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Research on the Distribution and Trends of Domestic Low-Carbon Logistics Based on Citespace

Lingyu Zhou. Jialiang Wang
School of Economics and Management of Southwest Petroleum University, Southwest Petroleum University, Chengdu, 610500, China

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Abstract

The logistics industry is one of the major contributors to carbon emissions. Low-carbon logistics is crucial for achieving the goals of "carbon peak" and "carbon neutrality". This article employs bibliometric analysis, utilizing Excel and CiteSpace software, to analyze 964 Chinese academic journal articles on low-carbon logistics published on the China National Knowledge Infrastructure (CNKI) database between 2008 and 2024. The study investigates publication volume trends, core authors and institutions,high-frequency keywords, keyword clustering, and the evolution of research within the low-carbon logistics field.The research findings indicate that studies on low-carbon logistics have undergone a shift from macro-level to micro-level explorations, and from localized to systemic perspectives. The results demonstrate that, with the advancement of technologies such as artificial intelligence and big data, digital logistics has emerged as a new research hotspot. Furthermore, decarbonization and systematization of logistics activities represent significant future research directions.

Keywords

Low-carbon logistics; Visualization analysis; CiteSpace

Introduction

At present, global society is actively taking measures to address climate change, and sustainable development has become a worldwide consensus. Industries across all sectors are working together to drive the economy towards a green and low-carbon transformation. In October 2021, China released the "Action Plan for Carbon Dioxide Peaking Before 2030". This critical strategic decision is vital for ensuring the sustainable development of the Chinese nation.

In December 2022, the State Council of China issued the "14th Five-Year Plan for Modern Logistics Development". The plan outlines that by 2025, "China aims to establish a modern logistics system characterized by supply-demand alignment,internal and external connectivity,security and efficiency, and smartness and

greenness." In 2023, China's total social logistics volume reached 352.4 trillion yuan (RMB), representing a year-on-year growth of 5.2% and an increase of 1.8 percentage points compared to the growth rate in 2022. This marks a new record high in logistics scale.

Achieving the carbon neutrality goal fundamentally relies on low-carbon reforms across all sectors of the socio-economy. Particularly significant is the logistics industry. As a significant energy consumer and a major source of carbon emissions, its transition towards green and low-carbon development plays a pivotal role in achieving this national objective.

1. Research Methodology and Data Sources

1.1 Research Methods

To comprehensively analyze the research landscape of low-carbon logistics in China, this study employs bibliometric analysis. Both Excel and CiteSpace software were utilized for data processing and visualization.Excel was primarily used to analyze the current state of low-carbon logistics research. CiteSpace, developed by Professor Chaomei Chen, is a specialized software system for information visualization and scientific knowledge discovery. This tool enables the processing of large-scale bibliographic data by extracting key elements such as keywords, authors, and affiliated institutions from imported literature datasets. Through its advanced algorithms, CiteSpace performs bibliometric measurements, identifies relational network structures among publications, and generates visual representations of these analytical findings.

1.2 Data Sources

This study retrieved literature from the China National Knowledge Infrastructure (CNKI) database using "low-carbon" and "logistics" as search keywords. The search was limited to academic journal articles published between 2008 and 2024, yielding 964 Chinese-language publications. To ensure academic quality, sources were filtered to include only journals indexed in SCI,CSSCI,CSCD, and Peking University Core Journals. All identified publications were exported as the research sample.

2. Literature Review

Research on low-carbon logistics spans a broad spectrum, with numerous scholars approaching carbon emission reduction in logistics activities from diverse perspectives. Yue Xin1 emphasized that a low-carbon economic system is crucial for achieving China's sustainable economic development. She argued that the advancement of a low-carbon economy is inseparable from the logistics sector and proposed recommendations for enterprises to establish low-carbon logistics systems.Han Huimin2, through theoretical research on low-carbon logistics, highlighted logistics' role as a nexus connecting various industries. She identified new opportunities

emerging in the era of network development and explored strategies for constructing China's low-carbon logistics system and implementing supportive policies.Hu Yunchao et al.3 examined domestic and international measures aimed at improving urban delivery greenization. They subsequently summarized common problems in distribution operations, analyzed their underlying causes, and designed a framework for a new urban green delivery system.

Fan Jun and Lu Yingjin4 conducted a detailed study on the requirements and existing challenges of the "last-mile delivery" within a low-carbon economy context. They introduced a joint distribution model and demonstrated its effectiveness in reducing carbon emissions, thereby achieving low-carbon last-mile delivery.Wu Xiaowei5 posited that implementing reverse logistics management enhances environmental benefits. He proposed an eco-efficiency indicator system tailored for a low-carbon economic environment and validated its simplicity and effectiveness through case study analysis.

Zhang Hanjiang et al.6 investigated optimal emission reduction in vertical supply chains under low-carbon constraints, considering government-imposed carbon taxes. They developed three analytical models, concluding that: a) cooperative R&D within the supply chain yields higher optimal emission reduction than independent R&D; b) optimal emission reduction correlates negatively with R&D cost coefficients and positively with cost-sharing ratios.Zhu Li et al.7 constructed a two-tier vehicle resource collaboration super-network structure. They established a multi-objective optimization model enabling logistics enterprises to simultaneously maximize operating profit and minimize carbon emissions. Numerical simulations revealed the impact of parameters like carbon taxes on collaborative vehicle deployment decisions.Li Zonghuo and Liu Meilian8 developed an indicator system encompassing five dimensions influencing low-carbon development in logistics enterprises. Using Interpretative Structural Modeling (ISM), they analyzed inter-indicator relationships and employed an Analytic Hierarchy Process (AHP) modelto identify key factors.Zhou Zhangjin et al.9 studied the impact of carbon tax pricing on operational decisions inwaste product recycling. They created a recycling cost model incorporating customer behavior and carbon emission costs, analyzing how carbon tax prices influence facility location planning and total costs. Their findings emphasized the significance of reasonable carbon tax pricing for operational efficiency.Yang Liu et al.10 exploredcold chain distribution route optimization from a low-carbon perspective. They formulated a distribution model incorporating carbon emission costs and utilized an improved whale optimization algorithm for solution, effectively balancing corporate profit and environmental cost. Case studies confirmed the algorithm's efficacy in optimizing routes and advancing smart cold chain logistics.Ren Zezhong et al.11 applied the ISM method to analyze critical factors and development mechanisms for low-carbon rural logistics, identifying 12 decisive factors and their interrelationships. The study stratified the low-carbon system into four progressive

levels, collectively propelling green development in rural logistics.Pu Xujin and Li Xiufeng12 addressed the multi-station e-commerce logistics distribution problem. They developed a fuel consumption model considering loading impact and a delivery delay function, formulating a multi-objective path planning problemminimizing both cost and delay. A multi-objective evolutionary algorithm based on decomposition (MOEA/D) was used for solution, with numerical experiments validating its effectiveness.Feng Ying et al.13 investigated the impact of carbon emissionsand carbon regulatory policies on fresh produce supply chains under scenarios involving manufacturer emission reduction and third-party logistics outsourcing. Game-theoretic models under different carbon policies revealed that carbon taxes and carbon trading significantly affect logistics service levels. The study also indicated that market demand and supply chain member profits can benefit from carbon reduction, with governments favoring carbon trading policies as technology matures.Liu Qi and Fan Xinkun14 analyzedcarbon emissions in China's logistics industry (2013–2019), identifying energy consumption, industrial scale, and freight turnover as the primary contributing factors.Wang Xuhui and Xie Xun15 employed acase study methodology to explore howdigital technology innovation drives the green and low-carbon transformation of the logistics industry. They identified internal and external pressures as key motivators for transformation. Their research illustrates how digital technologies, through foundational research, core technology, and service system innovation, fosterresource integration, industrial clustering, and green development. The study proposed three transformation pathways – capability enhancement, technological advancement, and industrial collaboration – offering management insights for greening the logistics sector.

3. Visualization Analysis of Low-Carbon Logistics Research

3.1 Analysis of Publication Trends

The volume of published literature serves as an indicator of a topic's research intensity and level of academic focus in a given year. A higher publication count reflects more active scholarly engagement with the subject. Based on bibliographic data, the annual distribution of publications is presented in Figure 1：

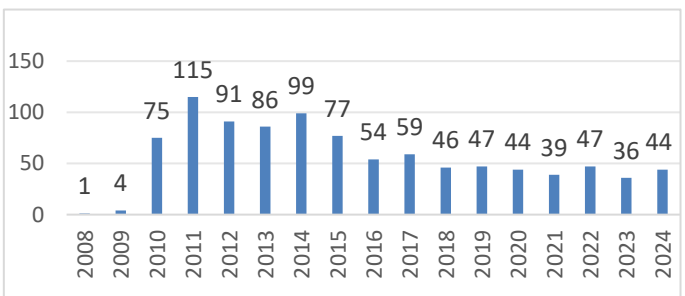

Figure 1. Publications from January 2008 to August 2024

Figure 1 reveals that domestic research on low-carbon logistics in China originated

in 2008. During the early 2000s, heightened global concern about climate change prompted scholars to integrate low-carbon dimensions into their respective fields. Consequently, low-carbon topics emerged as a prominent research focus, triggering a rapid surge in publication output. Research on low-carbon logistics reached its peak annual output in 2011 with 115 publications (accounting for 11.9% of the total sample). Subsequently, agradual declineoccurred until stabilizing around 2018, with annual publications maintaining within the 35–50 range. As of August 2024, 44 publications have been recorded, indicating a resurgent growth trajectory

3.2 Core Authors and Institutional Contributions

Compared to non-core researchers, core authors and institutions demonstrate greater proficiencyin identifying research trends, emerging hotspots, and disciplinary directions within this field. This study employs CiteSpace's co-occurrence clustering analysis to conduct a joint analysis of authors and institutions in the distribution center location research domain. The time slice was configured for 2010–2024。CiteSpace analysis identified 415 nodesand 303 links, yielding a network density of 0.0035. This indicates a relatively sparse co-occurrence networkbetween authors and institutions in this field. Collaborative relationships among researchers and organizations remain limited, forming primarily modest cooperation groups.The largest collaborative cluster originates from internal collaborations between schools within Shanghai Maritime University. Geographically, researchers from the same region demonstrate higher collaboration probabilities, exemplified by the network formed by Central South UniversityandCentral South University of Forestry and Technology in Hunan Province.

Beyond these primary networks,numerous independent researchers and single-institution teams conduct studies. Such isolated research efforts face two constraints:Limited thematic coverage，Challenges in resource integration.Increased institutional collaboration would enable complementary advantages, thereby maximizing research potential and impact.

3.3 Keywords Co-occurrence Network Analysis

Keywords encapsulate the core content and conceptual essence of scholarly articles.This network comprises 960 nodesand 2,209 links, revealing prominent high-frequency terms including "low-carbon economy", "carbon emissions", and "route optimization".

Based on CiteSpace analysis and data processing, Table 1 presents keywords with occurrence frequencies exceeding 20 times.

Table 1. High-Frequency Keywords Statistical Table

Rank	Keywords	Centrality	frequencies
1	Low-carbon economy	0.46	138
2	Low-carbon logistics	0.30	118
3	Logistics	0.27	102
4	Carbon emissions	0.26	88
5	Low-carbon	0.24	75

6	Green logistics	0.17	48
7	Logistics companies	0.10	27
8	Cold chain logistics	0.04	21

The keyword burst graph captures the temporal dynamics of research focus, revealing pivotal shifts in academic priorities through distinct bursts in specific terms. Below are the key findings:

1. Low carbon economy. The intensity of low-carbon economy is the highest, at 19.38, which was a research hotspot from 2010 to 2014. The reasons why it has become a hot topic are traceable. Firstly, the signing of international agreements such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol, as well as the commitments of governments to emission reduction targets, have promoted the research and practice of low-carbon economy. China has actively responded and the research on low-carbon economy has become an important topic.

2. Carbon emissions. The study of carbon emissions has been a research focus since 2010 and has become a research hotspot from 2018 to 2021. The 2018 United Nations Climate Change Conference led to the completion of negotiations on the implementation details of the Paris Agreement, resulting in a comprehensive, balanced, and impactful package of outcomes that increased academic attention to carbon emissions.

3. Path optimization. The path optimization problem in the logistics field has been studied since the last century. It first appeared in the low-carbon logistics field in 2015 and has since become a hot research direction. It has been an important research hotspot since 2018. Logistics transportation costs are an important component of logistics costs, and path optimization is the most direct method to save transportation costs. Considering the increasingly severe global climate change problem, controlling the carbon emissions of transportation vehicles is also crucial, making path optimization a hot research topic.

4. Cold chain logistics. The carbon emissions of cold chain logistics transport vehicles not only come from the operation of the vehicles, but also from the operation of refrigeration equipment, which generates a large amount of carbon emissions. The research on cold chain logistics is of great significance for the development of low-carbon logistics.

5. Logistics efficiency. Improving logistics efficiency can reduce logistics costs, while implementing low-carbon logistics can reduce energy consumption and avoid potential carbon emission costs. The combination of the two can bring dual economic and environmental benefits to enterprises. At the same time, consumers are increasingly concerned about the carbon footprint of products, and the market demand for green and environmentally friendly logistics services is increasing. In order to meet market demand and enhance brand image, logistics companies are beginning to pay attention to the combination of logistics efficiency and low-carbon logistics.

6. Digital logistics. With the development of artificial intelligence (AI) and the Internet of Things (IoT) technology, the integration of digital technology and logistics is becoming increasingly close. Digital logistics effectively improves logistics efficiency by optimizing logistics network layout, improving transportation utilization, and reducing inventory levels, which complements the goal of low-carbon logistics. The efficient management of digital logistics helps reduce ineffective transportation and empty loads, thereby lowering carbon emissions. Meanwhile, digital technology can help monitor and reduce energy consumption during the logistics process.

3.4 Keyword Cluster Analysis

Utilizing CiteSpace for keyword cluster analysis helps determine whether commonalities exist among research hotspots in the field. In CiteSpace, the clarity of clustering is measured by two metrics: the mean silhouette value (S-value) and the modularity value (Q-value). Typically, the Q-value falls within the range [0, 1], where Q > 0.3indicates a statistically significant network structure. Similarly, S > 0.7signifies highly focused clusterswith meaningful research implications. In our clustering model, the parameters reached Q = 0.5281and S = 0.8384, demonstratinghighly convincing and reliable clustering results. A total of 10 distinct clusters were formed, each representing a cohesive research theme within the low-carbon logistics domain. These robust metrics confirm the validity of the cluster structure and its capacity to accurately map the field's intellectual landscape.

The keyword clustering network reveals four dominant research themes in low-carbon logistics studies from 2010 to 2024:

1. Environmental Protection：Focused on sustainable logistics practices including cold chain distribution, multi-temperature joint delivery, and route optimization to minimize ecological impact.

2. Industrial Applications：Examines practical implementations such as energy conservation and emission reduction in logistics enterprises, corporate social responsibility, and green supply chain management.

3. Technological Innovation：Explores cutting-edge solutions like digital applications, innovative resource allocation, and digital transformation in logistics operations.

4. Policy Formulation：Addresses regulatory frameworks including low-carbon policies, countermeasures, and development strategies to guide industry practices.

This thematic evolution demonstrates a clear progression from theoretical exploration to practical implementation in low-carbon logistics research over the 14-year period. The clustering patterns show how academic focus has shifted from conceptual foundations (early policy studies) to technical solutions (recent digital innovations), reflecting the field's response to global sustainability challenges and technological advancements.

3.5 Temporal Evolution of Low-Carbon Logistics Research Themes

The timeline chart of keywords is a visualization of the time when they first ap-

peared, which helps to study the development stages and research hotspots of the field. Use CiteSpace tool to draw a timeline chart of domestic literature keywords.

The horizontal axis represents the time dimension, and the vertical axis represents the cluster label names. This article extracts the first 11 clusters to display the development of keywords in each cluster.

The nodes with relatively high popularity appeared from 2010 to 2012, including carbon emissions, logistics industry, low-carbon economy, low-carbon logistics, green logistics, etc. Since the emergence of low-carbon logistics, it has immediately become a hot research topic, and scholars have organically combined low-carbon, logistics, and economy for research.

The high-frequency keywords from 2013 to 2018 include logistics enterprises, multimodal transport, genetic algorithm, path optimization, etc. During this period, research on path optimization for transportation vehicles has become a hot topic, and genetic algorithms have become an important method for studying path optimization. Logistics companies also consider path optimization for transportation vehicles as an important means of reducing logistics costs.

The high-frequency keywords from 2019 to 2024 include: digital economy, digital logistics, green development, etc. During this period, artificial intelligence and big data have rapidly developed and been applied in the logistics field: the emergence of unmanned aerial vehicle delivery, smart logistics platforms, and intelligent logistics equipment has further reduced the carbon emissions of logistics activities while improving logistics efficiency.

4. Summary

Over the past decade, scholars have conducted extensive research in this field, yielding diverse and substantial outcomes that establish a solid foundation for future studies. Existing research employs a wide spectrum of methodologies and models, distinctly reflecting contemporary characteristics. The research perspective has progressively evolved from macro-level to micro-level investigations. Initially, scholars predominantly examined low-carbon logistics and the low-carbon economy from broad macroeconomic viewpoints or industry-wide perspectives. Subsequently, the focus gradually shifted toward individual logistics enterprises, emphasizing emission reduction in specific operational processes to achieve low-carbon objectives. More recently, over the last four years, studies have delved into ultra-micro analyses of logistics equipment, integrating artificial intelligence and IoT systems to enable precise management and refined operations. This granular approach targets the root causes of carbon emissions in logistics activities, ultimately advancing carbon neutrality goals.

Simultaneously, the research scope has expanded from fragmented components to systemic integration, transitioning from isolated low-carbon initiatives in specific logistics activities to comprehensive low-carbon logistics systems. Early research

concentrated on emission reduction within singular logistics segments, later broadening to enterprise-wide carbon management, and ultimately evolving toward decarbonizing entire supply chain ecosystems.

Regarding modeling approaches, current domestic research primarily relies on multi-objective optimization models, with limited application of virtual simulation techniques and empirical methodologies. Theoretical explorations of modeling methods dominate the literature. While China's logistics theory development started relatively late, its practical advancements have been rapid. Future research should address emerging challenges in logistics practice, particularly targeting the unique context of China's logistics landscape. Integrating evolving technological trends with localized empirical investigations will constitute a critical research trajectory going forward. This approach will bridge the gap between theoretical constructs and the dynamic realities of China's logistics sector, driving innovation tailored to its distinctive operational environment.

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