enterprises to take the initiative to shoulder emission reduction responsibilities and embark on the exploration path of low-carbon transformation. This is of great significance for China's and even the global carbon emission reduction process.

2. Overview of Carbon Trading Policies

Carbon trading policies follow the basic principle of "total quantity control and trading". The government precisely determines the upper limit of total carbon emissions based on scientific assessment and strategic planning, and then reasonably allocates the quotas to each enterprise[3]. In actual operation, if an enterprise's carbon emissions are lower than the allocated quota, it can sell the excess quota in the carbon market to obtain economic benefits. Conversely, if the emissions exceed the quota, the enterprise needs to purchase additional quotas from the market, which undoubtedly increases its operating costs. Since China launched the carbon emission rights trading pilot work in 2011, after years of exploration and practice, the national carbon market was officially launched for trading in 2021, and the logistics industry has gradually been included in the scope of regulation[4]. This policy ingeniously internalizes the external costs of carbon emissions into the enterprise's operating costs, forcing enterprises to re-examine their operation strategies and actively seek effective ways to reduce carbon emissions.

3. Influence Mechanisms of Carbon Trading Policies on the Low-Carbon Transformation of Logistics Enterprises

3.1 Cost-Driven Mechanism

After the implementation of carbon trading policies, logistics enterprises have deeply felt the heavy pressure of carbon emission costs. Once an enterprise's actual carbon emissions exceed the quota, it has to enter the carbon market to purchase additional quotas, and the cost rises sharply. For example, for a medium-sized logistics enterprise, due to the rapid expansion of its transportation fleet and the low energy efficiency of its vehicles, its carbon emissions far exceed the quota[5]. According to the market carbon price calculation, the additional expenditure is as high as hundreds of thousands of yuan. This has a huge impact on the enterprise's profits, forcing the enterprise to immediately put carbon emission control on the agenda.

3.2 Technological Innovation Incentive Mechanism

Carbon trading policies have injected strong impetus into the research and development of green logistics technologies by logistics enterprises. Enterprises are clearly aware that mastering advanced low-carbon technologies is the key to taking the initiative in the carbon trading market and reducing emission reduction costs. Many large logistics enterprises have successively established internal research and development centers and actively established industry-university-research cooperation relationships with universities and scientific research institutions[6]. They focus on cutting-edge fields such as new energy transportation and intelligent logistics algorithms, and spare no effort to tackle technical problems.

3.3 Market Competition and Cooperation Mechanism

Logistics enterprises are well aware that it is difficult to achieve the grand goal of low-carbon transformation alone, so they actively seek cooperation. On the one hand, they deeply cooperate with suppliers to promote green procurement practices, prompting suppliers to use environmentally friendly packaging and energy-saving equipment. On the other hand, they collaborate with downstream customers to optimize distribution plans and improve distribution efficiency. In addition, logistics enterprises in the same industry also form industrial alliances, jointly research and develop technologies, and formulate industry standards[7]. Through competition and

cooperation, they achieve industry-wide collaborative emission reduction and enhance the overall competitiveness.

4. Challenges Faced by Logistics Enterprises in Low-Carbon Transformation

4.1 Difficulties in the Research and Development of Green Logistics Technologies

Currently, the research and development of key green technologies in the logistics field face numerous challenges[8]. The problem of the mismatch between the cruising range of new energy vehicles and charging infrastructure is prominent. Drivers often experience cruising range anxiety during long-distance transportation, and the lagging layout of charging facilities seriously restricts the large-scale popularization of new energy vehicles. The precise temperature control technology for cold chain logistics is difficult to ensure a constant temperature in complex and changeable environments, and the high research and development cost makes many enterprises deterred, making the path of technological upgrading difficult.

4.2 Costs of Equipment Renewal and Transformation

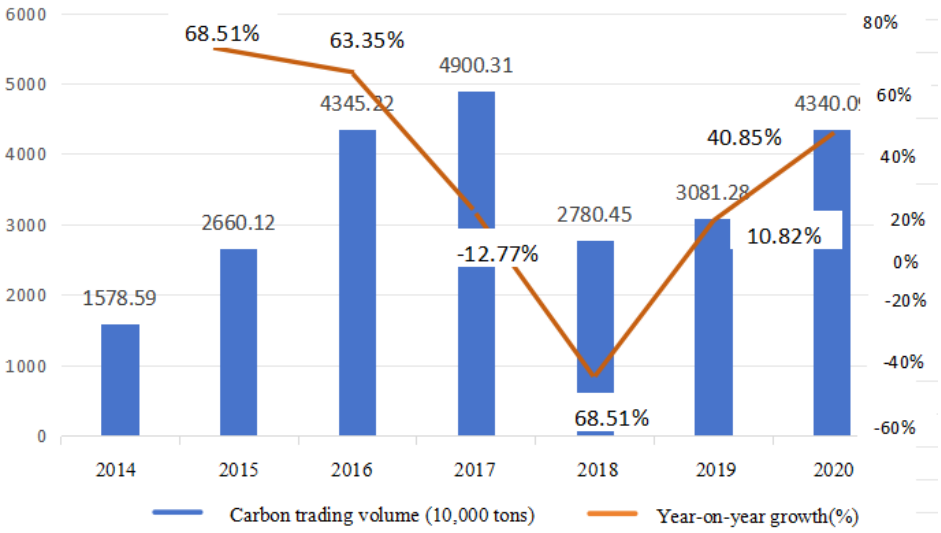
During the low-carbon transformation process of logistics enterprises, the costs of equipment renewal and transformation have become a huge obstacle. For traditional warehousing enterprises to transform into energy-saving intelligent warehouses, they need to install solar panels, intelligent ventilation and lighting systems, etc. The transformation cost of a medium-sized warehouse can easily reach several million yuan. For transportation enterprises to purchase new energy vehicles, the purchase cost is 20% - 50% higher than that of fuel vehicles, and the subsequent battery maintenance and replacement costs are also substantial. The capital chains of small and medium-sized logistics enterprises are already fragile. Facing such high costs, the pace of their transformation is forced to slow down.

4.3 Shortage of Professional Low-Carbon Logistics Talents

As the logistics industry rapidly moves towards low-carbon transformation, there is an urgent need for compound talents who are familiar with both logistics operation and low-carbon technologies as well as carbon trading rules. However, the reality is not optimistic. The curriculum updates of logistics majors in universities are lagging behind, and the teaching content in the field of low-carbon logistics is insufficient. The internal training system of enterprises is not perfect, making it difficult to effectively improve the low-carbon professional quality of employees. The shortage of talents seriously restricts the transformation efficiency of enterprises.

4.4 Uncertainty of Policies and the Market

On the one hand, the carbon trading policies are in a continuous dynamic improvement stage. The allocation of carbon emission quotas and the formation mechanism of carbon prices are frequently adjusted, as shown in Figure 1. Enterprises find it difficult to accurately predict the policy trends and face greater risks when formulating long-term transformation strategies[9]. On the other hand, the market demand for low-carbon logistics services is greatly affected by factors such as the economic situation and consumer preferences. During an economic downturn, some customers give up green logistics services to cut costs, resulting in unstable returns on enterprises' low-carbon investments and weakening the driving force for transformation.



Data source: China Carbon Trading Network

Figure 1: Quota turnover in China's carbon trading market (unit: 10,000 tons)

5. Low-Carbon Transformation Paths of Logistics Enterprises Driven by Carbon Trading Policies

5.1 Collaborative Path for the Research and Development of Green Logistics Technologies

Enterprises build a collaborative innovation platform for green logistics technology research and development, bringing together logistics enterprises, universities, scientific research institutions, relevant government departments and other parties. Enterprises put forward technical requirements based on their own practical experience, while universities and scientific research institutions use their scientific research advantages to provide technical solutions[10] . Government departments promote close cooperation among all parties through policy guidance and financial support. For example, enterprises establish joint research and development projects to solve problems such as mileage optimization of new energy vehicles and breakthroughs in cold chain logistics temperature control technology. Enterprises realize the sharing of technology research and development resources and complementary advantages, and accelerate the breakthrough and application process of green logistics technology.

5.2 Multi-Party Cost-Sharing Mechanism for Equipment Renewal

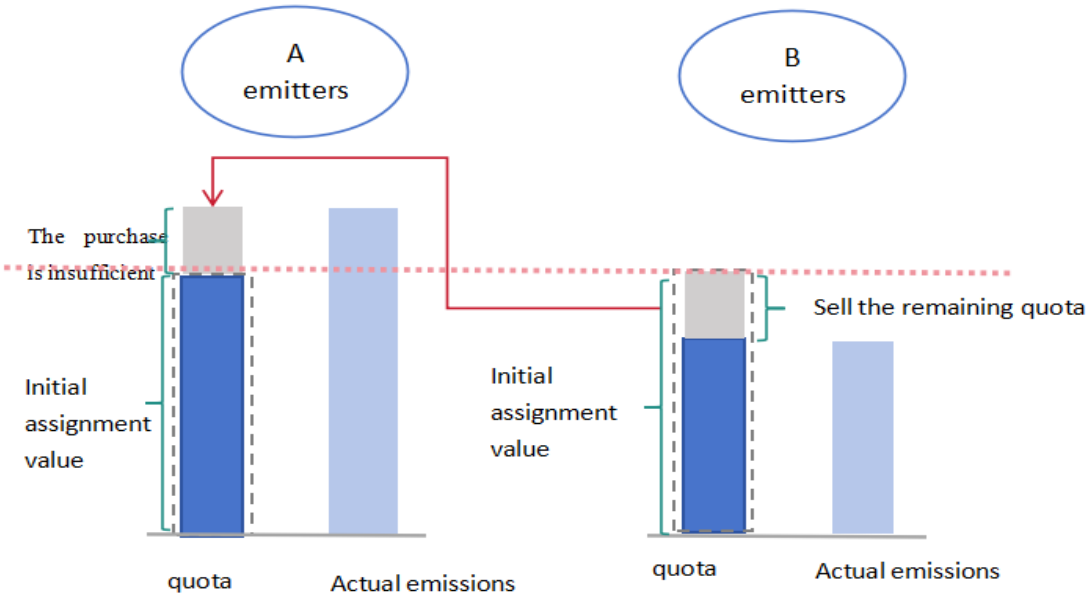
Explore the establishment of a multi-party cost-sharing model for equipment renewal. The government introduces special subsidy policies to provide financial subsidies to enterprises that purchase new energy logistics equipment and transform energy-saving warehouses, reducing the financial pressure on enterprises. Financial institutions innovate financial products to provide logistics enterprises with services such as low-interest loans and financial leasing to help enterprises finance equipment renewal. Industry associations take the lead in guiding upstream and downstream enterprises to jointly share part of the costs. For example, suppliers provide preferential equipment prices, and downstream customers pay part of the money in advance, forming a joint force of cost sharing in the industrial chain to promote the smooth progress of equipment renewal and transformation of logistics enterprises.

5.3 Construction Mode of a Low-Carbon Logistics Talent Echelon

Create a comprehensive construction system for a low-carbon logistics talent echelon. At the university level, accelerate the reform of logistics courses, increase the proportion of low-carbon logistics, carbon trading and other related courses, and cultivate undergraduate and postgraduate talents that meet the needs of the industry. Vocational colleges focus on cultivating operation-oriented skilled talents, offering practical courses such as the operation of new energy logistics equipment and intelligent warehouse management to provide front-line technical workers for enterprises. Within the enterprise, improve the training and promotion mechanism. The company designs hierarchical training courses for employees in different positions. The new employee induction training focuses on the popularization of low-carbon concepts, and the advanced training for old employees focuses on the application of new technologies and carbon trading strategies. The company provides promotion channels for outstanding employees to stimulate their enthusiasm to participate in the low-carbon transition.

5.4 Dual Adaptability Strategy towards Policies and the Market

Enterprises should establish a dynamic monitoring mechanism for policies and the market, arranging special personnel or teams to track the adjustment of carbon trading policies and changes in market demand. Based on the monitoring data, formulate multiple sets of response plans in advance. When the policy tightens the carbon emission quota, the enterprise quickly optimizes the operation process and increases investment in technology research and development. In the face of market demand fluctuations, such as during an economic downturn, the enterprise flexibly adjusts its service strategy, launches an economic green logistics package to meet the cost control needs of customers while maintaining a certain market share. At the same time, enterprises strengthen communication with government departments, feedback on the effect of policy implementation and enterprise demands, and strive for policy support. Enterprises gain insight into market trends, tap potential low-carbon logistics needs, and advance the layout of innovative businesses to achieve stable development driven by both policies and markets, as shown in Figure 2.



Data source: Qianzhan Industry Research Institute

Figure 2: China's carbon trading market mechanism

6. Conclusion and Outlook

This study deeply explores the complex issues of the low-carbon transformation of logistics enterprises under carbon trading policies, systematically expounds the theoretical basis, carefully analyzes the influence mechanisms, comprehensively reveals the challenges faced, and innovatively proposes transformation paths. The research shows that although carbon trading policies provide a strong driving force for the transformation of enterprises, enterprises still face many challenges in terms of technology, cost, talent, and policy-market adaptability. Looking ahead, with the continuous refinement and improvement of carbon trading policies, the rapid development of science and technology, and the high attention of all sectors of society to low-carbon development, logistics enterprises will encounter more opportunities in their low-carbon transformation. The government should further optimize the policy environment, increase support for technology research and development, and strengthen market supervision. Enterprises need to firm up their determination to transform, continuously invest resources to promote technology innovation and talent cultivation, and deepen supply chain collaborative cooperation. It is believed that with the joint efforts of all parties, the logistics industry will surely achieve low-carbon and intelligent development, contribute key forces to the achievement of China's "Dual Carbon" goals, and provide valuable reference experience for the global logistics industry in responding to climate change.

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