Opportunities and Challenges for the Sustainable Development of Railway Logistics

Zifei Wang[1*], and Songwut Deechongkit[2]

[1]Student of the Master of Science in Management of Logistics, Graduate School, Rangsit University, Thailand
[2]Lecturer of the Master of Science in Management of Logistics, Graduate School, Rangsit University, Thailand
*Corresponding Author E-mail: 768364928@qq.com

(Received: March 19, 2025; Revised: April 10, 2025; Accepted: April 22, 2025)

Abstract

This study assesses the current status of railway logistics development, emphasizes the rapid development of railway logistics technology in China and the strategic advantages of Thailand, and explores the opportunities and challenges of railway logistics in sustainable development. A qualitative research methodology was used to obtain primary data through interviews with three Chinese railway logistics company managers and three Thai railway logistics experts, and secondary data, such as government reports and industry publications, were content analyzed in order to integrate the results of the literature review and expert interviews. The study finds that policy support and technological innovation are key opportunities for advancing sustainable development, while infrastructure constraints, technological upgrades, and inadequate policy frameworks are the main challenges. This paper proposes recommendations to strengthen technological research, infrastructure investment, green policy reforms, and optimize international cooperation to promote sustainable development of railway logistics and provide strategic guidance for railway logistics enterprises, policymakers, and future research on the sustainable development of railway logistics.

Keywords: Railway Logistics, Sustainable Development, Green Logistics, Logistics Management

Introduction

The impact of environmental pollution on human existence is increasing, and sustainable development has become a global strategic consensus. As an efficient and economical mode of long-distance freight transportation, railways have great potential for energy saving and emission reduction (Wang & Chen, 2023). According to the International Energy Agency (IEA), railways consume only 3% of global transportation energy, but carry 9% of passengers and 7% of freight, and their energy consumption is only one-fifth of that of trucks. However, the electrification rate of the global rail network is only one-third, and as low as 1% in North America (Annika et al., 2022).

According to the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the sustainability of rail logistics is reflected in economic, environmental and social benefits. Enhanced rail connectivity and intermodal transport can improve transport efficiency and reduce the high emissions associated with road transport, bringing rail emissions close to zero. In addition, rail logistics can create jobs and improve regional connectivity (Secretariat of the Trans-Asian Railway Network Working Group, 2023). China's railway logistics is undergoing a digital transformation, but the degree of informatization is still below global standards and the system has limited openness, which affects resource integration (Jiao, 2024). Nonetheless, the energy efficiency advantage of rail freight fits China's ecological goals (Zhang, 2021).

This study explores the opportunities and challenges of sustainable development of China-Thailand railway logistics in the context of national policies, economic benefits and technological advances, and provides strategic recommendations for enterprises and policy makers. As the construction of the China-Thailand railway progresses, Thailand can improve transport efficiency, reduce carbon emissions, and modernize its infrastructure for sustainable development by introducing Chinese smart equipment.

Research objectives

1. To compare the current level of development of the railway logistics industry in China and Thailand.

2. To explore opportunities and challenges for further sustainable development of railway logistics.

Literature Review

1. Current Status of the Rail Logistics Industry in China and Thailand

Rail transport accounts for 1% of global inland transport carbon emissions, while road transport accounts for 69% (Tianpeining, Maobaohua, Tongruiyong, Zhanghaoxiang, & Zhouqi, 2023). In 2023, global road transport carbon emissions will account for 75.2%, and rail transport carbon emissions will still account for 1% (Statista, n.d.). Relying on the Internet of Things (IoT), real-time tracking, and intermodal transportation, rail logistics in China has grown by 29% (Singh et al., 2021). Policy support and infrastructure investment have driven modernization, but uneven regional development has also led to uneven logistics development (Zhang, W., Zhang, X., Zhang, M., & Li, 2020).

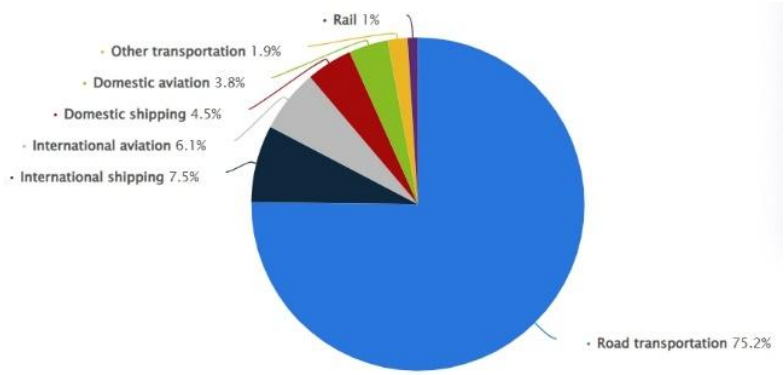

Figure 1 Distribution of carbon dioxide emissions produced by the transportation sector worldwide in 2023
Source: Statista, n.d.

The share of rail transportation in Thailand's total freight transport is only about 2.4%. 81.85% of the rail network is single-track, limiting transportation capacity (Hengsadeekul, Chaosakul, Parichatprecha, & Pakdeenarong, 2024). The government promotes the double-track project and the “Eastern Economic Corridor” railway plan, but is constrained by old infrastructure, insufficient capacity, and intermodal inefficiencies (Peetawan & Suthiwartnarueput, 2018). Cross-border railways (China-Laos-Thailand) promote regional integration (Hengsadeekul et al., 2024).

2) Ideal State of Sustainable Development of Railway Logistics

Sustainable railway logistics relies on green technologies, optimal dispatching and intermodal transportation (Singh, Elmi, Krishna Meriga, Pasha, & Dulebenets, 2022). Fuel-efficient locomotives, electrification and renewable energy are key (Larina, Larin, Kiriliuk, & Ingaldi, 2021). Policy support, infrastructure investment and intermodal transportation can reduce carbon emissions and improve efficiency (Pinto, Mistage, Bilotta, & Helmers, 2018).

3) Key Opportunities for Sustainable Development of Rail Logistics

3.1) Policy support: China's 14th Five-Year Plan promotes railway expansion and tax incentives. Belt and Road promotes international railway connectivity, and Thailand benefits from China-Thailand railway cooperation. The construction and operation of high-speed rail will not only bring a large number of direct, indirect and induced jobs, such as Spain's "Basque Y" project created about 100,000 jobs, but also promote the development of tourism, for example, high-speed rail has increased foreign tourists in Spain by 1.3%, tourism revenue increased by 1.7%, and the extension of Japan's Shinkansen has also brought about 20% growth in leisure tourists. In addition, high-speed rail also has significant external benefits, with Australian research showing that it can bring about A $48 billion in total social benefits, including time savings, emissions reductions, congestion relief and road accidents, reflecting the important role of high-speed rail in promoting sustainable transport development

3.2) Technological innovation: High-speed railways, Internet of Things (IoT), and automation to improve logistics efficiency and tracking capabilities (Liu, Schraven, de Bruijne, de Jong, & Hertogh, 2019).

3.3) Cooperation strategies: China-ASEAN cooperation and AIIB funding to improve infrastructure and promote regional economic integration (Punyaratabandhu & Swaspitchayaskun, 2021).

4) Key Challenges for Sustainable Development of Rail Logistics

4.1) Environmental issues: Rail transportation is still dependent on fossil fuels and needs to invest in green technologies (Godil, Yu, Sharif, Usman, & Khan, 2021).

4.2) Technological challenges: High costs, limited coverage, and old equipment affecting transportation efficiency, need to expand rail network and upgrade infrastructure (Pinto et al., 2018).

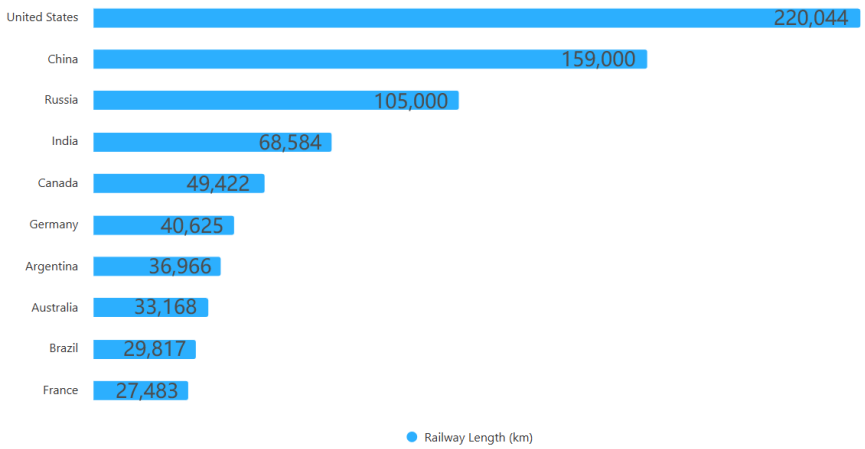

Figure 2 Countries with the Largest Railway Networks (2025 Ranking)

Source: Mfk, 2024

4.3) Market competition: High initial investment in railways, low flexibility, high road competition, need to optimize intermodal transport and modernize infrastructure (Hengsadeekul et al., 2024).

5) Adaptation Strategies for Railway Logistics Companies

Logistics service providers need to integrate green practices, improve information technology, and invest in artificial intelligence and the Internet of Things (Singh et al., 2022). Open up logistics information systems and enhance market information sharing to improve competitiveness (Jiao, 2024).

Table 1 Shows the current status of the railway logistics industry in China and Thailand

Current Status of the Rail Logistics Industry in China and Thailand	**Cited in or Reference**
Current Status of the Rail Logistics Industry in China	Tian, Mao, Tong, Zhange, and Zhou (2023) Singh et al. (2021) Zhang et al. (2020)
Current Status of the Rail Logistics Industry in Thailand	Hengsadeekul et al. (2024) Peetawan and Suthiwartnarueput (2018)

Table 1 Shows the current status of the railway logistics industry in China and Thailand (continued)

Current Status of the Rail Logistics Industry in China and Thailand	**Cited in or Reference**
Ideal State of Sustainable Development of Railway Logistics	Singh et al. (2022) Larina et al. (2021) Pinto et al. (2018)
Key Opportunities for Sustainable Development of Rail Logistics	Liu et al. (2019) Punyaratabandhu and Swaspitchayaskun (2021)
Key Challenges for Sustainable Development of Rail Logistics	Godil et al. (2021) Pinto et al. (2018) Hengsadeekul et al. (2024)
Adaptation Strategies for Railway Logistics Companies	Singh et al. (2022) Jiao (2024)

Methodology

The study utilized a qualitative research methodology and semi-structured interviews with six experts covering technological innovations, policy frameworks, and industry practices. The interviews were conducted using open-ended questions to guide the experts in sharing their insights, and data were collected using high-quality recording equipment. Secondary data sources included government reports, sustainability reports, industry publications, and case studies.

Interviewed experts included three academics from the University of Thailand (two lecturers in logistics management and one associate professor of industrial engineering and government logistics advisor), all of whom have been in the field for more than 30 years, and three senior engineers from a prominent railway logistics company in China who are currently in leadership positions and have deep theoretical and practical experience. Intentional sampling was used to ensure that the experts provided in-depth insights into the sustainable development of railway logistics (Iriste & Katane, 2018). Data were analyzed using content analysis to systematically identify terminology, phrases, and conceptual frequencies in the

literature and secondary data, and integrating the results of the literature review and interviews through the framework synthesis method to draw conclusions.

Table 2 Key Themes and Expert Consensus on China–Thailand Development Factors

Theme	Key Insights	Frequency
Infrastructure investment	Major in China, limited in Thailand	5 out of 6 experts
Regulatory barriers	Present in both countries	4 out of 6 experts
Technological innovation	Strong in China, emerging in Thailand	5 out of 6 experts
Environmental goals	Shared commitment, different progress levels	6 out of 6 experts

Research Results

The interview results obtained from expert interviews, analyzing the current state, advantages, ideal conditions, key challenges, and strategic directions for sustainable railway logistics development in China and Thailand.

Although both China and Thailand are actively developing railroad logistics to improve logistics and transportation efficiency, there are significant differences in actual operations, system advantages and challenges.

Table 3 Current Status of the Railway Logistics System

Feature	China	Thailand	Commonalities	Differences
Infrastructure	Extensive and advanced	Outdated, mostly single track	Both are modernizing	China is more advanced
Technology	High-speed, digitalized	Basic, undergoing upgrades	Both improving efficiency	China is leading in smart tech

Table 3 Current Status of the Railway Logistics System (continued)

Feature	China	Thailand	Commonalities	Differences
Policy Support	Railroad fixed asset investment is expected to remain above RMB 650 billion by 2025	PPP model & gradual support	Both support expansion	China has larger-scale funding
International Cooperation	Broad under Belt & Road	Regional focus (China-Thailand rail)	Both promote cross-border logistics	China has global partnerships
Transport Capacity	High domestic & international freight	Limited, road-reliant	Both aim to increase freight capacity	China's system is more efficient
Environmental Goals	The annual reduction in greenhouse gas emissions is equivalent to nearly 15 million tons of carbon dioxide	Promoting eco-friendly transport	Both prioritize sustainability	-

The railroad logistics system of China and Thailand have their own advantages, and although they are jointly committed to environmental protection and technological upgrading, there are differences in the application of technology, the way of policy support and the scope of international cooperation, reflecting the different levels of economic development and strategic priorities of the two countries.

Table 4 Significant Advantages of Railway Logistics

Feature	China	Thailand	Commonalities	Differences
Transport Capacity	Large-scale & cost-effective	Strategic location for trade	Both enhance connectivity	China excels in logistics volume
Environmental Goals	Advanced green technologies	Infrastructure upgrades for sustainability	Both reduce carbon footprint	China is ahead in green tech
Technology	Integrated smart logistics	Needs further modernization	Both investing in technology	China leads in automation
International Trade	Belt & Road-driven freight corridors	ASEAN trade connections	Both improve cross-border efficiency	China has a wider network

China and Thailand's geographic location and policies are conducive to the development of rail logistics, and both emphasize technological advancement and international cooperation. However, while China relies on a well-developed railroad network and advanced technology, Thailand needs to optimize its infrastructure and promote regional cooperation to strengthen its position as a logistics hub in Southeast Asia.

Table 5 Key Opportunities in Railway Logistics Development

Feature	China	Thailand	Commonalities	Differences
Geography	Belt and Road routes	SE Asia hub for cross-border transport	Use location to boost rail logistics	China: global focus; Thailand: regional focus
Technology	Smart, high-tech railway systems	Upgrade tech & management systems	Tech = key to efficiency	China: advanced systems; Thailand: basic upgrade

Table 5 Key Opportunities in Railway Logistics Development (continued)

Feature	**China**	**Thailand**	**Commonalities**	**Differences**
Policy	Direct gov't investment & incentives	PPP model for infrastructure funding	Gov't support plays key role	China: state-led; Thailand: public-private
Environment	Aligns with global carbon goals	Local green strategies	Emphasize sustainability	China: global impact; Thailand: local focus
Cooperation	Global (e.g., China-Europe Express)	Regional (ASEAN & neighbors)	Committed to international collaboration	China: global; Thailand: regional

Both Chinese and Thai experts agree that achieving ideal rail logistics requires upgrading infrastructure and promoting technological innovation and policy support, but the strategies have different emphases: China focuses on the application of technology and the optimization of domestic demand, while Thailand focuses on infrastructure and regional cooperation, reflecting the differences between the two countries in terms of their economic development and geographic location.

Table 6 Key Challenges in Railway Logistics Development

Feature	China	Thailand	Commonalities	Differences
Infrastructure	Upgrading needed in some areas	Requires large-scale investment	Both require modernization	China optimizes, Thailand builds
Technology	Requires continuous upgrades	Lacks advanced systems	Both face tech challenges	China focuses on leadership, Thailand on adoption

Table 6 Key Challenges in Railway Logistics Development (continued)

Feature	China	Thailand	Commonalities	Differences
Policy	More market-driven reforms	Needs stronger incentives	Both depend on policy support	China moves toward marketization
Environment	Reducing large-scale impact	Introducing green logistics	Both focus on carbon reduction	China is globally aligned, Thailand is regional
International Cooperation	Belt & Road-driven expansion	Regional logistics partnerships	Both emphasize cooperation	China has broader outreach

Railroad logistics service providers in China and Thailand share common needs and challenges in realizing sustainable development, such as investment in technology, human resource development, and environmental practices, but with different implementation priorities: China focuses on technological upgrading and international expansion, while Thailand needs to strengthen basic technology and regional cooperation. These preparations will help to better respond to future trends and market demands.

Table 7 Strategic Directions for Future Development

Feature	**China**	**Thailand**	**Commonalities**	**Differences**
Infrastructure	Expand high-speed & freight rail	Upgrade single to double-track	Both upgrading networks	China expands, Thailand modernizes
Technology	IoT & AI-driven logistics	Introducing smart systems	Both integrating digitalization	China has advanced AI logistics

Table 7 Strategic Directions for Future Development (continued)

Feature	China	Thailand	Commonalities	Differences
Policy & Market	Flexible market-driven strategies	PPP-based incentives	Both need strong policy backing	China focuses on deregulation
Environmental Sustainability	Electrification & renewables	Green logistics strategies	Both promote sustainability	China invests in clean energy
International Partnerships	Belt & Road global projects	ASEAN regional cooperation	Both enhance connectivity	China operates at a larger scale

From semi-structured interviews with six experts, can be analyzed systematically and integrating the results of the literature review for being concluded as follow.

Conclusion, Discussions and Recommendation

1. Conclusion

1) Development Status and Infrastructure

Thailand relies on an aging single-track rail system (Hengsadeekul et al., 2024), while China has more advanced technology and an extensive rail network (Singh et al., 2021). This study points out that there are significant differences in rail logistics infrastructure between China and Thailand. In contrast, existing studies may focus more on the current state of infrastructure in a single country and lack cross-country comparisons, especially in terms of technology and infrastructure.

2) Technology Applications

This study emphasizes the application of information technology and intelligence in railway logistics, such as China's more advanced information management in high-speed rail and freight services. This is consistent with the existing literature that emphasizes the key role of technological innovation in improving logistics efficiency (Liu et al., 2019), but this study adds a new dimension to cross-country research by providing a specific comparison of the extent of technological application in China and Thailand.

3) Policy Supports and International Cooperation

The study found that both China and Thailand emphasize the importance of national policy support and international cooperation (Punyaratabandhu & Swaspitchayaskun, 2018). However, compared to previous studies, this study can explore in more detail the specifics of different national policies and their impact on the sustainable development of railway logistics, especially in the context of the PPP model and the “Belt and Road” initiative.

4) Environmental Objectives and Sustainable Development

This study emphasizes the centrality of environmental protection and sustainable development in railway logistics strategies (Godil et al., 2021). While the concept of green logistics is also widely discussed in the existing literature, this study provides more specific data and comparative analysis to illustrate the differences and challenges in achieving these goals in China and Thailand.

2. Discussion

1) Infrastructure

China's railroads are technologically advanced and well networked, while Thailand still relies on an old monorail system, showing a significant development gap.

2) Technology application

China is more mature in informationization and intelligent management, especially in high-speed rail and freight services; this study is the first cross-country study that compares China and Thailand in terms of technology application.

3) Policies and cooperation

Both countries emphasize policy support and international cooperation, especially in the context of the PPP model and the “Belt and Road”, which provide more in-depth policy analysis for existing studies.

4) Environmental protection and sustainable development

The study emphasizes the importance of green logistics and reveals the differences and challenges in achieving environmental protection goals in China and Thailand through concrete data and comparisons.

3. Recommendation

1) Recommendations for Enterprises

Enterprises should actively adapt to new technologies to improve service quality and operational efficiency, while focusing on environmental practices and rapid changes in the market. Chinese firms can concentrate more on the integrated application of high-end technologies (e.g., AI, IoT, Big Data Analytics, Blockchain Technology, Automation and Robotics), while Thai firms should focus more on the application of basic technologies and the deepening of regional cooperation.

2) Suggestions for Policymakers

The government should continue to provide strong policy support and financial investment to promote market reform orientation and enhance the market competitiveness of railway logistics. In addition, policymakers should pay attention to international cooperation and regional economic integration, especially in terms of policies on cross-border transportation and environmental protection, in order to support the sustainable development of railway logistics.

3) Suggestions for Future Research Directions

Future research on the sustainable development of railway logistics should focus on the application and challenges of information and smart technologies (e.g., the Internet of Things, artificial intelligence and big data) in enhancing transport efficiency, as well as analyzing countries' strategies for upgrading and expanding railway infrastructure and their impact on transport capacity. The study should also assess the environmental and economic benefits of green technologies in railway logistics and promote the development of low-carbon transportation modes. In addition, the impact of policies, regulations and market incentives on the sustainable development of railway logistics is crucial, especially how governments can support private investment and international cooperation through policies. Further research should also explore the optimization of international cooperation and intermodal transport systems, as well as how market demand drives innovation in railway logistics services. These research directions will not only contribute to the development of the industry, but also provide strategic guidance to policymakers and practitioners.

Reference

Annika, Z., Felix, R., Mirko, P., Henning, S., Dustin, B., Bruno, V., & Maeyce, T. (2022). *Riding the rails to sustainability*. Retrieved from https://www.bcg.com/publications/2022/riding-the-rails-to-the-future-of-sustainability

Economic and Social Commission for Asia and the Pacific. (2023). *Policies and Issues Related To the Development and Operationalization of the Trans- Asian Railway Network*. Bangkok: United Nations ESCAP.

Godil, D. I., Yu, Z., Sharif, A., Usman, R., & Khan, S. A. R. (2021). Investigate the role of technology innovation and renewable energy in reducing transport sector CO emission in China: A path toward sustainable development. *Sustainable Development, 29*(4), 694-707.

Hengsadeekul, T., Chaosakul, T., Parichatprecha, R., & Pakdeenarong, P. (2024). The current situation and the directions of changes in rail freight transport in thailand. *Journal of Infrastructure, Policy and Development, 8*(9), Article 6790. https://doi.org/10.24294/jipd.v8i9.6790

Iriste, S., & Katane, I. (2018). Expertise as a Research Method in Education. In *Rural Environment. Education.Personality (REEP)* (Vol. 11, pp. 74-80). https://doi.org/10.22616/REEP.2018.008

Jiao, P. (2024). Research on the informatization and optimization of railway freight logistics. *Engineering Management, 5*(2), 97-99.

Larina, I. V., Larin, A. N., Kiriliuk, O., & Ingaldi, M. (2021). Green logistics— Modern transportation process technology. *Production Engineering Archives, 27*(3), 184-190.

Liu, X., Schraven, D., de Bruijne, M., de Jong, M., & Hertogh, M. (2019). Navigating transitions for sustainable infrastructures—The case of a new high-speed railway station in jingmen, China. *Sustainability, 11*(15), 4197. https://doi.org/10.3390/su11154197

Mfk. (2024). *Countries with the largest railway networks (2025 ranking)*. Retrieved from https://worldostats.com/infrastructure/railway-network-by-country/

Peetawan, W., & Suthiwartnarueput, K. (2018). Identifying factors affecting the success of rail infrastructure development projects contributing to a logistics platform: A thailand case study. *Kasetsart Journal of Social Sciences, 39*(2), 320-327.

Pinto, J. T. D. M., Mistage, O., Bilotta, P., & Helmers, E. (2018). Road-Rail Intermodal Freight Transport as a Strategy for Climate Change Mitigation. *Environmental Development, 25*, 100-110. https://doi.org/10.1016/j.envdev.2017.07.005

Punyaratabandhu, P., & Swaspitchayaskun, J. (2018). The political economy of China–thailand development under the one belt one road initiative: Challenges and opportunities. *The Chinese Economy, 51*(4), 333-341.

Punyaratabandhu, P., & Swaspitchayaskun, J. (2021). Thailand's perception and strategy toward China's BRI expansion: Hedging with cooperating. *The Chinese Economy, 54*(1), 69-77.

Secretariat of the Trans-Asian Railway Network Working Group. (2023). *Policies and issues related to the development and operationalization of the Trans-Asian Railway Network. Economic and Social Commission for Asia and the Pacific*. Retrieved from https://www.unescap.org/sites/default/d8files/event- documents/ESCAP_TARN(8)_5_C.pdf

Singh, P., Dulebenets, M. A., Pasha, J., Gonzalez, E. D. R. S., Lau, Y. -Y., & Kampmann, R. (2021). Deployment of Autonomous Trains in Rail Transportation: Current Trends and Existing Challenges. *IEEE Access, 9*, 91427-91461. doi:10.1109/ACCESS.2021.3091550

Singh, P., Elmi, Z., Krishna Meriga, V., Pasha, J., & Dulebenets, M. A. (2022). Internet of things for sustainable railway transportation: Past, present, and future. *Cleaner Logistics and Supply Chain, 4*, 100065. https://doi.org/10.1016/j.clscn.2022.100065

Statista. (n.d.). *Transport CO2 emissions shares by type*. Retrieved from https://www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/

Tian, P. -N., Mao, B. -H., Tong, R. -Y., Zhange, H. -X., & Zhou, Q. (2023). Analysis of carbon emission level and intensity of China's transportation industry and different transportation modes. *Climate Change Research, 19*(3), 347-356. doi:10.12006/j.issn.1673-1719.2022.183

Wang, T., & Chen, J. (2023). Exploration of Design Strategies for International Public Logistics Product Services in the Context of Sustainable Development: A Case Study of the "The China Railway Express". In Z. Wang, Q. Wu, S. Liu, G. Wang, & J. Li (Eds.), *Proceedings of the 2023 2nd International Conference on Public Service, Economic Management and Sustainable Development (PESD 2023)* (pp. 283-291). Dordrecht: Atlantis Press.

Zhang, W., Zhang, X., Zhang, M., & Li, W. (2020). How to coordinate economic, logistics and ecological environment? Evidences from 30 provinces and cities in China. *Sustainability, 12*(3), 1058. https://doi.org/10.3390/su12031058

Zhang, Y. (2021). *Analysis on the current situation and trend of high-speed rail freight development*. Retrieved from https://chn.oversea.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2021&filename=WLJS202104007&uniplatform=OVERSEA&v=1mEA9r8RWLE7zMy_eaXiS7Ih4PYIwhgWrHUvBvhRAl99_5yl2t56Z9C1q3Qhyju2