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Разработка российско-китайской омниканальной логистической сети продукции биотоплива

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Аннотация. Актуальность данной темы обусловлена важностью решения логистических проблем в условиях глобального роста биотопливной промышленности, повышенной потребности в устойчивом управлении логистическими процессами и снижении углеродного следа. Разработка интегрированных логистических решений становится особенно своевременной, поскольку она позволяет учитывать быстро меняющиеся требования рынка и экологические стандарты. **Пробел в научных исследованиях**. На сегодняшний день существующие подходы к оптимизации мультимодальной логистики имеют существенные недостатки, связанные с несинхронизированным управлением информационными и материальными потоками. Кроме того, наблюдается нехватка эмпирических данных по интеграции омниканальных методов, среди которых применяются: цифровое планирование с использованием алгоритмов искусственного интеллекта; мониторинг углеродных выбросов; оптимизация интермодальных (мультимодальных) перевозок. **Цель исследования**. Цель исследования заключается в разработке модели оптимизации омниканальной логистической сети для биотоплива, основанной на методах анализа данных и искусственного интеллекта. Это позволяет создать эффективный инструмент для управления российско-китайскими логистическими сетями в трансграничном контексте. **Научная новизна исследования**. Разработанная оптимизационная модель на основе данных позволяет значительно снижать логистические затраты, сокращать выбросы углерода и повышать устойчивость цепи поставок. Такой подход расширяет теоретические основы в области логистической омниканальности и открывает новые перспективы для использования современных цифровых технологий в оптимизации транспортных систем. **Научная дискуссия и направления для дальнейшего исследования**. Авторы предлагают обсудить возможности адаптации предложенной модели для решения схожих логистических задач в других отраслях народного хозяйства. Также важным направлением дискуссии является совершенствование организационно-экономических механизмов интеграции цифровых технологий в систему логистики, а именно доработка методов мониторинга углеродных выбросов, что позволит повысить общую эффективность оптимизации логистических процессов.

Ключевые слова: омниканальная логистическая сеть, российско-китайская сеть продукции биотоплива, трансграничная логистика, устойчивость цепей поставок, мультимодальные перевозки

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Developing Russian-Chinese omnichannel logistics network of biofuel products

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Abstract. The relevance of the topic is determined by the importance of addressing logistical issues in the context of the global growth of the biofuel industry, the increased need for sustainable management of logistics processes, and the reduction of the carbon footprint. The development of integrated logistics solutions is particularly timely, as it enables the consideration of rapidly changing market demands and environmental standards. **Research Gap**. Currently, existing approaches to optimizing multimodal logistics have significant shortcomings related to the unsynchronized management of information and material flows. In addition, there is a lack of empirical data on the integration of omnichannel methods, among which the following are applied: Digital planning using artificial intelligence algorithms; Carbon emission monitoring; Optimization of intermodal (multimodal) transportation. **Research Objective**. The objective of the research is to develop an optimization model for an omnichannel logistics network for biofuel, based on data analysis methods and artificial intelligence. This approach enables the creation of an effective tool for managing Russian-Chinese logistics networks in a cross-border context. **Scientific Novelty**. The data-driven optimization model developed significantly reduces logistics costs, cuts carbon emissions, and enhances the resilience of the supply chain. This approach expands the theoretical foundations in the field of omnichannel logistics and opens up new prospects for the use of modern digital technologies in optimizing transportation systems. **Scientific Discussion and Future Research Directions**. The authors propose to discuss the possibilities of adapting the suggested model to solve similar logistical challenges in other sectors of the economy. An important direction of the discussion is also the improvement of organizational and economic mechanisms for the integration of digital technologies into the logistics system, particularly the refinement of carbon emissions monitoring methods, which will enhance the overall efficiency of optimizing logistical processes.

Keywords*:* omnichannel logistics network, Russian-Chinese biofuel products, cross-border logistics, supply chain resilience, multimodal transportation

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Введение / Introduction

The term “biofuel products” explicitly narrows the focus to the tangible, marketable items – such as biodiesel or bioethanol – that are being distributed. So, the article topic “Developing the Russian-Chinese Omnichannel Logistics Network of Biofuel Products” clearly indicates that the research centers on the logistics aspects related to the distribution and handling of the finished biofuel commodities. The focus of the research is on the network for handling the final biofuel products rather than the broader concept of bioenergy. The phrase “logistics network of biofuel” might be interpreted in a broader sense. It can imply an analysis of the entire biofuel sector, including production, distribution, and even technological aspects related to bioenergy.

As a clean and renewable form of energy, biofuel has gradually become an important component of global energy strategies in the context of the transition of the global energy mix towards renewable energy and a low-carbon economy. Overuse of traditional fossil fuels has led to serious environmental problems such as climate change, air pollution and resource depletion. In order to meet these challenges, the international community has set targets to reduce carbon emissions and promote green energy development. Biofuel (e.g., bioethanol) has become one of the key areas in the global energy transition because of its low carbon emissions, renewability and wide application prospects. According to the International Energy Agency (IEA) [1], biofuel share of global renewable energy consumption is rising every year and is expected to account for more than 20% of global energy consumption to 2030.

As globally important energy producing and consuming countries, China and Russia have significant complementarities and potential for cooperation in the field of biofuel. Russia has abundant bioethanol resources (e.g., agricultural waste, raw materials such as grain by-products), and its wide land area provides favorable conditions for the cultivation and collection of biomass resources. China is one of the world's largest energy consumers, and with rapid economic development, the demand for clean energy continues to increase. The Chinese government has proposed a “dual carbon target” [2] (i.e., carbon peaking by 2030 and carbon neutrality by 2060) [3], and has made biofuel an important element in realizing this target, and China's technology for processing into bioethanol and scale are relatively mature. Under the cooperation framework of the Belt and Road Initiative and the Eurasian Economic Union, Russian-Chinese Biofuel cross-border trade is becoming more and more frequent, and the logistics demand for renewable energy products such as bioethanol is growing rapidly.

Traditional cross-border logistics networks usually use single channel (linear transport structure) for energy transportation, without high degree of synergy among various logistics links, and information flow, capital flow and logistics operation are relatively independent, resulting in low overall operational efficiency. By building omnichannel logistics network [4,5], it can break the isolated island effect of traditional supply chain [5,6], realize the real-time monitoring of cross-border logistics data, and improve the adaptability of logistics network. Therefore, author's suggestions to build a Russian-Chinese omnichannel logistics network of biofuel products to cope with the complexity and dynamics of Russian-Chinese biofuel transport and to provide important support for Russian-Chinese energy cooperation and the realization of global sustainable development goals are of great practical significance.

The aim of research is to develop an optimized omnichannel logistics network framework to improve the efficiency of collaboration in the Russian-Chinese logistics network of biofuel products. By optimizing the transparency, traceability and responsiveness of the logistics network, this research seeks to reduce operational costs, enhance the sustainability and resilience of the supply chain, and ultimately provide theoretical guidance and decision-making support for the efficient development of Sino-Russian energy trade.

Research subject focuses on exploring how to improve the synergistic efficiency and sustainability of the Russian-Chinese omnichannel logistics network of biofuel products through the construction and optimization of omnichannel logistics network.

Research object focuses around the Russian-Chinese omnichannel logistics network of biofuel products, aiming to explore the deep integration mechanism of omnichannel logistics network model in the complex cross-border trade environment.

The scientific novelty of the research is reflected in the following aspects.

1. The research breaks through the traditional scope of application of omnichannel logistics network and introduces it into the Russian-Chinese biofuel products for the first time, proposing a new type of logistics optimization strategy applicable to energy trade.

2. The research establishes a real-time data-driven logistics network collaborative optimization mechanism based on real-time data, integrating logistics data, policy information and market demand to improve the real-time decision-making ability and adaptability of cross-border logistics.

3. For the first time, the research incorporates environmental indicators such as carbon emission and energy consumption in the optimization model of Russian-Chinese omnichannel logistics network of biofuel products, which provides scientific basis for the development of low-carbon economy and green energy logistics, and enhances the practical significance and policy value of the research.

4. Research on the use of modern logistics information technology (e.g., Internet of Things, big data analysis) to enhance the level of intelligence in the logistics network, improve the efficiency of logistics resource allocation, and then enhance the overall operational effectiveness of the supply chain.

МАТЕРИАЛЫ И МЕТОДЫ / MATERIALS AND METHODS

Policy and market environment directly affect the feasibility and stability of cross-border supply chains. Market demand for bioenergy is extremely dependent on international oil prices [7, 8] and policy drivers (implementation of China's "dual-carbon" policy [9,10]). The expansion of the China-Europe liner train [11] provides new channel for the transportation of biofuel products, and the "One Belt, One Road" initiative [12] also promotes the cooperation between China and Russia in the field of energy, which provides policy protection for the synergistic development of the biofuel logistics network.

Related data show that in 2023, China produced about 3.4 million tons of biofuel ethanol. [13] China produces about 1.35 billion tons of agricultural waste per year, of which a significant portion can be used for bioenergy production. The "14th Five-Year Plan" for a modern energy system explicitly proposes to increase the proportion of non-fossil energy consumption. [14] By 2030, China's carbon dioxide emissions per unit of GDP will be reduced by more than 65% compared with 2005, and the proportion of non-fossil energy in primary energy consumption will reach about 25%. [15]

Omnichannel logistics network refers that an intelligent logistics system with high integration and multi-level synergy. Information network [16] is the key to realize the intelligence and synergy of Russian-Chinese omnichannel logistics network of biofuel products, and enhance the transparency, traceability and decision-making ability of logistics process through digital technology [17]. Big Data Analytics [18] optimizes the resource allocation and decision-making capability of the logistics network by analyzing historical and real-time data [19]. By analyzing demand data for biofuel products in the Chinese market, can forecast demand for the next three months and adjust production and transportation plans. Big data analytics also be used to optimize the layout of warehousing facilities [20] and the scheduling of transportation means to improve the utilization efficiency of logistics resources. The research suggests adopting blockchain technology to build a smart payment system [21] to improve the transparency and liquidity of cross-border transactions.

The research adopted a systematic approach to construct [22] and optimize the Russian-Chinese omnichannel logistics network of biofuel products, and the authors proposed an optimization framework based on an omnichannel logistics network (Fig. 1. Russian-Chinese omnichannel logistics network of biofuel products) covering three levels, namely, the physical level, the information level, and the decision-making level, which are in collaboration with each other.

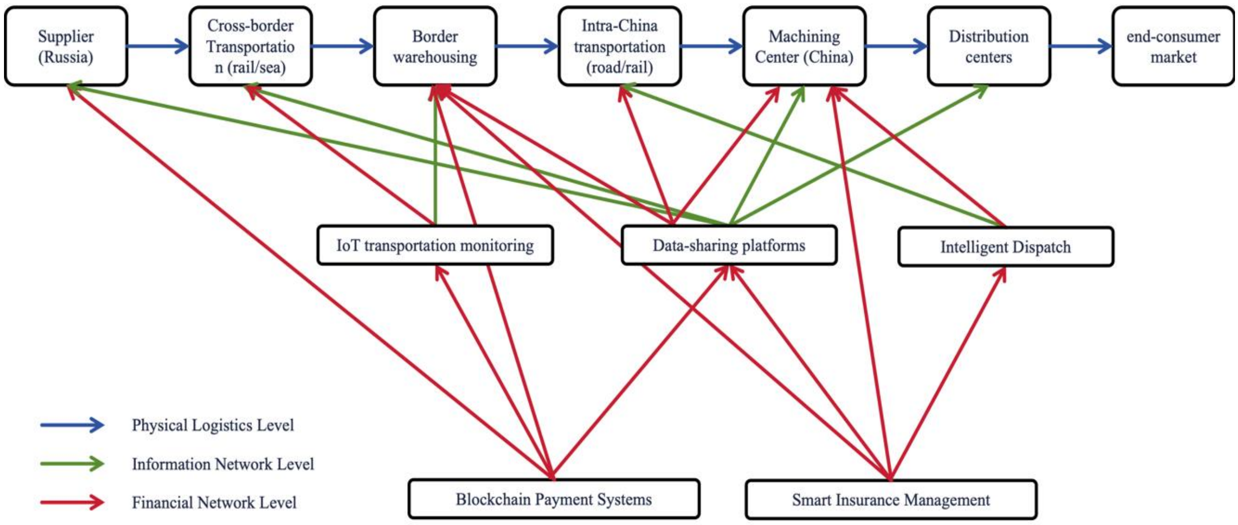

Рис. 1. *Российско-китайская омниканальная логистическая сеть продукции биотоплива*

Fig. 1. *Russian-Chinese omnichannel logistics network of biofuel products*

The model sets three major optimization objectives to improve the operational efficiency o of logistics network of biofuel products as a whole. The aim of the model is to improve the economic feasibility of the Russian-Chinese logistics network of biofuel product and to provide a scientific basis for cross-border logistics management and supply chain optimization.

The main objectives of this model include:

(1) Minimizing logistics costs to ensure cost-effective cross-border transportation and storage of biofuel products.

(2) Minimizing carbon emissions to reduce the environmental impact of the biofuel product transport and conform to the requirements of green and sustainable development.

(3) Maximize supply chain resilience and enhance the adaptability of the supply chain to changes in market demand, policy changes and emergencies.

In the model construction, firstly defined the core nodes in the logistics network (Table 1. Core nodes in the logistics network).

Таблица 1. Основные узлы логистической сети

Table 1. Core nodes in the logistics network

Logistics Network Nodes	$i \in S$, Supply points (e.g. Russian biofuel production sites)
	$i \in D$, Demand points (e.g. Chinese biofuel processing sites)
	$k \in W$, Warehouse centers (e.g., logistics hubs on the Russian-Chinese border)
Logistics Flow Variables	x_{ijk}, Flow of goods from supply point i to demand point j through storage center k
	y_{ik}, Supply points i Flow of goods transported directly to storage centers k
	Z_{kj}, Storage center k Flow of goods transported to demand point j
Mode of Transportation	T_r, T_s, T_a denotes the volume of rail, road, and sea transportation, respectively
	C_r, C_s, C_a denotes the unit cost of transportation by rail, road, and sea, respectively
	E_r, E_s, E_a denotes carbon emissions per unit of rail, road, and sea transportation, respectively
Cost of Storage and Distribution	C_k is the unit storage cost for k of storage centers
	C_m is the cost of the distribution terminal

With the synergy of physical, information and decision-making levels, the model achieves the intelligence, efficiency and sustainability of the Russian-Chinese logistics network of biofuel products with the optimization objectives of minimizing the logistics cost, minimizing the carbon emission and maximizing the resilience of the supply chain. By constructing this mathematical model, we are able to systematically optimize the cross-border logistics network, improve the operational efficiency of the supply chain, provide scientific decision-making support for the government and enterprises, and thus promote the in-depth development of Russian-Chinese green energy cooperation.

Minimize logistics costs

$$minC = \sum_i \sum_k y_{ik} C_{ik} + \sum_k \sum_j z_{kj} C_{kj} + \sum_k S_k C_k + \sum_m D_m C_m \quad (1)$$

Minimize carbon emissions

$$minE = \sum_i \sum_k y_{ik} E_{ik} + \sum_k \sum_j z_{kj} E_{kj} + \sum_m D_m E_m \quad (2)$$

Maximize supply chain resilience

$$maxR = \sum_n P_n S_n - \sum_p F_p \quad (3)$$

The constraints ensure the rational operation of the logistics network and make the optimization objective feasible in the real environment. The supply-demand balance constraint ensures the matching of logistics flows between the nodes of the logistics network, i.e., the output of raw materials at the supply point must be equal to the reception at the storage center, and the logistics flows at the storage center must also match the final demand point to avoid supply-demand imbalance.

$$\sum_k y_{ik} = \sum_j x_{ijk},\ \forall i \in S \quad (4)$$

$$\sum_j z_{kj} = \sum_i x_{ijk},\ \forall k \in W \quad (5)$$

At the same time, it is necessary to ensure that in each storage center the total cargo flow x_{ijk} cannot exceed the maximum storage capacity of the storage center C_k, avoiding operational inefficiencies or cost increases due to overloaded storage.

Constraint transport mode restraints specify the ratios between different modes of transport (e.g. rail, road and sea) that need to satisfy $T_r + T_s + T_a \leqslant Tmax$, and T_r, T_s, T_a, $\geqslant 0$. For example, the proportion of road transportation should not exceed a certain ceiling in order to reduce the carbon footprint, while the use of rail and sea transportation needs to be maintained at a certain level in order to increase the sustainability of the supply chain.

Carbon emissions E needs to be less than the total GHG emissions of the entire supply chain E_{max}, ensuring that the logistics network is optimized for transportation efficiency while meeting green development goals. To adapt to market changes, market demand constraints are adopted to ensure that the omnichannel logistics network optimization scheme maintains stable operations despite fluctuations in market demand.

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ / RESEARCH RESULTS

Based on the results of simulation data calculations, we evaluated the optimization of the Russian-Chinese omnichannel logistics network of biofuel products in terms of cost, sustainability and supply chain resilience.

In the developed omni-channel logistics network optimization model for biofuel, data analysis methods and artificial intelligence techniques are integrated to achieve comprehensive and adaptive management of logistics processes. More specifically:

• **Data Analysis:** Data analysis methods are used to collect, process, and interpret information on logistics flows, including raw material intake, finished product distribution, as well as monitoring carbon emissions for various modes of transport (for example, road and rail transport). This analysis makes it possible to identify key nodes in the network, evaluate transportation efficiency, detect bottlenecks in the supply chain, and simulate optimization scenarios based on statistical patterns and empirical data.

• **Artificial Intelligence:** Artificial intelligence techniques are employed to develop intelligent routing and scheduling algorithms. They provide:

○ **Intelligent Planning:** An automated selection of optimal routes and transportation modes based on current data regarding demand, transport capacity, and environmental performance indicators.

○ **Adaptive Optimization:** AI algorithms allow the logistics network to be adjusted promptly in response to changing market conditions and transport environments by taking into account carbon emission dynamics and the need to reduce logistics costs.

○ **Forecasting and Decision-Making:** On the basis of historical data and scenario modeling, AI generates forecasts regarding changes in logistics flows and aids decision-making to further enhance the network.

Thus, the combination of data analysis methods and artificial intelligence algorithms enables the creation of a multifunctional model that not only optimizes the management of the Russian-Chinese logistics networks but also supports sustainable development by lowering emissions and improving resource redistribution efficiency.

Total transportation cost in the optimized omnichannel logistics network is approximately $7.368 million, accounting for the largest proportion of the overall supply chain operating costs. Through data analysis (Fig. 2. Distribution of total transportation volume by different modes of transportation), it is found that rail transportation accounts for the highest proportion, followed by sea transportation and road transportation. Rail transport dominates cross-border long-distance transportation due to its low-cost and large-capacity features, but is not flexible enough, while road transport has irreplaceable advantages in short-distance and terminal distribution, even in view of its higher costs. Sea transport has a relatively low usage rate, but it has the lowest unit transportation cost and is suitable for long-distance and high-volume transportation. Based on these results, it is proposed to further increase the proportion of sea transport, optimize the combination of multimodal transport and reduce redundant transport costs through intelligent scheduling.

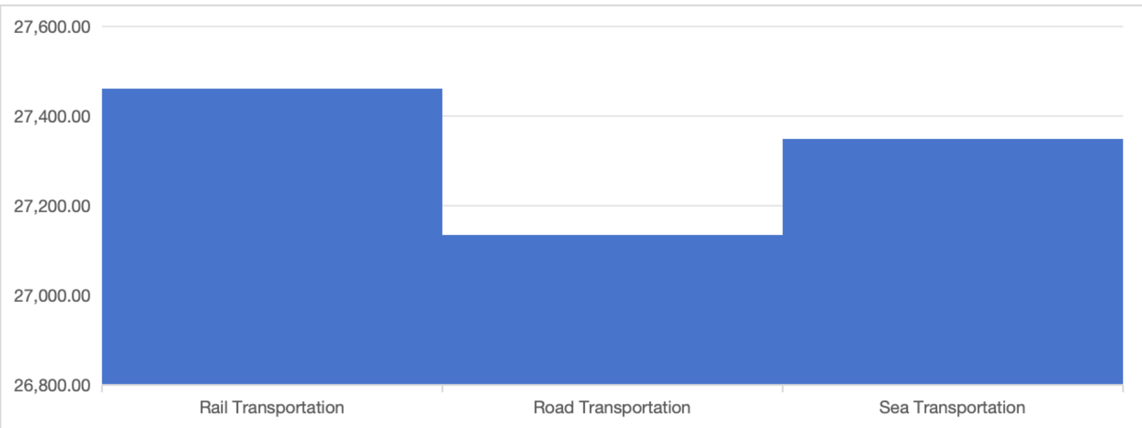

Рис. 2*. Распределение общего объема перевозок по видам транспорта*

Fig. 2*. Distribution of total transportation volume by different modes of transportation*

Total carbon emission of the omnichannel logistics network reaches 1.537 million tons of carbon dioxide, of which the carbon emission of road transportation is the highest and that of railroad transportation is the lowest (Fig. 3. Carbon Emission Distribution of Omnichannel Logistics Network). From the simulation data, road transportation has the highest share of carbon emissions, indicating that it consumes more energy in short-distance transportation and distribution, and at the same time its carbon emission factor is higher. And rail transportation has the lowest percentage, indicating that it has more environmental advantages in long-distance large-scale transportation. Therefore, in order to reduce the carbon footprint of the omnichannel logistics network, it is possible to optimize the multimodal transport scheme, further increase the proportion of rail and sea transport used, and adopt new energy vehicles in the short-distance distribution link.

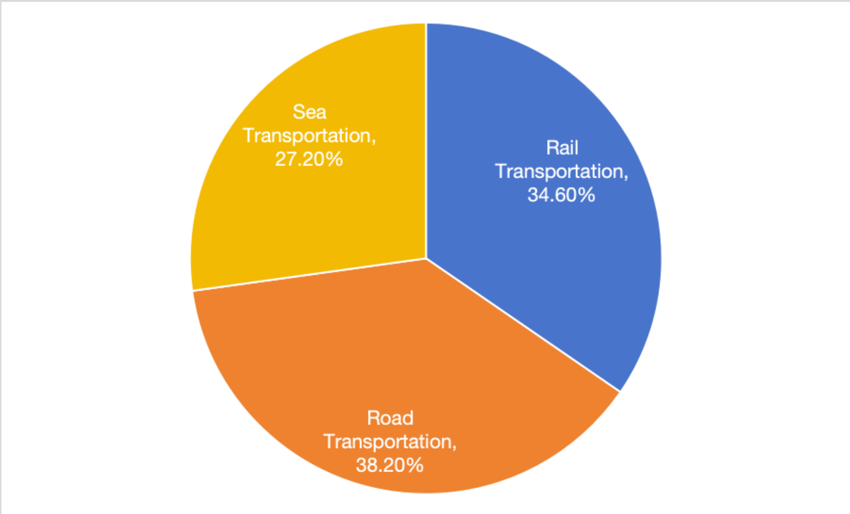

Рис. 3. *Распределение выбросов углерода в омниканальной логистической сети*

Fig. 3. *Carbon Emission Distribution of Omnichannel Logistics Network*

The calculation results of the supply chain resilience index show that (due to more simulation data, only part of the sample is shown) (Fig. 4. Supply chain resilience index), the stability score of the supply chain is 0.758 (out of 1.0), the overall resilience is strong, but there is still room for improvement. The demand side of the market is relatively stable, but there are large fluctuations on the supply side, which are affected by elements such as climate, policies and energy market prices. In addition, storage capacity is sufficient, but there is more room for optimization of logistics scheduling.

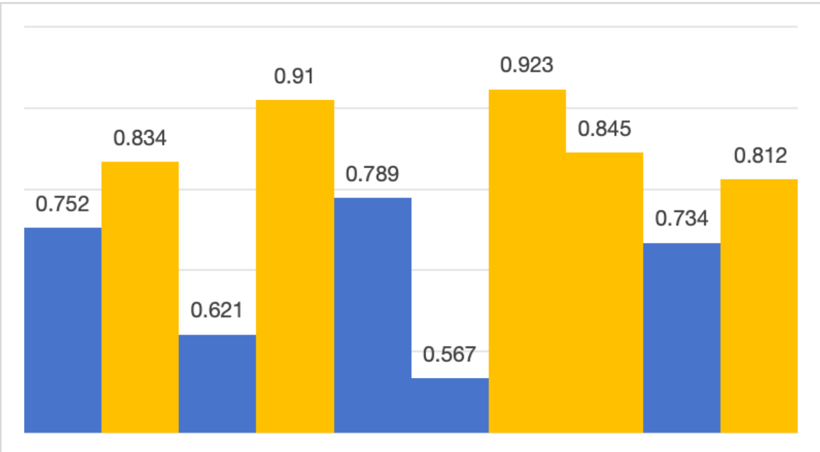

Рис. 4. *Индекс устойчивости цепи поставок*

Fig. 4. *Supply chain resilience index*

Among the current modes of transportation, the volume of rail, road and sea transport is basically balanced, but rail transportation accounts for slightly more. Rail transportation offers advantages in terms of carbon emissions and cost control, but its fixed scheduling affects the flexibility of logistics. Sea transportation has a low utilization rate, which may be mainly due to the absence of suitable port facilities at some logistics network nodes, resulting in inefficient trans-shipment. Therefore, the research suggests increasing the proportion of sea-rail intermodal transport and establishing an intelligent transit and storage system at border crossings to optimize the connection between different modes of transport. At the same time, automated scheduling systems should be applied in the terminal distribution chain to improve the efficiency of "last-mile" logistics and reduce distribution time and costs.

Заключение / Conclusion

In this research, an innovative model for optimizing an omnichannel logistics network has been developed, based on data analysis. The use of this solution enables the minimization of logistics costs and a significant reduction in the carbon footprint, contributing to the development of theoretical principles in the field of omnichannel logistics in supply chains and establishing a solid foundation for further research and practical application in conditions of sustainable development.

By integrating the physical level, information level and decision-making level, an efficient, intelligent and cooperative logistics network framework is constructed, which enriches the theoretical system of cross-border logistics management. The framework is not only applicable to both Russian and Chinese biofuel products, but also provides theoretical references for other cross-border energy products.

The results of simulation data analysis show that the total carbon emissions of the Russian-Chinese omnichannel logistics network of biofuel products are 1.537 million tons, with road transport accounting for the highest share (38.2%), maritime transport (34.6%), and railroads (27.2%). Due to the high unit carbon emissions of road transportation, despite its flexibility, the environmental advantages in long-distance transportation are significantly lower than those of rail and sea transportation. Therefore, the current logistics model needs to be further optimized to reduce reliance on road transport and increase the share of green modes of transport to achieve more sustainable cross-border biofuel products supply chain management.

In the long view, the optimization of the Russian-Chinese omnichannel logistics network of biofuel products needs to pay attention to economic benefits, and must be based on the perspective of sustainable development to promote the construction of a low-carbon and digitalization development. The optimization scheme of research is not only in conformity with China's "dual-carbon" strategy, but also provides a green and sustainable development direction for the global cross-border logistics network. In the future, omnichannel logistics network optimization should be further combined with intelligent scheduling system, AI predictive analysis, carbon emission monitoring and multimodal transportation optimization, so as to ensure the stability of the supply chain while realizing the green and low-carbon transformation and the in-depth development of cross-border energy cooperation.

СПИСОК ЛИТЕРАТУРЫ / REFERENCES

1. International Energy Agency. Renewables 2024: Analysis and forecast to 2030. IEA. 2024. 177 p. URL: https://iea.blob.core.windows.net/assets/17033b62-07a5-4144-8dd0-651cdb6caa24/Renewables2024.pdf (accessed 05.02.2025)

2. Jiang Q., Yin Z. The optimal path for China to achieve the "Dual Carbon" target from the perspective of energy structure optimization. *Sustainability*. 2023. Vol. 15(13). 10305. P. 32. DOI: 10.3390/su151310305

3. PRCEE, Environmental Defense Fund. China's Peak Carbon Neutrality Policies and Actions, *Policy Research Center for Environment and Economy*. 2023. p. 41. URL: http://www.prcee.org/yjcg/yjbg/202403/W020240313623893353900.pdf (accessed 10.02.2025)

4. Barykin S.E., Sergeev S.M., Provotorov V.V., et al. Sustainability Analysis of Energy Resources Transport Based on A Digital ND Logistics Network. *Engineered Science*. 2024. Vol. 29: 1093. P. 16. DOI: 10.30919/es1093

5. Barykin S.E., Sergeev S.M., Provotorov V.V., et al. Energy efficient digital omnichannel marketing based on a multidimensional approach to network interaction. *Frontiers in Energy Research*. 2022. Vol. 10: 946588. P. 8. DOI: 10.3389/fenrg.2022.946588

6. Barykin S.E., Smirnova E.A., Chzhao D., et al. Digital echelons and interfaces within value chains: end-to-end marketing and logistics integration. *Sustainability*. 2021. Vol. 13(24): 13929. P. 18. DOI: 10.3390/su132413929

7. IEA Bioenergy. Potential contribution of bioenergy to the world's future energy demand. *IEA Bioenergy*. 2007. P. 12. URL: https://www.ieabioenergy.com/wp-content/uploads/2013/10/Potential-Contribution-of-Bioenergy-to-the-Worlds-Future-Energy-Demand.pdf (accessed 06.02.2025)

8. Su C.W., Wang X.Q., Tao R., et al. Do oil prices drive agricultural commodity prices? Further evidence in a global bio-energy context. *Energy*. 2019. Vol. 172. Pp. 691–701. DOI: 10.1016/j.energy.2019.02.028

9. Jiang B., Raza M.Y. Research on China's renewable energy policies under the dual carbon goals: A political discourse analysis. *Energy Strategy Reviews*. 2023. Vol. 48: 101118. P. 10. DOI: 10.1016/j.esr.2023.101118

10. Zhu Y., Hu Y., Zhu Y. Can China's energy policies achieve the" dual carbon" goal? A multi-dimensional analysis based on policy text tools. *Environment, Development and Sustainability*. 2024. Pp. 1–40. DOI: 10.1007/s10668-024-05190-4

11. CAITEC, CASS. Report on the Development of China's Pilot Free Trade Zones (2013-2023), *Chinese Academy of International Trade and Economic Cooperation*. 2023. P. 70. URL: https://www.caitec.org.cn/upfiles/file/2023/10/20231127095033478.pdf (accessed 06.02.2025)

12. High-quality joint construction of the Belt and Road to build a connectivity partnership. *Advisory Committee of the "Belt and Road" International Cooperation Summit Forum*. 2021. P. 49. URL: http://munich.china-consulate.gov.cn/zgzt/111a/202112/P020211222776477377927.pdf (accessed 07.02.2025)

13. BEIPA. Annual Report on the Development of China's Biomass Industry, 2024 – Abstract Version. *Biomass Energy Industry Promotion Association*. 2024. URL: https://www.beipa.org.cn/newsinfo/7147401.html (accessed 01.02.2025)

14. National Energy Administration. "Modern Energy System Planning for the 14th Five-Year Plan. *National Energy Administration*. 2022. P. 41. URL: https://www.nea.gov.cn/1310524241_16479412513081n.pdf (accessed 01.02.2025)

15. China's Policies and Actions to Counter Climate Change 2022 Annual Report. *Ministry of Ecology and Environment of the People's Republic of China*. 2022. P. 55. URL: https://www.mee.gov.cn/ywgz/ydqhbh/syqhbh/202210/W020221027551216559294.pdf (accessed 01.02.2025)

16. Jiang W. An intelligent supply chain information collaboration model based on internet of things and big data. *IEEE access*. 2019. Vol. 7. Pp. 58324–58335. DOI: 10.1109/ACCESS.2019.2913192

17. Khan M., Parvaiz G.S., Dedahanov A.T., et al. The impact of technologies of traceability and transparency in supply chains. *Sustainability*. 2022. Vol. 14(24): 16336. P. 15. DOI: 10.3390/su142416336

18. Monino J.L. Data value, big data analytics, and decision-making. *Journal of the Knowledge Economy*. 2021. Vol. 12. Pp. 256–267. DOI: 10.1007/s13132-016-0396-2

19. Sazu M.H., Jahan S.A. Can big data analytics improve the quality of decision-making in businesses? *Iberoamerican Business Journal*. 2022. Vol. 6(1). Pp. 04–27. DOI: 10.22451/5817.ibj2022.vol6.1.11063

20. Yan Z., Ismail H., Chen L., et al. The application of big data analytics in optimizing logistics: a developmental perspective review. *Journal of Data, Information and Management*. 2019. Vol. 1. Pp. 33–43. DOI: 10.1007/s42488-019-00003-0

21. Ahmed M.R., Meenakshi K., Obaidat M.S., et al. Blockchain based architecture and solution for secure digital payment system. *ICC 2021-IEEE International Conference on Communications*. Montreal, IEEE. 2021. Pp 1–6. DOI: 10.1109/ICC42927.2021.9500526

22. Rossi P.H., Lipsey M.W., Freeman H.E. *Evaluation: A systematic approach*. SAGE Publications. 2003. P. 480.

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