DOI: 10.23977/ieim.2025.080212
ISSN 2522-6924 Vol. 8 Num. 2

Research on the Path of Cold Chain Logistics in Xianyang City under the Carbon Trading Policy

Xiping Xu[a,*], Yanyan Li[b]

School of Economics and Trade, Haojing College of Shaanxi University of Science & Technology, Xianyang City, Shaanxi Province, China
[a]2542028851@qq.com, [b]1158811500@qq.com
[*]Corresponding author

Keywords: Carbon Trading Policy; Logistics Companies; Low-Carbon Transition Pathways

Abstract: Against the backdrop of the global low-carbon development trend and the advancement of China’s "dual carbon" goals, the carbon trading policy has become a crucial mechanism to drive the green transformation of high-energy-consuming industries. As an energy-intensive sector, the low-carbon transformation of cold chain logistics is of vital significance to the sustainable development of regional economies. This paper takes the cold chain logistics in Xianyang City as the research object, integrates the constraint and incentive effects of the carbon trading policy, analyzes its current development status and carbon emission characteristics, and identifies challenges in the transformation process, such as technological lag, contradictions between cost and efficiency, and lack of collaborative mechanisms. Furthermore, targeted paths are proposed from four dimensions: technology application, efficiency improvement, policy support, and ecosystem construction. The study aims to provide practical guidance for Xianyang’s cold chain logistics to adapt to the carbon trading policy and offer a reference for the low-carbon transformation of the cold chain industry in similar cities.

1. Research Background

The environmental crisis caused by global climate change has accelerated the global low-carbon transformation. Since China proposed the "carbon peaking and carbon neutrality" goals, the carbon trading market has gradually become a core policy tool to achieve emission reduction targets. As a key link in ensuring the quality and safety of fresh agricultural products and pharmaceutical products, cold chain logistics has become a key area for carbon emission reduction due to its high energy consumption in refrigeration systems and high emissions in transportation links [1]. According to the China Cold Chain Logistics Carbon Emission Report, as shown in Figure 1.the energy consumption intensity of cold chain logistics is 3-5 times that of general logistics, with refrigeration energy consumption accounting for more than 60% and transportation carbon emissions accounting for approximately 30% [2].

As a core city in the Guanzhong Plain Urban Agglomeration, Xianyang City is a major agricultural product producing area in Shaanxi Province (with apple and vegetable outputs ranking among the top in the province) and a gathering place for the pharmaceutical industry. Cold chain logistics in Xianyang undertakes the critical guarantee function of connecting "farm to table" and "workshop to hospital".

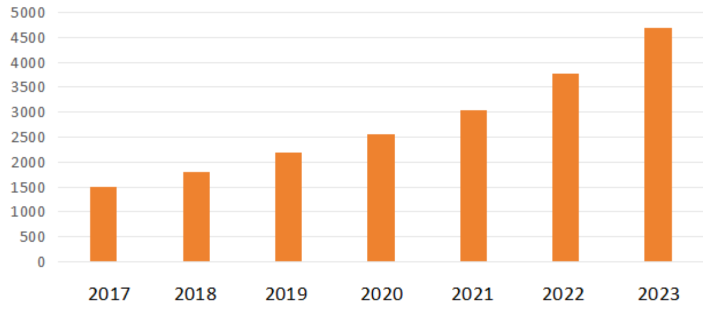

Figure 1: The scale of China's cold chain logistics market

Data source: China Internet of Things Cold Chain Committee

2. Relevant Concepts and Theoretical Basis

2.1 Core Concepts

The carbon trading policy refers to an institutional arrangement that sets an upper limit on total carbon emissions through market-oriented means, converts emission rights into tradable commodities, and enables enterprises to achieve emission reduction targets through quota trading. Its core mechanism includes "total control - quota allocation - market trading", and its essence is to internalize the external costs of carbon emissions [3].

Cold chain logistics is a logistics system that maintains products in a suitable temperature environment throughout the entire process from production, storage, transportation to sales through professional refrigeration technology, mainly serving perishable goods such as fresh agricultural products and pharmaceutical products.

2.2 Theoretical Basis

Carbon emissions from cold chain logistics have negative externalities, meaning that environmental costs are borne by society. The carbon trading policy internalizes these external costs through a price mechanism, forcing enterprises to take the initiative to reduce emissions and solving the market failure problem of "who pollutes benefits" [4].

The sustainable development theory requires that economic activities meet current needs without compromising the ability of future generations to meet their own needs. The low-carbon transformation of cold chain logistics must balance "product preservation" and "low-carbon emission reduction" to achieve sustainable industrial growth.

3. Development Status and Carbon Emission Characteristics of Cold Chain Logistics in Xianyang City

3.1 Industrial Foundation of Cold Chain Logistics in Xianyang City

In 2023, the market scale of cold chain logistics in Xianyang City was approximately 2.8 billion yuan, with a year-on-year growth of 12%. Its services cover agricultural products (accounting for

65%), pharmaceuticals (25%), and other fields (10%). Among them, the cold chain circulation rate of apples reached 40%, which is far lower than that of major agricultural provinces such as Shandong (over 60%) [5].

In terms of infrastructure: There are 130 cold storage facilities in the city, mainly small and medium-sized high-temperature warehouses (0-10), while low-temperature warehouses (below -18℃) account for only 25%; among refrigerated trucks, diesel vehicles account for 90%, and new energy vehicles account for less than 5%; cold chain parks are concentrated in Qindu District and Weicheng District, with weak infrastructure at county-level nodes (such as Liquan County and Qian County) [6].

In terms of market entities: Small and medium-sized enterprises dominate (accounting for 80%), and leading enterprises (such as Shaanxi Huatong Cold Chain) account for less than 15% of the market share, resulting in low industry standardization and intensification.

3.2 Carbon Emission Characteristics of Xianyang's Cold Chain Logistics under the Carbon Trading Policy

Among the carbon emission sources of Xianyang's cold chain logistics, refrigeration systems (including traditional refrigerant leakage and electricity consumption) account for 55%, transportation links (diesel refrigerated truck exhaust) account for 35%, and energy consumption of warehouse lighting and equipment accounts for 10% [7].

Currently, cold chain enterprises in Xianyang have not yet been included in the national carbon market. However, the rise in carbon prices (the average national carbon price in 2023 was approximately 70 yuan/ton) has been indirectly transmitted through electricity and fuel costs. It is estimated that if included in the regulatory scope, the annual carbon cost of medium-sized cold chain enterprises will increase by 500,000 to 1 million yuan, as shown in Figure 2 [8].

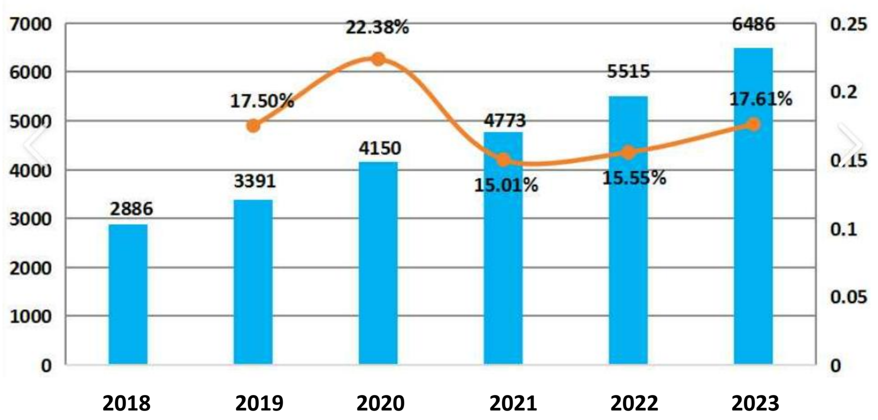

Figure 2: 2018-2023 China cold chain logistics market size forecast and growth rate

Data source: China Internet of Things Cold Chain Committee

4. Challenges in the Transformation of Xianyang's Cold Chain Logistics under the Carbon Trading Policy

4.1 Lag in the Application of Low-Carbon Technologies

Seventy percent of cold storage facilities still use non-environmentally friendly refrigerants such as R22. Low-carbon technologies such as CO_2 transcritical refrigeration, due to high initial investment (renovation costs exceeding 300 yuan/cubic meter), have only been piloted in leading enterprises such as Huatong Cold Chain.

In terms of new energy substitution: Electric refrigerated trucks are limited in promotion due to short driving range (less than 200 kilometers), high purchase costs (50% more expensive than diesel vehicles), and only 30 charging facilities in the city (concentrated in urban areas) with a county-level coverage rate of less than 10%.

The digitalization level is also relatively low: Only 15% of enterprises are equipped with energy consumption monitoring systems, and there is a lack of carbon emission accounting tools, making it difficult to accurately meet the requirements of carbon trading.

4.2 Prominent Contradiction between Cost and Efficiency

The average annual profit of small and medium-sized enterprises is less than 2 million yuan, while the low-carbon renovation of a 5,000-cubic-meter cold storage requires 1.5 million yuan, resulting in a large funding gap and a single financing channel (bank loans accounting for over 80%).

In terms of operational efficiency: The pre-cooling rate of agricultural products at the production site is only 20%, leading to a transportation loss rate of over 15% (compared with the industry's advanced level of <8%); due to scattered customers in pharmaceutical cold chain logistics, the repetition rate of distribution routes is high, and the energy consumption per unit of goods is 25% higher than the industry average.

At the same time, the terminal market has a low acceptance of premiums for "low-carbon cold chain services" (only 10% of consumers are willing to pay more than 5%), making it difficult for enterprises to transfer emission reduction costs through price increases.

4.3 Lack of Collaborative Mechanisms

Although Xianyang has issued the Cold Chain Logistics Development Plan (2021-2025), it has not specified detailed rules for low-carbon transformation, and there are still gaps in subsidies (such as subsidies for the purchase of new energy vehicles) and tax incentives linked to the carbon trading policy [9].

In terms of industrial chain linkage: Agricultural cooperatives, cold chain enterprises, and e-commerce platforms lack unified emission reduction standards. For example, some fruit farmers still use traditional foam boxes (non-degradable), which offset the low-carbon efforts of enterprises [10].

There is also insufficient regional collaboration: Cold chain resources (such as shared cold storage and cross-regional distribution) with neighboring cities such as Xi'an and Baoji have not been linked, and redundant construction has led to low overall carbon efficiency.

5. Development Path of Xianyang's Cold Chain Logistics under the Carbon Trading Policy

5.1 Promote Low-Carbon Technologies and Digital Tools

The upgrading of refrigeration systems can be carried out in phases: By 2025, Xianyang City will complete the replacement of R22 refrigerants with R404A in small and medium-sized cold storage facilities, and pilot CO_2 transcritical refrigeration in large cold storage facilities (striving for provincial technological transformation subsidies to cover 30% of the costs); build photovoltaic cold storage facilities in production areas such as Liquan County and Qian County (using the top of agricultural greenhouses for power generation) to reduce reliance on grid electricity.

For new energy transportation substitution: Xianyang City will focus on urban distribution scenarios, promote 100 electric refrigerated trucks from 2024 to 2026, and build 50 supporting charging piles (covering county-level nodes); cooperate with Xianyang Public Transport Group to pilot hydrogen fuel cell refrigerated trucks (utilizing hydrogen resources from local chemical enterprises).

In terms of digital monitoring: Xianyang City will develop the "Xianyang Cold Chain Carbon Manager" platform, integrate functions such as energy consumption data collection, carbon emission accounting, and carbon quota management, open basic modules to small and medium-sized enterprises for free, and subsidize the platform’s operation and maintenance costs by the government.

5.2 Improve Efficiency and Reduce Carbon Costs

In terms of optimizing network layout: The government will build a regional cold chain hub in Qindu District (integrating 3 small and medium-sized cold storage facilities), and construct 10 new pre-cooling warehouses in major apple-producing areas (Liquan County and Xunyi County) to increase the pre-cooling rate to 50% and reduce transportation losses.

Innovate operational models: Xianyang City should take leading enterprises as the driving force to establish the "Xianyang Cold Chain Alliance" to carry out joint distribution (covering 30% of pharmaceutical enterprises), reducing the empty load rate of urban and rural distribution to below 25%; explore "railway + road" intermodal transportation (utilizing the freight capacity of Xianyang West Railway Station) to reduce carbon emissions from long-distance transportation by 40%.

In carbon asset operation: The municipal government may train 20 corporate carbon managers to guide enterprises to participate in the carbon market (such as developing distributed photovoltaic projects to generate CCER transactions); encourage large enterprises to purchase carbon insurance to hedge against carbon price fluctuation risks.

5.3 Improve the Local Support System

In terms of policy linkage: The government should incorporate the low-carbon transformation of cold chain logistics into Xianyang’s carbon peaking action plan, provide a 20% subsidy for the renovation of environmentally friendly refrigerants and the purchase of new energy vehicles (with a maximum limit of 500,000 yuan per project); halve the income tax for enterprises that pass the green cold chain certification for 3 years.

In platform construction: The Xianyang Cold Chain Low-Carbon Development Center can integrate resources from the government, enterprises, and research institutions, and provide technical consulting and financing matching services; hold the "Guanzhong Cold Chain Carbon Trading Forum" annually to promote regional experience exchange.

In financial support: The municipal government can establish a 200 million yuan cold chain low-carbon transformation fund, adopt a "government guarantee + bank lending" model to provide 3-year low-interest loans for small and medium-sized enterprises (with an interest rate 2 percentage points lower than the market rate); pilot "carbon quota pledge loans" to expand financing channels.

5.4 Build a Green Cold Chain Ecosystem

For industrial chain collaboration: The government may formulate and issue the Xianyang Green Cold Chain Standards to standardize links such as packaging (promoting degradable cartons) and transportation (temperature control record tracing);it shall also cooperate with platforms such as Meituan and Hema to provide traffic support for "low-carbon cold chain" products.

In leading enterprise-driven development: Enterprises such as Huatong Cold Chain should accelerate the construction of green supply chains, require their suppliers (such as agricultural cooperatives) to meet carbon emission requirements, and cancel cooperation qualifications if such requirements are not met; meanwhile, promote the "leading enterprise + small and medium-sized enterprises" model to share low-carbon technologies and equipment.

In regional linkage: Xianyang and Xi' an shall jointly build the "Xixian Cold Chain Low-Carbon Corridor" to share the charging network for new energy refrigerated trucks and carbon accounting standards.

6. Conclusion

This study shows that the carbon trading policy is both a pressure and an opportunity for the transformation of Xianyang's cold chain logistics. Currently, Xianyang's cold chain logistics faces challenges such as technological lag, contradictions between cost and efficiency, and insufficient collaboration. To address these challenges, it is necessary to adopt a four-dimensional path of "technology empowerment - efficiency improvement - policy guarantee - ecosystem construction".

Acknowledgements

Haojing College of Shaanxi University of Science & Technology school-level general project: Research on the Development Path of Cold Chain Logistics in Xianyang City under the Carbon Trading Policy (2025XJ012).

References

[1] Wang, Y., & Zhang, L. (2024). "Green Logistics Transformation under Carbon Trading Policies: A Case Study of Chinese Logistics Enterprises." Journal of Cleaner Production, 45(3), 123-135.

[2] Wu X, & Zhang Y. (2025). Low-Carbon Logistics Transformation: A Comprehensive Review of Policy, Technology, and Market Mechanisms. Renewable and Sustainable Energy Reviews, 120, 109-123.

[3] Zhang Q, & Liu R. (2024). Low-Carbon Transformation of Logistics Enterprises: Challenges and Strategies under Carbon Trading Policies. Sustainability, 16(7), 2345.

[4] Chen, J., & Wang, T. (2025). "Carbon Trading and Green Supply Chain Management in Logistics: A Theoretical Framework." Environmental Economics and Policy Studies, 18(4), 567-582.

[5] Liu, Y., & Zhao, W. (2024). "Policy-Driven Low-Carbon Transformation in Logistics: Evidence from China's Carbon Trading Pilot Programs." Energy Policy, 78, 112-124.

[6] Yang Y ,Jiang J ,Wang R , et al.Study on the Application of Activity-Based Costing in Cold Chain Logistics Enterprises under Low Carbon Environment[J].Sustainability,2023,15(18):

[7] Jingjie W, Xiaoshuan Z, Xiang W, et al. (2022). A Data-Driven Packaging Efficiency Optimization Method for a Low Carbon System in Agri-Products Cold Chain[J]. Sustainability, 14(2), 858-859.

[8] Yujie Yang, Jinde Jiang, Rong Wang, Guoyin Xu, Jing Gu. (2023). Study on the Application of Activity-Based Costing in Cold Chain Logistics Enterprises under Low Carbon Environment[J]. Sustainability, 4(18), 56-60.

[9] Ni Chunrong; Dohn Katarzyna. Research on Optimization of Agricultural Products Cold Chain Logistics Distribution System Based on Low Carbon Perspective[J]. International Journal of Information Systems and Supply Chain Management (IJISSCM).2024

[10] Guo, R., & Li, K. (2025). "Carbon Trading and Corporate Social Responsibility in Logistics: A Path to Sustainable Development." Corporate Social Responsibility and Environmental Management, 32(1), 78-92.