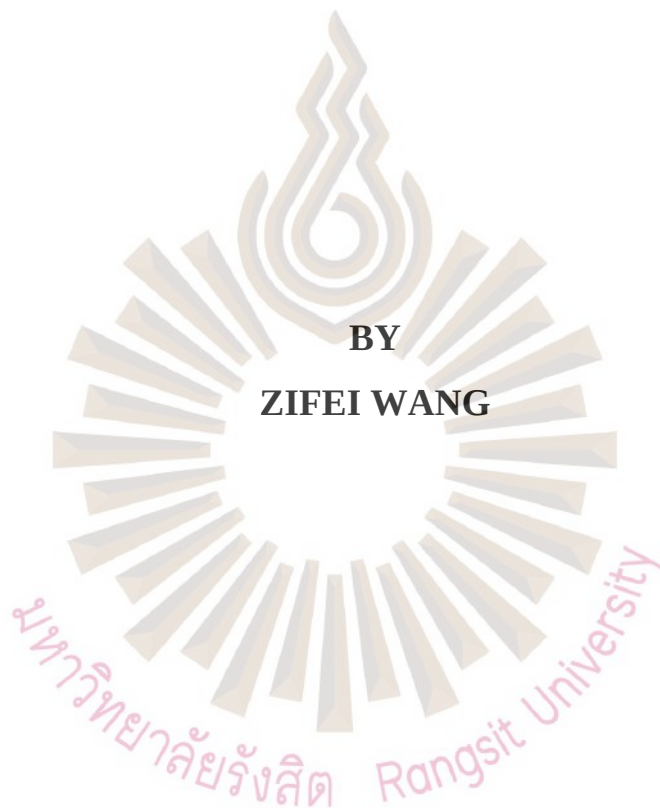




**OPPORTUNITIES AND CHALLENGES FOR SUSTAINABLE
DEVELOPMENT OF RAILWAY LOGISTICS**



**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
IN MANAGEMENT OF LOGISTICS**

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**OPPORTUNITIES AND CHALLENGES FOR SUSTAINABLE
DEVELOPMENT OF RAILWAY LOGISTICS**

by

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was submitted in partial fulfillment of the requirements
for the degree of Master of Science in Management of Logistics

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Abstract

Focusing on China and Thailand, this thesis explores the opportunities and challenges of sustainable development of railroad logistics in the global context. The study outlines the current status of railroad logistics in the two countries, emphasizing the advantages of energy-saving and low-carbon railroad transport.

The study assesses the current state of railroad logistics development, emphasizing the rapid advancement of railroad logistics technology in China and the superior strategic location of Thailand. The study found that key opportunities include policy support and technological innovation, which are essential to advancing the sustainable development of railroad logistics. Key challenges include infrastructure constraints, technological upgrades, and effective policy frameworks that hinder the sustainable development of railroad logistics.

This study provides policy recommendations, suggesting that increasing investment in technology research and infrastructure, encouraging green practice policy reforms, and optimizing international cooperation can achieve the sustainable development of railroad logistics. The study advocates an integrated approach that combines technological innovation with strong policy support to optimize the sustainable development of global rail logistics.

The study aims to provide strategic guidance to businesses, policymakers and future research directions to help them cope with the complexities of sustainable development in the rail logistics industry.

(Total 61 pages)

Keywords: Railway Logistics, Railway Transportation, Sustainable Development,
 Green Logistics, Logistics Management, Supply Chain Management

Student's Signature Thesis Advisor's Signature

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CHAPTER 1

INTRODUCTION

1.1 Background and Significance of the Problem

At present, the impact of environmental pollution on human survival is expanding, and sustainable development has become a global strategic consensus that guides all walks of life. This applies to all economic sectors, including logistics, and railway logistics, as an important mode of cargo transportation, has a pivotal position in the modern logistics system, providing an efficient and economical mode of transportation for long-distance cargo transportation (Wang & Chen, 2023). However, with the expansion of the world economy, the development of the logistics industry and its carbon footprint have become more and more serious (Allison, 2015). Railway logistics has more potential than any other mode of logistics and transportation to combat greenhouse gas emissions and global warming. According to the latest data from the International Energy Agency (IEA), railways account for only 3% of global transportation energy consumption, but are responsible for 9% of passenger traffic and 7% of freight traffic, making them highly energy efficient. Compared with trucks, railway transport per ton of goods only consumes one fifth of the energy required by trucks. And while the advancement of railway electrification is making the role of railways increasingly important in achieving logistics sustainability goals, only about one-third of the global rail network has been electrified, with North America's electrification level being particularly low at only about 1% (Annika et al., 2022). Therefore, the road to sustainable development of international railway logistics is full of challenges, and the realization of sustainable development of railway logistics is a long way to go.

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Working Group on the Trans-Asian Railway (TAR), at its eighth meeting,

discussed “Policies and Issues Related to the Development and Operationalization of the Trans-Asian Railway”, which covers sustainable development of railway logistics. Logistics Sustainability. The meeting recognized the novel coronavirus pandemic of 2019, an epidemic that clearly demonstrated the resilience of rail transport, which, given its inherent advantages, could be identified as a core dimension of sustainable transport. The conference pointed out the need for sustainable development of rail logistics through three dimensions: economic, environmental and social. Positive economic impacts could be achieved by removing physical and non-physical barriers to rail connectivity and by integrating with other modes of transportation. Transport accounts for nearly a quarter of global greenhouse gas emissions, with about three quarters of emissions coming from road transport, while railways produce lower emissions than other modes of transport and can be further reduced to near-zero levels, promoting environmental sustainability. The contribution to society can be expanded by improving rail accessibility to rural areas, creating jobs, expanding employment for socially disadvantaged groups, and strengthening regional links (Economic and Social Commission for Asia and the Pacific, 2023).

China’s railway logistics industry is currently in the stage of large-scale information technology development. Although information technology has been widely used in many aspects such as transportation scheduling, logistics tracking, loading and unloading operations and customer service, the overall level of informatization is still low and there is an obvious gap with the international advanced standards. Railway freight informatization system is relatively closed, the system's internal information resources are limited to the exchange of users within the system, not open to the market logistics customers. Therefore, it is necessary to realize the efficient integration of resources and common development of the railway logistics industry in order to ensure its sustainable development in the modern logistics competition (Jiao, 2024). However, compared with highway and air transportation, railway freight transport has obvious advantages in energy saving and emission reduction, with low energy consumption, low emission, low pollution and other advantages, which is an important initiative to promote the sustainable development of

China's logistics industry, protect the "green water and green mountains" strategy, and respond to the call of "winning the battle of defending the blue sky". It is an important initiative to promote the sustainable development of China's logistics industry and to protect the strategy of "green water and green mountains" and respond to the call of "winning the battle for blue sky" (Zhang, 2021). The road of sustainable development of railway logistics is also a road full of challenges and opportunities, how to overcome the difficulties to meet the challenges and grasp the opportunities is the significance of this study.

This paper analyzes the necessity of sustainable development of railway logistics based on national policy, economic benefits, technology and equipment, and studies the opportunities and challenges that will be faced by the sustainable development of China's railway logistics, so as to provide guidance and reference for the sustainable development of railway logistics enterprises and policy makers. At the same time, the construction of the China-Thailand Railway is being accelerated, which will help to promote the construction of the "One Belt, One Road" mutually beneficial and win-win road. The benefits of the study for Thailand include promoting the sustainable development of railway logistics, improving transportation efficiency, reducing energy consumption and pollution emissions, and promoting the coordinated development of the economy and the environment. By introducing China's energy-saving and environmentally friendly technologies and intelligent equipment, Thailand will be able to improve its logistics network and realize an efficient, green and intelligent transportation system, thereby increasing the cost-effectiveness of logistics and environmental protection, and promoting the modernization of the country's infrastructure.

1.2 Research Objectives

Based on the above research background, the main objectives of this study are:

1.2.1 Assess the current level of development of China's railway logistics industry.

1.2.2 Clarify the necessity of sustainable development of railway logistics.

1.2.3 Explore the opportunities and challenges to further realize the sustainable development of railway logistics.

1.2.4 To provide guidance and reference for sustainable development for railway logistics enterprises and policy makers.

1.3 Research Questions/ Assumptions

Therefore, the main issues of this study are:

1.3.1 What is the current status of the survey and analysis of China's railway logistics industry?

1.3.2 What is the ideal situation of the sustainable development of railway logistics?

1.3.3 What are the opportunities in promoting sustainable development of railway logistics?

1.3.4 What are the main challenges hindering the sustainable development of railway logistics?

1.3.5 What are the issues related to the sustainable development of railway logistics that logistics service providers need to understand and adapt to?"

1.4 Research Framework

The following is a diagram of the research framework of this paper.

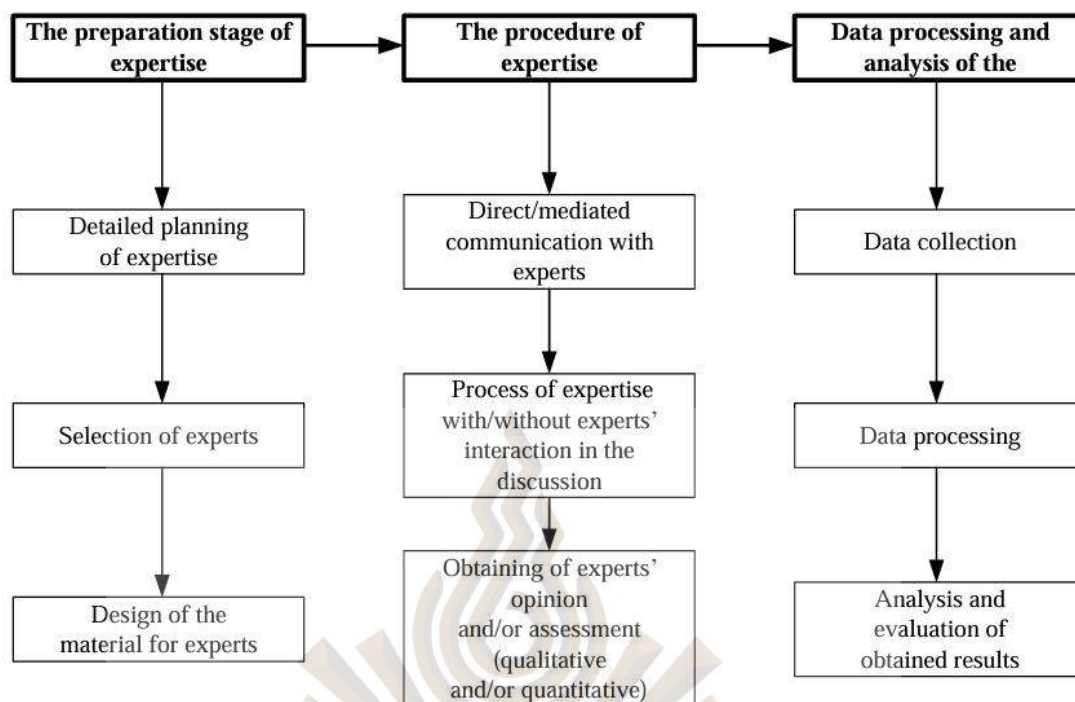


Figure 1.1 Thesis Research Framework

Source: Iriste & Katane, 2018

1.5 Definition of Terms

Railway Logistics: Railway logistics refers to the transportation of goods and related logistics services in the railway transportation system. Through the efficient transportation organization and management, information technology and multimodal transport, it provides stable, heavy-duty, long-distance, energy-saving and environmentally friendly logistics services. Its goal is to meet the needs of enterprises in transportation, warehousing, distribution, etc., optimize supply chain management, and achieve efficient integration of logistics, capital flow and information flow (Guo, 2021).

Sustainable Development: Sustainable development is a multidimensional concept that integrates development, environmental sustainability and equity. It emphasizes the need to preserve resources for future generations while meeting current socio-economic needs. Sustainable development involves a balance between economic growth, environmental protection and social well-being. The importance of clear

indicators and metrics to measure progress was also emphasized, as was the need for coherent policy responses to ensure long-term sustainability (Parris & Kates, 2003).

International Energy Agency: The International Energy Agency (IEA) was established in 1974, initially to ensure the security of oil supply. With the expansion of its functions, the IEA now covers a wide range of topics such as electricity security, climate change, air pollution, energy investment and efficiency, and has become an important organization in the global energy sector. Its overall goal has also expanded from oil security to promoting a secure and sustainable global energy transition (Liu, 2023).

Trans-Asian Railway: The Trans-Asian Railway (TAR), originating as an initiative from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) in 1959, envisions a network of railways connecting Asia to Europe. This project aims to enhance connectivity and trade across multiple countries in Eurasia, offering an alternative land route to traditional maritime shipping lanes. The TAR involves multiple corridors across diverse regions, aiming to facilitate economic integration, improve logistics efficiency, and promote regional development by providing seamless rail connectivity for both freight and passenger transport.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP): The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) serves as the United Nations' main regional hub promoting cooperation among Asia-Pacific countries to achieve sustainable development goals. As the largest intergovernmental platform in the region, with 53 member states and 9 associate members, ESCAP focuses on providing analytical insights into regional economic, social, and environmental issues. Through research, policy advisory services, capacity-building initiatives, and technical assistance, ESCAP supports the 2030 Agenda for Sustainable Development, with a focus on regional connectivity, financial cooperation, and market integration.

CHAPTER 2

LITERATURE REVIEW

This chapter analyzes the necessity of sustainable development of railway logistics based on national policies, economic benefits, and technological equipment, examines the opportunities and challenges that will be faced by the sustainable development of railway logistics in China, and simultaneously understands the sustainable development of railway logistics in Thailand. This study collects existing literature on the sustainable development of railway logistics, including books, academic journals, newspapers, conference literature, scientific and technical reports, standard literature, patent literature, dissertations, technical archives, and electronic literature, which together inform the research objectives outlined in this chapter.

2.1 The Current Situation of China's Railway Logistics Industry

The official website of the United Nations released the “United Nations decarbonization strategy for global inland transport to achieve carbon neutrality by 2050”, the data in the article show that the transportation sector accounts for about 23% of the annual global greenhouse gas emissions, and inland transportation accounts for 72% of the emissions from this sector; and among this part of the emissions, 69% comes from road transportation, 2% from inland waterway navigation, and only 1% from railways. Tian, Mao, Tong, Zhange, and Zhou (2023) the study estimates that China's transportation sector will emit 1.274 billion tons of CO₂ in 2019, accounting for 12.42% of the country's total CO₂ emissions. The structure of China's transportation carbon emissions is relatively decentralized, with road transportation emissions as the main body of carbon emissions accounting for 79.15%, while the carbon emissions from aviation, waterways and rail transportation are 9.13%, 7.06% and 4.39% respectively. It can be seen that the environmental load of railway transportation is much smaller compared with road transportation.

2024 On February 28, the Information Office of the State Council held a briefing on the high-quality development of transportation to serve Chinese-style modernization. At the conference, Fei Dongbin, director of the State Railway Administration, introduced the rapid development of China's railways, with the electrification rate reaching 73.8 percent by the end of 2023. Compared with 2012, the national railway freight traffic increased by 29%, in a strong service to economic and social development, but also for the construction of a beautiful China to make a positive contribution.

Rail logistics is improving service levels, speed of delivery and operational efficiency through the adoption of a wide range of advanced technologies. The application of IoT integrated technologies in railway transportation systems is also becoming more common, allowing real-time collection and analysis of logistics data to monitor the progress of cargo transportation and optimize the logistics transportation process, thus improving overall transportation safety and efficiency (Singh et al., 2021). On June 21, 2016, the People's Republic of China General Office of the State Council issued the "Implementation Plan for Creating a Good Market Environment to Promote the Integrated Development of Transportation and Logistics", which specifies the implementation roadmap for the integrated development of transportation and logistics in China, accelerates the transformation and development of railway freight transport into modern logistics, and gives full play to the backbone role of railways in the social logistics system. On April 23, 2024, Yunnan Provincial Department of Transportation published an article titled "Innovative Practice of 'Transportation + Logistics' Integrated Development". The article reported on the innovative practice of integrated development of transportation and logistics led by Yunnan Provincial Transportation Investment and Construction Group, focusing on the Kunming National Comprehensive Freight Hub Chain Replenishment and Chain Strengthening Project Yunnan Highway (Reading Shop) Central Warehouse Project, which is part of the 14th Five-Year Plan for Yunnan's modern logistics development. The project aims to enhance the emergency logistics capacity and multimodal transportation services, through the freight corridor, can be seamlessly connected to the reading pavement railway freight station within the

railway line, to carry out containerized public-railway intermodal transport business, improve the regional logistics infrastructure construction, and promote regional economic development.

While the expansion of the logistics industry has been beneficial to economic growth, it also poses ecological challenges. Green logistics is promoted as a key strategy for sustainable development by minimizing the environmental impact of railway logistics activities, using renewable energy sources, and enhancing ecological protection measures in railway logistics practices (Zhang, Zhang, Zhang, & Li, 2020). Based on evidence from 30 provinces and municipalities in China, it is concluded that there are regional differences in the integration of logistics and ecological management in different regions of China, with developed regions such as Shanghai and the eastern coastal provinces performing better in harmonizing economy, logistics and ecology, while less developed regions lag behind in terms of sustainable practices. The article concludes with recommendations for policy reforms to improve the sustainability of rail logistics operations, including investing in green technologies, enforcing stricter environmental regulations, and providing support for companies that are practicing sustainable rail logistics.

2.2 The Current Situation of Thailand's Railway Logistics Industry

Thailand's railway network consists mainly of single-track (81.85%), with a relatively small proportion of double-track (15.5%) and triple-track (2.65%), which limits transport capacity and efficiency. The current development plan for rail freight mainly includes the double-tracking project and the "Eastern Economic Corridor" rail plan, which aims to expand the rail network and develop modern railways to increase the capacity and efficiency of rail transport (Hengsadeeikul, Chaosakul, Parichatprecha, & Pakdeenarong, 2024).

As of 2022, the total freight transported by rail is 11.08 Mt, and the proportion of rail transportation in Thailand's total freight transportation is only about 2.4%, still

relying mainly on road transportation. Despite the growth in freight traffic in recent years, rail's share of the overall freight market is relatively small and there is room for significant growth in the future (Peetawan & Suthiwartnarueput, 2018). Thai railways are seen as a key node in the intermodal system connecting trucks and ships, but need to become more competitive in the 200-500km intermediate distances in order to reduce transportation costs and enable more efficient freight transport options (Hengsadeekul et al., 2024).

Hengsadeekul et al. (2024) mentions that rail transportation has higher energy efficiency and lower carbon emissions compared to road transportation, which can help Thailand to achieve the Sustainable Development Goals (SDGs) and contribute to the reduction of greenhouse gas (GHG) emissions. Thailand's geographic location gives its railways the potential for cross-border transport with connections to neighboring countries to support regional economic integration, such as trade through the Thailand-Laos-China route. The Thai government promotes rail infrastructure improvements through policies and investments, such as the public-private partnership (PPP) model, which can be effective in reducing public debt while bringing in external capital (Peetawan & Suthiwartnarueput, 2018).

Thailand has a high proportion of single-track railways, which leads to inefficiencies in transportation. In addition, many tracks and bridges have insufficient load-bearing capacity, limiting train speed and capacity, which is a major obstacle to increasing the proportion of freight transported by rail (Hengsadeekul et al., 2024). Insufficient number of freight train cars and old facilities to meet current freight demand affect the reliability of cargo transportation, and the lack of proper container space also hinders the improvement of transportation efficiency. The problem of backhaul empties increases the overall cost of rail transportation (Peetawan & Suthiwartnarueput, 2018).

2.3 The Ideal State of Sustainable Development of Railway Logistics

According to the Mobilizing Sustainable Transport for Development report released in 2016 by the United Nations Secretary-General's High-Level Information Panel on Sustainable Transport, sustainable transport is the provision of services and infrastructure for the movement of people and goods in a safe, affordable, accessible, efficient and resilient manner that promotes economic and social development for the benefit of present and future generations; while ensuring that the impact of carbon and other emissions and impacts on ecosystems, particularly biodiversity, are minimized. Sustainable rail logistics aims to minimize the environmental impact of transport activities, including the reduction of greenhouse gas emissions, pollution and energy consumption through the use of “green” logistics and technologies. Larina, Larin, Kiriliuk, and Ingaldi (2021) suggests that the integration of green technologies into railway operations and infrastructure is a priority for railways, including the use of fuel-efficient vehicles, improved fuel technologies, and the adoption of advanced systems for monitoring and managing environmental performance. Railway logistics can be made sustainable by optimizing resource use and reducing energy consumption. Singh, Elmi, Krishna Meriga, Pasha, and Dulebenets (2022) sustainability in rail logistics can be achieved through better train scheduling, improved route management and increased asset utilization, reducing the carbon footprint of rail operations.

Yuan (2017) it has been demonstrated in studies that sustainable projects in railway logistics are not only about environmental sustainability, but also about sustainability at the economic and social level, which includes ensuring the economic viability of railway transport and further promoting social welfare, addressing issues such as accessibility and affordability of railway logistics, and incorporating the interests of a wide range of stakeholders. interests, etc. The sustainability of railway logistics relies heavily on the active participation of various stakeholders, including government agencies, environmental organizations and the public.

Pinto, Mistage, Bilotta, and Helmers (2018) argues that the ideal state of sustainable railway logistics is to significantly reduce greenhouse gas emissions, such as CO₂, by integrating intermodal transport by road and rail, and that by shifting goods from road to rail transport, environmental impacts can be significantly reduced and climate change mitigated due to the lower per-unit emissions from rail transport. It also improves fuel efficiency and reduces transportation costs. Rail transport can efficiently move large quantities of goods over long distances, and in combination with road transport, it provides flexible last-mile connectivity, thus optimizing logistics operations.

He, Shen, Wu, and Luo (2018) argues that the ideal state of sustainable development of railway logistics also requires proactive government policies that promote infrastructure development, ensure the availability of land for logistics, and incorporate policies to improve railway infrastructure to support economic development and environmental considerations into logistics planning. Sustainable railway logistics development should be integrated with urban planning to optimize the use of land and infrastructure. Sustainability of cities as a whole and of rail logistics can be improved by planning logistics facilities and infrastructure, such as rail and intermodal terminals, to reduce urban sprawl and congestion.

2.4 Key Opportunities for Sustainable Development of Railway Logistics

2.4.1 Policy Support

The Chinese Government, in its Fourteenth Five-Year Plan and Vision 2035 Outline, explicitly proposes to strengthen the construction of railway logistics networks and to enhance the capacity and service level of railway freight transportation. The government's measures to support the development of railway logistics include increasing public investment, promoting the construction of inter-regional railway logistics centers, and optimizing related administrative and service processes to ensure the efficient operation and sustainable growth of the railway logistics industry. The

Chinese government has provided a number of tax incentives to promote the sustainable development of the rail logistics industry.

In April 2021, the Department of Tariff Collection and Management of the General Administration of Customs of the PRC issued the “Guidelines on the Valuation of Return Transportation and Related Costs of China-European Union Liner Train”, which clarifies that the transportation and related costs of the internal section that meet the relevant conditions for deduction are not counted as part of the duty-paid price of the imported goods, and promotes the initiative of deduction of freight charges of the internal section of the return cargo of the China-European Union Liner Train on a nationwide scale, so as to support the enterprises in enjoying the full benefit of the national policy of tax reduction and fee reduction.

On October 10, 2023, China's Ministry of Finance and the State Administration of Taxation jointly issued an announcement on the continuation of the preferential policy on urban land use tax for land used for storage facilities for bulk commodities by logistics enterprises. From January 1, 2023 to December 31, 2027, the urban land use tax on land for bulk commodity warehousing facilities owned (including self-use and lease) or leased by logistics enterprises will be reduced by 50% of the applicable tax standard of the land class to which it belongs.

The Chinese government, through the National Development and Reform Commission (NDRC) and other agencies, has invested directly in key railway construction projects to provide financial support, reduce the pressure on enterprises to invest in sustainable technologies and equipment, enhance the modernization and sustainability of the railway network, encourage enterprises to participate in the modernization and green reform of railway logistics, and accelerate the transformation and development of the industry in the direction of environmental protection, high efficiency and energy conservation. Policy banks such as the Development Bank of China (DBC) have provided substantial loans to support the construction of railway infrastructure. For example, the Development Bank of China issued a loan of RMB

105.5 billion in 2023 to support the construction of about 2,300 kilometers of new railway lines. Through the support of international financial institutions such as the Asian Infrastructure Investment Bank (AIIB), China has secured \$300 million in funding proposed by the AIIB for the China-ASEAN Sea-Rail Multimodal Logistics Project to develop green, resilient, and smart logistics parks to facilitate regional and cross-border trade.

The “Belt and Road” initiative has brought a once-in-a-lifetime development opportunity for international rail intermodal transport, and is promoting the containerization of China's rail freight, intermodal transport, operational efficiency and international cooperation. China Railway has become a national business card to promote the construction of “Belt and Road”. From the news released by National Development and Reform Commission of the People's Republic of China on December 09, 2021, we can find that as an important carrier and platform of “Belt and Road”, China-European liner has initially unleashed the development of Asian-European railway transportation and has become an important platform for the development of international railway transportation. As an important carrier and platform of the “Belt and Road”, it has initially unleashed the potential of the Asia-Europe land logistics and trade corridor, and promoted economic and trade cooperation between China and the countries along the route as well as other European countries. In recent years, under the framework of “One Belt, One Road”, China Railway has been accelerating the pace of “going out”, and the China-Laos Railway, the Hungarian-Serbian Railway, the Monnet Railway, the Yavan High Speed Railway Railway has been put into operation, which makes railway construction an important part of China's economic and trade cooperation. Put into operation, railway construction has become an important aspect of the “Belt and Road” and international production capacity cooperation, which not only promotes the economic development of the countries and regions under construction, but also enhances regional connectivity, strengthens infrastructure investment and construction, and optimizes the multimodal transportation system.

Thailand has a clear geopolitical advantage in developing railway logistics. As one of the core countries in Southeast Asia, it plays a key role in regional logistics and has the opportunity to enhance trade links with neighboring countries through railway logistics. Investing in railway infrastructure development, including high-speed railways and intercity transportation, will not only improve logistics efficiency but also help reduce carbon emissions. The China-Thailand Railway is not only a bilateral flagship project under China's Belt and Road Initiative, but also a key component of the Trans-Asian Railway network. On July 13-14, 2024, the cross-border railway linking Thailand and Laos reportedly underwent a trial run. Immediately after, on July 19, Express Train 133 departed Bangkok for Vientiane, Laos, the first shuttle train between China and Thailand. In just one and a half months, the number of Thai passengers inspected and cleared at China's Mohan Railway Port has increased by nearly 50 percent compared to the same period last year, and 13,000 tons of Thai fruits have been shipped to China via this railway. The new Prime Minister Paetongtarn Shinawatra, who takes office on August 18, 2024, has also emphasized his desire for more cooperation with China, injecting a shot in the arm for the future of the China-Thailand railway project.

2.4.2 Technological Innovation

Technological innovation is an indispensable key factor for the development of any industry in any country. Science and technology innovation plays a role in the sustainable development of railway logistics. “International Symposium on Lightweight Technology for High-speed Railway” was held in Bangkok, Thailand on June 1, 2023, the scientific and technological cooperation of high-speed railway continues to deepen, and China and Thailand discuss the new ideas of high-speed railway technology development, with the aim of sharing the experience of China's technical innovation in rail transportation and the popularization and application of lightweight technology, and boosting the development of Thailand's high-speed railway. Thailand's high-speed rail development. And the sustainable development of railway logistics will in turn counteract the scientific and technological innovation and bring many opportunities for scientific and technological innovation. The two complement each other, which will not

only improve the efficiency and safety of railway logistics, but also help the Thai railway system to integrate into the global green logistics network in a more environmentally friendly and efficient way, while enhancing international competitiveness and market adaptability.

High-speed rail improves the accessibility between regions, thus accelerating the flow of production factors and industrial transfer, optimizing the allocation of resources, and improving the capacity of railway transportation. The time and space compression effect of regional space brought about by high-speed rail reduces the cost of trade between cities and offers the possibility of lowering the physical cost, and it can also promote the flow of high-tech talents between cities and regions, providing high-skilled talents for railway logistics, which helps to promote the sustainable development of railway logistics. High-speed rail promotes the economic development of cities along the route through spillover effect, which helps further integration of economy, society and culture in the region and promotes regional economic growth (Guo & Ke, 2020).

The use of sustainable development concepts and circular economy (CE) concepts in the construction and planning of the XRL aims to reduce environmental impacts by improving energy efficiency, reducing material consumption and promoting resource reuse. By introducing circular economy, the HSR project can realize multi-dimensional sustainability benefits, for example, the reuse of materials not only helps to reduce costs, but also helps to reduce carbon emissions, thus realizing both economic and environmental benefits (Liu, Schraven, de Bruijne, de Jong, & Hertogh, 2019).

2.4.3 Cooperation Strategy

According to the report of the United Nations Commission on Economic and Social Affairs, Review of Sustainable Transport Connectivity in Asia and the Pacific 2019, regional cooperation and infrastructure integration are key to achieving sustainable transport (e.g., cross-modal transport). The sustainable development of rail logistics can be enhanced through cooperation between governments and support from

multilateral development agencies (Economic and Social Commission for Asia and the Pacific, 2019).

China's Belt and Road Initiative provides opportunities for Thailand to cooperate, for example, through investment in the Thailand-China High-Speed Rail Project and infrastructure development to enhance Thailand's regional connectivity and logistics efficiency. The construction of these railway infrastructures will help Thailand to better connect with other ASEAN countries, thereby expanding trade and investment cooperation and increasing economic linkages within and outside the region (Punyaratabandhu & Swaspitchayaskun, 2021).

The Asian Infrastructure Investment Bank (AIIB) has supported Thailand's infrastructure development under the Belt and Road framework, including rail transportation links. This financial support will help Thailand improve its rail logistics system and promote Thailand as a logistics hub in the ASEAN region, thereby increasing the sustainability and efficiency of the overall transportation network. Cooperation between China and ASEAN countries in the areas of transportation, trade, investment and energy also provides opportunities for the sustainable development of railway logistics. Such cooperation enhances intra-regional transportation connectivity, contributes to lowering logistics costs, strengthens intra-regional economic integration, and promotes the economic and social development of each country (Punyaratabandhu & Swaspitchayaskun, 2018).

2.5 Key Challenges for Sustainable Development of Railway Logistics

2.5.1 Environmental Issues

Carbon and greenhouse gas (GHG) emissions from railway logistics remain a major environmental concern. Although rail transport has lower emissions relative to road transport, the lack of investment in rail infrastructure makes it difficult to achieve full rail transport substitution for road transport. While rail-road intermodal transport is

an effective strategy for reducing emissions, it faces challenges in terms of infrastructure investment and expansion (Pinto et al., 2018). For example, Godil, Yu, Sharif, Usman, and Khan (2021) the study mentions that economic growth and energy consumption, in particular the use of fossil fuels, directly contribute to the increase in greenhouse gas emissions, which affects environmental sustainability. Railway logistics faces challenges in technological innovation and the use of renewable energy. Emphasized the important role of technological innovation and renewable energy in reducing carbon emissions from the transport sector, but technological progress in the railway sector was limited by financial and policy constraints. Rail transportation has a comparative advantage in terms of energy consumption and emissions, but remains dependent on fossil fuels. Further reductions in energy consumption and pollution emissions require energy-efficient upgrades to existing railway systems and the application of new energy technologies (Kelle, Song, Jin, Schneider, & Claypool, 2019).

2.5.2 The Technical Challenge

Railway infrastructure is expensive to build, especially for developing countries, with high capital requirements and long lead times. Pinto et al. (2018) states that the often-high cost of railway construction and maintenance is one of the main barriers to realizing large-scale rail transport. Financial and infrastructure constraints in many countries make it difficult to expand and modernize rail transport, which also limits the potential of railways to reduce emissions.

Current infrastructure development for rail transport is relatively underdeveloped and there are limitations in capacity and network coverage, which affects the potential of railways to improve overall transport sustainability. In addition, difficulties in coordination and connectivity between the existing rail transport network and new infrastructure affect transport efficiency and environmental performance. In order to reduce the pollution associated with road transport, higher environmental performance can be achieved through intermodal transport (a combination of rail, road and water transport). However, achieving this modal shift faces challenges in

interconnecting with existing infrastructure, such as junctions between modes of transportation that can become bottlenecks, increasing overall transport time and emissions (Kelle et al., 2019).

The current Thai rail network has aging and under-maintained infrastructure, with mostly single-track railway tracks, leading to operational inefficiencies that increase train delays and transit times. Infrastructure upgrades, such as the construction of double or multi-track railways, as well as improvements to bridges and track systems are necessary to meet the growing demand for freight transportation and improve operational efficiency. Thailand's rail freight has a limited number of wagons and locomotives to meet current freight demand, which leads to inadequate service capacity. Lack of facilities and inadequate equipment at railway stations and container yards increase operating costs and limit access for small businesses. The lack of modern technology in rail freight transportation, such as real-time tracking systems, limits operational efficiency and customer trust, and the inadequacy of predictive maintenance technology to identify equipment failures in advance, leading to disruptions in operations (Hengsadeekul et al., 2024).

2.5.3 Market Competition

Punyaratabandhu and Swaspitchayaskun (2018) pointed out that cooperation between China and Thailand under the Belt and Road framework through the railway logistics network had been affected by political and economic factors. Despite Thailand's geopolitical advantage as the center of Southeast Asia, China's growing influence has led to geopolitical and economic challenges, especially in attracting foreign investors and securing domestic infrastructure investment.

Thailand's railways are not well connected to other modes of transportation (e.g., road, air, and water), making it difficult to form a seamless intermodal transportation system, which affects the competitiveness of railway freight transport (Hengsadeekul et al., 2024). CRE suffers from an imbalance of imported and exported

goods during transportation, whereby the exported goods are much larger than the imported goods, and this imbalance increases the logistics costs, which This imbalance increases logistics costs and reduces transportation efficiency (Choi, 2021). Similarly, Thailand's tourism logistics supply chain faces similar imbalances, especially in terms of the relationship between urban infrastructure and economic development.

To summarize, both China and Thailand face challenges in the sustainable development of railway logistics in terms of inadequate infrastructure, insufficient policy and operational efficiency, and increased market competition. In particular, Thailand, as a logistics hub in Southeast Asia, still has deficiencies in its infrastructure and policies in adapting to the needs of China's Belt and Road Initiative, which require further development and improvement.

2.6 What Rail Logistics Companies Should Know and Adapt to

With the development of social and economic and logistics needs increase, railway logistics in the future development prospects are very broad, and strategic planning and technological progress in the development of railway logistics play a key role. Local governments and enterprises promote the sustainable development of railway logistics through strategic planning and investment. With the continuous progress of science and technology and the expansion of application fields, the railway logistics industry will usher in more technological innovation. In particular, the further expansion of technologies such as artificial intelligence, big data, and the Internet of Things (IoT) can effectively increase work efficiency, reduce human error and improve the safety of railway logistics operations (Singh et al., 2022). Future trends in China's railway logistics focus on four key areas: expanding logistics capacity through infrastructure improvements, enhancing connectivity to improve the efficiency of logistics routes, diversifying transportation routes to reduce dependence on traditional routes, and promoting intermodal transportation to reduce logistics costs (Wang, Wong, Li, & Yuen, 2021).

Logistics Service Providers (LSPs) can tailor a structured green practices framework for themselves, can fully implement an environmentally sustainable strategy, increase their efforts to investigate effective synergies between green practices and technical support, and clarify their roles and needs in the sustainable development of railway logistics (Centobelli, Cerchione, & Esposito, 2020).

Logistics Service Providers (LSPs) should also actively engage in research cooperation with the railway logistics sector to expand the breadth and diversity of research. Green practices and technology applications in railway logistics are still in their infancy, lacking mature technical support and a systematic green logistics network. Although information technology has been widely used in many aspects such as transportation scheduling, logistics tracking, loading and unloading operations and customer service, it is important to pay attention to the overall level of informatization while developing it on a large scale. Railway freight informatization system is relatively closed, and the information resources within the system are limited to the exchange of users within the system, and are not open to the market logistics customers (Jiao, 2024).

2.7 China's Best Benchmarks for Achieving Sustainable Development of Railroad Logistics

Li et al. (2019) In the article, it is said that China's railroad logistics should be Optimize the transportation speed, service frequency and transportation cost of railroad logistics to enhance its market competitiveness and sustainable development ability.

Li, Jin, Qi, Shi, and Ng (2018) emphasized that under the Belt and Road Initiative, logistics infrastructure should be optimized to enhance its market competitiveness and sustainable development. "The role of logistics infrastructure as a driver for economic growth under the Belt and Road Initiative is emphasized. For example, the construction of high-speed rail stations has not fully taken into account the needs of high-speed rail express transportation business, and there is a lack of specialized freight stations and supporting facilities. High-speed rail express trains could

effectively relieve the pressure on road transportation and reduce the problem of transportation pollution. The advantages of high-speed rail should be fully utilized to optimize the operation mode and plan of high-speed rail freight trains, so as to provide low-cost, environmentally friendly and fast logistics services (Yu et al., 2018).

China's rail freight is gradually transitioning to clean energy. While most rail transportation still relies on fossil fuels, the use of clean energy such as electricity and hydrogen is gradually increasing. The key to reducing the negative environmental impact of logistics and transportation is the adoption of advanced green logistics technologies. Electric freight vehicles, modal shift and intermodal transportation are implemented to reduce pollution emissions and promote sustainable development of railroad logistics (Ren et al., 2020).

2.8 Thailand's Best Benchmarks for Achieving Sustainable Development of Railroad Logistics

Peetawan and Suthiwartnarueput (2018) it is noted that the master plan for railroad development plays a decisive role in the success of the project. It is recommended that the Thai government develop a long-term, large-scale, comprehensive railroad development master plan covering both freight and passenger transport to ensure coordinated development of railroad infrastructure.

Hengsadeekul et al. (2024) emphasizes that the capacity of Thai rail freight will be significantly increased through the expansion of the double-track system, with a target of 10% of total freight volume by 2037. Upgrading infrastructure and expanding rail freight capacity would help promote a modal shift from road to rail, reduce greenhouse gas emissions and improve energy efficiency. To achieve a modern and sustainable rail logistics system, Thailand needed technological innovations such as automated rail systems, real-time tracking through the Internet of Things, blockchain to ensure supply chain transparency, and predictability to improve operational efficiency and reliability.

CHAPTER 3

RESEARCH METHODOLOGY

This study utilizes the qualitative research method of expert interviews, which are semi-structured interviews with experts. This chapter provides a comprehensive methodological framework for the expert interviews to ensure the quality and depth of the study, as well as to provide practical and theoretical contributions to the study of sustainable development of railway logistics. However, this study is limited by the willingness of experts to participate in the interviews.

3.1 Samples

3.1.1 Target Group

Selection of experts with relevant technical backgrounds such as railway logistics company from Thailand and China. A prominent railway logistics company in China is located in an important hub of China's railway transportation. It is an important channel for economic development and foreign trade transportation in eastern China and has regional representativeness. At the same time, the region where the company is located faces multiple challenges such as growing freight demand, environmental pressure and technological upgrading. It also has advantages such as policy support and technological innovation. Its front-line employees can provide profound and specific insights into sustainable development from the perspective of combining practice and theory.

3.1.2 Sample Size and Selection Method

In accordance with the needs of the study, six experts were interviewed. Three of the experts were from universities in Thailand, and two were faculty members of the logistics management program at University in Thailand who had worked in the logistics industry for

more than 30 years. Another expert is an associate professor in the Department of Industrial Engineering at University, Thailand, and is also a consultant in logistics for the Thai government. The other three experts were from a prominent railway logistics company in China and all three were senior engineers with more than 30 years of experience in the railroad industry, and were now in leading positions in the company. In order to ensure that the interviewed experts were able to provide insights into the sustainable development of railroad logistics, an intentional sampling method was used to select representative experts.

3.1.3 Sample Diversity

Ensure that the sample includes experts of different genders, years of experience, areas of specialization, and geographic locations to increase the breadth and depth of the study.

3.2 Research Instruments

3.2.1 Interview Outline

Develop a semi-structured interview outline (utilization of IOC), including open-ended questions, to guide the experts in sharing their insights and experiences. Questions should cover technological innovations, policy frameworks, industry practices, etc.

3.2.2 Recording Equipment

Use high-quality recording equipment to ensure that all interviews are clearly recorded.

3.2.3 Informed Consent

Sign an informed consent form to ensure the legality and ethical nature of the interview, clearly informing participants of their rights. The informed consent form contains information on the purpose, content, and privacy protection measures of the

interview to ensure that the interviewed experts participate voluntarily and agree to their statements and information being used in the study or publicly released.

3.3 Data Collection

3.3.1 Primary Data

Interviews with stakeholders such as rail logistics companies in China and academic experts in rail logistics in Thailand.

3.3.2 Secondary Data

Publicly available data from governmental sources, sustainability reports, industry publications, and case studies.

3.4 Data Analysis

3.4.1 Content Analysis

Content Analysis to systematically analyze the frequency and context of specific terms, phrases, or concepts within the literature or the related secondary data.

3.4.2 Framework Synthesis

Framework Synthesis to integrate the results of both sources into a unified framework. This study will integrate and harmonize the findings from the literature review and expert interviews to draw conclusions.

CHAPTER 4

RESEARCH RESULTS

This chapter summarizes in detail the data and insights obtained through the expert interviews and provides comprehensive answers to the various research questions posed at the beginning of the article. Through in-depth analysis of the interviews, this chapter not only reveals the actual situation of the current sustainable development of railway logistics, but also identifies future-oriented development strategies and challenges, providing a solid foundation for subsequent research and policy formulation.

4.1 Current Status of the Operation of the Railway Logistics System

Both China and Thailand are actively developing their railway logistics systems to improve the efficiency of domestic and cross-border logistics and transportation, but there are significant differences in terms of actual operation, system advantages, and challenges faced.

Table 4.1 Current Status of the Operation of the Railway Logistics System

Feature	China Railway Logistics	Thailand Railway Logistics	Commonalities	Differences
Infrastructure status	Extensive and continuously expanding railway network with advanced technology	The infrastructure is relatively old, mostly single track, and in urgent need of modernization	Both countries are promoting the modernization and technological upgrading of railway logistics systems	China's railway network is more extensive and technologically advanced

Table 4.1 Current Status of the Operation of the Railway Logistics System (Cont.)

Feature	China Railway Logistics	Thailand Railway Logistics	Commonalities	Differences
Technical Level	Information management of high-speed railways and freight services is relatively advanced	The infrastructure and technology level are low, and technology upgrades are being promoted	All are committed to improving transportation efficiency through technology	China's information and intelligent management are more developed
Policy support	The Chinese government strongly supports the development of railroad logistics, including capital investment. In the Fourteenth Five-Year Plan, it is expected that by 2025, China's investment in railroad fixed assets will remain above RMB 650 billion.	Policies gradually promote railway development, relying on the public-private partnership model (PPP)	Both governments are promoting the development of railway logistics	China's policy support is more direct and larger in scale, while Thailand relies more on international cooperation and private sector support

Table 4.1 Current Status of the Operation of the Railway Logistics System (Cont.)

Feature	China Railway Logistics	Thailand Railway Logistics	Commonalities	Differences
International Cooperation	The Belt and Road Initiative strengthens international logistics cooperation	Railway connections with neighboring countries are being promoted, such as the China-Thailand Railway	Emphasis on the role of railway logistics in regional integration and international cooperation	China's international railway logistics cooperation is more extensive, with cooperation projects with many countries
Transport Capacity	Large-scale domestic and international freight capabilities	Mainly relies on roads, with limited rail freight capacity	Both are trying to increase railway freight capacity	China's railway transportation capacity and efficiency are much higher than Thailand's
Environmental goals	Emphasis on reducing carbon emissions and improving energy efficiency	We are also committed to environmental protection and promoting railways to reduce carbon emissions from transportation	All are committed to reducing carbon emissions and improving the environmental friendliness of transportation	-

4.2 Significant Advantages of the Current Railway Logistics System

The Chinese and Thai railway logistics systems each have their own distinctive strengths and share common goals in terms of promoting environmental protection and technological upgrading. However, there are some differences between the two countries in terms of the degree of technological application, the manner of policy support, and the scope of international cooperation, which reflect the different levels of economic development and strategic priorities of the respective countries.

Table 4.2 Significant Advantages of the Current Railway Logistics System

Feature	Advantages of China's Railway Logistics	Advantages of China's Railway Logistics	Commonalities	Differences
Advantages	1. Large transportation capacity, low cost, strong environmental protection 2. Efficient international and domestic cargo transportation capabilities, for example: China-European trains	1. Excellent geographical location, connecting to many neighboring countries 2. Policies are favorable, gradually developing cross-border transportation capabilities, examples: Simplified customs procedures, LMC, GMS, MGC and ASEAN cooperation	Both focus on environmental protection and sustainable development	1. China's railway network is more extensive and technologically advanced 2. Thailand has a geographical advantage in cross-border transportation

Table 4.2 Significant Advantages of the Current Railway Logistics System (Cont.)

Feature	Advantages of China's Railway Logistics	Advantages of China's Railway Logistics	Commonalities	Differences
Environmental goals	Reducing carbon emissions from transport worldwide	Reducing environmental impact by improving rail infrastructure	Both are committed to reducing environmental impact	China is more advanced in technology application, while Thailand has made greater efforts in infrastructure transformation
Technology Application	Advanced information management system and freight services, for example, JD Logistics cooperates with China Railway Express to undertake the landing distribution business of high-speed railway express parcels nationwide.	Infrastructure modernization needs to be improved, and more advanced technologies should be gradually introduced, Example: double track railroad	Both are promoting technological upgrades	China's technology is more widely used, while Thailand is in the stage of catching up and transformation

4.3 Ideal State of the Railway Logistics System

In envisioning the ideal state of the railway logistics system, experts from both China and Thailand emphasized the importance of technological upgrades, environmental goals, and multimodal transport, but there are differences in the implementation approach and focus between the two countries.

Table 4.3 Ideal State of the Railway Logistics System

Feature	China's ideal state	Thailand's ideal state	Commonalities	Differences
Technology Application	Deeply integrate big data, the Internet of Things and artificial intelligence to achieve efficient scheduling and seamless connection	Comprehensive infrastructure upgrade, adoption of green logistics technology, and improved energy efficiency	Both emphasize technology upgrades and efficiency improvements	China emphasizes informatization and intelligence, while Thailand focuses on infrastructure modernization and green technology
Environmental goals	Maintaining our leading edge and committed to reducing carbon emissions and environmental impact	Introducing low-carbon and environmentally friendly technologies to reduce energy consumption through train scheduling and route management	Both are committed to reducing their impact on the environment	China focuses more on overall emission reduction, while Thailand focuses on improving the environmental efficiency of specific technologies

Table 4.3 Ideal State of the Railway Logistics System (Cont.)

Feature	China's ideal state	Thailand's ideal state	Commonalities	Differences
Multimodal transport	Flexible service capabilities and multimodal transport to optimize the use of transportation resources	Promote multimodal transport and optimize the effective intermodal transport of railways and other logistics transport modes	Both value the development of multimodal transport	China focuses more on internal optimization, while Thailand emphasizes cross-border and regional intermodal transport
International Cooperation	Promoting international cooperation in railway transport under the “Belt and Road” initiative	Strengthen rail links with neighboring Southeast Asian countries and develop cross-border rail transport	Both view railway logistics as a tool for regional cooperation	China’s international cooperation covers a wider range, while Thailand mainly focuses on regional cooperation

4.4 Key Changes from the Status Quo to the Ideal State of the Rail Logistics System in Both Countries

When discussing the key changes needed to move the railway logistics system from the status quo to the ideal state, experts from both China and Thailand indicated that the infrastructure needed to be transformed and upgraded in the process of moving towards the ideal state, such as technological innovations and policy support, but the specific strategies and focuses differed. China focuses more on advanced applications of technology and optimization of the internal market, while Thailand concentrates more on fundamental improvements in infrastructure and expansion of regional cooperation, reflecting the differences in economic development and geographic location between the two countries.

Table 4.4 Key Changes to Achieve the Desired State

Feature	Key changes in China	Key changes in Thailand	Commonalities	Differences
Technological innovation	Promote informatization and intelligence, especially the application of intelligent dispatching and real-time tracking systems	Introduce and adopt low-carbon and environmentally friendly technologies, develop electrified railways, and achieve intelligence through technological innovation	Both emphasize the importance of technological innovation for transformation	China focuses more on informatization, while Thailand focuses more on environmental protection technology and infrastructure upgrades
Infrastructure upgrades	Undertake a comprehensive infrastructure upgrade, including the expansion and modernization of the rail network	Upgrading and expanding infrastructure, such as building a double-track railway	Both require a large-scale upgrade of infrastructure	China's infrastructure upgrades are more focused on expanding existing networks, while Thailand needs to start from a lower base
Policy support	Implement market-oriented reforms, improve institutional flexibility, and promote technological innovation and market competitiveness	Strengthen policy support and international cooperation to develop cross-border railway transport	Both value the driving role of government policies	China's policies are more inclined towards the internal market and technological innovation, while Thailand focuses on international cooperation and infrastructure

Table 4.4 Key Changes to Achieve the Desired State (Cont.)

Feature	Key changes in China	Key changes in Thailand	Commonalities	Differences
Multimodal transport optimization	Strengthen the connection between railways and other modes of transportation, and optimize multimodal transport configuration and coordinated operations	Promote multimodal transport and optimize the effective intermodal transport of railways and other logistics and transportation modes	Both focus on improving the efficiency of multimodal transport	China's adjustments focus more on technology and management optimization, while Thailand needs to start with infrastructure improvement
International cooperation expansion	Deepening international railway transport cooperation under the "Belt and Road" initiative	Strengthen railway connections with Southeast Asian countries and expand the railway network in the region	Both seek to enhance international cooperation through railway logistics	China's cooperation is more global, while Thailand focuses on regional cooperation

4.5 Key Opportunities to Promote the Development of Railway Logistics

China and Thailand's geographic location and government policies can facilitate the development of rail logistics, and both countries value technological advances and international cooperation. However, China's rail logistics relies more on an extensive rail network and advanced technological applications, while Thailand needs to optimize infrastructure and promote regional cooperation to strengthen its role as a logistics hub in Southeast Asia.

Table 4.5 Key Opportunities for Development

Feature	Key opportunities in China	Key opportunities in Thailand	Commonalities	Differences
Geographical advantages	Expanding international rail transport networks through the Belt and Road Initiative	Located in the center of Southeast Asia, it is conducive to the development of cross-border railway transportation	Both have the opportunity to expand railway logistics by taking advantage of geographical advantages	China uses global networks; Thailand focuses more on regional cooperation
Policy support	National policy support, including fiscal investment and tax incentives	Government encourages private investment in railway infrastructure through PPP model	All benefited from the government's positive policies and investment support	China's government directly invests, while Thailand relies on public-private partnerships
Technological advancement	Promote the development of high-tech and intelligent railway systems	Introducing modern railway technology and management systems	Both see technological advancement as the key to improving efficiency	China focuses more on intelligent and efficient management, while Thailand needs to start with infrastructure modernization

Table 4.5 Key Opportunities for Development (Cont.)

Feature	Key opportunities in China	Key opportunities in Thailand	Commonalities	Differences
International Cooperation	Deepen railway logistics cooperation with countries along the route, especially the China-Europe Express	Strengthen railway connections with ASEAN, China and other countries	Both are committed to improving railway logistics efficiency through international cooperation	China's cooperation is more global, while Thailand focuses on regional cooperation
Environmental Policy	Responding to the global trend of carbon reduction and promoting green transportation	Implement green logistics strategies to improve the environmental friendliness of transportation	Both regard environmental protection and sustainable development as important goals	China seeks opportunities in global environmental policy, while Thailand focuses on local and regional environmental impacts

4.6 Key Challenges to the Development of Railway Logistics

Both China and Thailand face the challenges of infrastructure, technological innovation, policy support, environmental sustainability and international cooperation, but the specific focus and solution strategies differ. China needs to build on its already extensive network and technology base to further optimize and upgrade, while Thailand needs to start from the ground up, focusing on improving infrastructure and introducing advanced technology. Both countries need effective policy support and international cooperation to further promote the development of railway logistics.

Table 4.6 Key Challenges to Development

Feature	The Chinese Challenge	Thailand's Challenge	Commonalities	Differences
Infrastructure bottlenecks	Although the railway network is extensive, some areas still need to be upgraded to improve transportation efficiency and capacity	The infrastructure is old and needs large-scale upgrading, especially upgrading the single track to double track to increase transportation capacity	Both face the need for infrastructure improvement	China needs to optimize its existing facilities, while Thailand needs to start with more basic upgrades
Technical Challenges	Highly dependent on advanced technology, continuous investment is required to maintain technological leadership	Lack of advanced technology and management system, technology introduction and localization are key	Both need to solve the challenges of technology application and management	China's challenge is to maintain its technological advantage, while Thailand's challenge is to introduce and implement technology
Policy and Regulation	More flexible policies and market-oriented reforms are needed to improve competitiveness	Insufficient policy support, more incentives are needed to attract private and international investment	Both require policy and regulatory support	China's policies are more inclined towards marketization and technological innovation, Thailand needs to enhance its policy attractiveness

Table 4.6 Key Challenges to Development (Cont.)

Feature	The Chinese Challenge	Thailand's Challenge	Commonalities	Differences
Environment and Sustainability	Reducing environmental impact in large-scale transportation is an ongoing challenge	Improved transport methods are needed to reduce environmental impact, especially carbon emissions	Both are concerned about reducing the impact of transportation on the environment	China's environmental challenges are more global, while Thailand focuses more on local and regional environmental issues
International Cooperation	Despite the Belt and Road Initiative, multilateral relations need to be managed and optimized	Geopolitical influences: the need to balance cooperation and competition with neighboring countries, especially on cross-border railway projects	Both face challenges and opportunities in international cooperation	China's international cooperation is broader, while Thailand focuses on regional cooperation

4.7 Long-term Planning to Address Challenges in the Development Process

China and Thailand face a variety of challenges in the development of railway logistics, and long-term planning should be undertaken to address these challenges. Long-term development in both countries has overlapping focuses on infrastructure, technological innovation, environmental sustainability, policy and market reforms, and international cooperation and regional integration. However, the two countries differ in their implementation strategies and specific focuses: China's plan is more comprehensive

and involves the upgrading of technology and the further development of international markets, while Thailand's focus is more on the optimization and upgrading of infrastructure and the strengthening of regional cooperation.

Table 4.7 Long-term Planning to Address Challenges

Feature	China's long-term planning	Thailand's long-term planning	Commonalities	Differences
Infrastructure expansion	Continue to expand and upgrade the rail network, especially by adding high-speed rail and freight lines	Large-scale upgrading of existing railways, especially upgrading single-track to double-track to increase freight capacity	Both plan to significantly upgrade and expand railway infrastructure	China is more focused on expanding its existing efficient network, while Thailand needs to start with basic infrastructure upgrades
Technology and Innovation	Deepen the application of information and automation technologies, such as the Internet of Things and AI in railway transportation	Introducing advanced railway management and operation technologies to improve efficiency and safety	Both emphasize the importance of technological innovation and intelligence	China focuses more on high-end technology applications, while Thailand focuses on the introduction and localization of basic technologies

Table 4.7 Long-term Planning to Address Challenges (Cont.)

Feature	China's long-term planning	Thailand's long-term planning	Commonalities	Differences
Environmental Sustainability	Promoting green transportation, such as electrified railways and the use of renewable energy	Implement green logistics strategies to reduce the environmental footprint of rail transport	Both are committed to reducing environmental impact and promoting green transportation	China may focus more on technology-driven environmental solutions, while Thailand starts with policies and practices
Policy and market reforms	Promote more flexible market-oriented reforms to improve the competitiveness and openness of the railway logistics market	Strengthen government support and provide incentives such as tax breaks to attract more private and foreign investment	Both require policy support and market reform	China adopts more market-oriented and international strategies, while Thailand relies on government policies and public-private partnerships
International cooperation and regional integration	Strengthen railway transport cooperation with the countries along the Belt and Road Initiative and promote the integration of regional logistics networks	Strengthen railway connections with ASEAN countries and develop regional railway networks	Both value the expansion of international cooperation	China is developing both globally and regionally, while Thailand is mainly focusing on regional cooperation

4.8 Issues that Suppliers Need to Recognize and Adapt to in Achieving Sustainable Development

In the process of achieving sustainable development of railroad logistics, railroad logistics service providers in China and Thailand share commonalities on key issues that need to be adapted and recognized, such as technological upgrading, environmental practices, market adaptability, policy and regulatory compliance, and international cooperation. However, the specific focus and implementation strategies of the two countries differ depending on their respective economic environments, levels of technological development, and political contexts. Chinese service providers may focus more on technology integration and global market expansion, while Thai service providers need to focus on deepening regional cooperation and the application of basic technologies.

Table 4.8 Issues for Suppliers to Recognize and Adapt to

Feature	China Railway Logistics Service Provider	Thailand Railway Logistics Service Provider	Commonalities	Differences
Technology Upgrade	Need to adopt the latest technologies such as IoT and AI to improve operational efficiency and transparency	It is necessary to introduce and adapt modern railway logistics technology to improve service quality and operational efficiency	Both need to adapt and utilize new technologies to improve efficiency	China focuses more on the deep integration of high-end technologies, while Thailand focuses on the application and popularization of basic technologies

Table 4.8 Issues for Suppliers to Recognize and Adapt to (Cont.)

Feature	China Railway Logistics Service Provider	Thailand Railway Logistics Service Provider	Commonalities	Differences
Environmental Practices	Promote green logistics practices, such as using environmentally friendly materials and reducing energy consumption	Adopt low-carbon solutions and green technologies to reduce environmental impact	Both emphasize the importance of environmental protection and sustainable development	China may have more experience and technology accumulation in green logistics practice, while Thailand is still in the early stages.
Market adaptability	Must adapt to rapidly changing market demands and improve service flexibility and customization	Need to be more sensitive to market changes, especially in cross-border and regional logistics services	Both need to improve the response speed to market changes	The Chinese market is more dynamic and competitive, Thailand needs to focus on cooperation and services in the region
Policies and regulations	Adapt to changes in domestic and international regulations and ensure compliance	Understand and comply with new government policies and regulations, especially new rules on public-private partnerships	All face the need to comply with constantly updated policies and regulations	Thailand may rely more on government policy guidance, while China needs to balance the requirements of domestic and foreign regulations

Table 4.8 Issues for Suppliers to Recognize and Adapt to (Cont.)

Feature	China Railway Logistics Service Provider	Thailand Railway Logistics Service Provider	Commonalities	Differences
International Cooperation	Expand international cooperation, especially in Belt and Road related projects	Strengthen railway logistics cooperation with neighboring countries, especially in Southeast Asia	Both values expanding international or regional cooperation	China's cooperation is more extensive and global, while Thailand focuses on Southeast Asian cooperation

4.9 Railroad Logistics Service Providers Prepare for the Future

Railroad logistics service providers in China and Thailand should prepare for sustainable development in the future, and both countries share common needs and challenges in terms of technology investment, talent development, environmental practices, market adaptability, policy compliance and international cooperation. However, there are differences in implementation strategies and focus, with Chinese rail logistics service providers focusing more on technological advancement and international market expansion, while Thai rail logistics service providers need to strengthen basic technology and regional cooperation. These preparations will help railroad logistics service providers in both countries to better adapt to future development trends and market demands and realize sustainable development.

Table 4.9 Railroad Logistics Service Providers Prepare for the Future

Feature	China Railway Logistics Service Provider	Thailand Railway Logistics Service Provider	Commonalities	Differences
Technology investment and update	Continued investment in the latest logistics technologies such as automation, IoT and AI	Introduce and adapt advanced logistics management systems and automation equipment	Both need to invest and update technology to improve efficiency	China is more focused on the application of high-end technology, while Thailand needs to catch up in the introduction and localization of technology
Training and Talent Development	Strengthen staff skills training, especially in new technology operation and international logistics management	Strengthen technical and management training to improve employees' adaptability to the new system	Both need to improve employee skills through training	China may need more international talent training, while Thailand needs to strengthen basic skills training
Market adaptability and flexibility	Develop flexible service models to adapt to rapidly changing domestic and international market demands	Improve market adaptability, especially in serving regional and international freight customers	Both need to improve their adaptability to market changes	China needs to pay more attention to international market dynamics, while Thailand focuses on regional market demand

Table 4.9 Railroad Logistics Service Providers Prepare for the Future (Cont.)

Feature	China Railway Logistics Service Provider	Thailand Railway Logistics Service Provider	Commonalities	Differences
Policy and Compliance	Track policy changes to ensure all operations comply with domestic and international regulations	Understand and adapt to the country's new logistics policies to ensure compliance operations	Both face challenges in policy tracking and compliance	China may face more complex international regulations, while Thailand will focus more on domestic policies
International Cooperation	Strengthen cooperation with international partners, especially in the Belt and Road Initiative projects	Establish and strengthen logistics cooperation with ASEAN countries	Both value expanding international or regional cooperation	China's cooperation is more global, while Thailand focuses on Southeast Asian cooperation

CHAPTER 5

CONCLUSION, DISCUSSIONS AND RECOMMENDATIONS

Based on the research findings, this chapter provides railroad logistics enterprises and policy makers with strategic guidance and practical references for the sustainable development of railroad logistics. It summarizes and distills key findings and explores potential directions for future research.

5.1 Conclusion of Study

5.1.1 Development Status of China's Railroad Logistics Industry

China's railroad logistics industry has an extensive and expanding railroad network and a high level of technology. Strong national policies and financial support have enabled China's rail logistics to demonstrate efficient transportation capabilities for both domestic and international shipments. At the same time, China is actively promoting environmental and sustainable development goals, such as reducing carbon emissions and improving energy efficiency. Although the railroad network is extensive, there are still some bottlenecks in terms of transportation capacity and information management of intermodal transportation.

5.1.2 Clarify the Necessity of Sustainable Development of Railroad Logistics

Railway logistics, as a low-carbon and high-efficiency mode of transportation, plays an important role in promoting environmental protection and energy conservation and emission reduction. In the process of sustainable development of railroad logistics, it can continuously improve logistics efficiency and help realize international trade and regional economic integration. In addition, the development of sustainable railroad logistics can enhance the technical level of railroad logistics system, such as

informatization and intelligence, which is crucial for responding to fast-changing market demand and improving market competitiveness.

5.1.3 Explore the opportunities and challenges to further realize the sustainable development of railroad logistics

Opportunities: China and Thailand have different advantages in terms of geographic location, which, together with the policy support of their governments, provide favorable conditions for the development of railroad logistics. China has an extensive railroad network and advanced technology, while Thailand is in the center of Southeast Asia, which contributes to the development of cross-border rail transportation. Carrying out scientific and technological innovation and realizing technological progress, such as the application of technologies like big data and artificial intelligence, can enhance the transportation efficiency and management space of railroad logistics.

Challenges: Although there are many opportunities, there are also many challenges. Examples of challenges include infrastructure bottlenecks, scientific and technological innovation, insufficient policy and regulatory support, environmental sustainability issues, and the complexity of international cooperation. China needs to further optimize its existing technology applications and markets, while Thailand needs to start with infrastructure development and technology introduction.

5.2 Discussions of Findings

5.2.1 Development Status and Infrastructure

This study points out that the rail logistics infrastructures of China and Thailand show significant differences, with China having more advanced technology and an extensive rail network, while Thailand relies on an old monorail system. 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.

5.2.2 Technology Applications

This study highlights the application of information technology and intelligence in railroad logistics, such as China's more advanced information management for high-speed rail and freight services. This is consistent with the existing literature, which also usually emphasizes the key role of technological innovation in improving logistics efficiency, but this study provides a specific comparison between China and Thailand in terms of the extent of technology application, adding a new dimension to cross-country studies.

5.2.3 Policy Support and International Cooperation

This study finds that both countries emphasize the importance of national policy support and international cooperation. Compared to previous studies, this study may explore in more detail the specifics of different national policies and their impact on the sustainable development of rail logistics, especially in the context of the PPP model and the Belt and Road Initiative.

5.2.4 Environmental Objectives and Sustainable Development

This study highlights the centrality of environmental protection and sustainable development in railroad logistics strategies. 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.

5.3 Recommendations

5.3.1 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.

5.3.2 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 railroad 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 railroad logistics.

5.3.3 Suggestions for Future Research Directions

For the direction of future researchers in the field of sustainable development of railroad logistics, it is recommended to focus on the following core areas: first, exploring the application of information technology and intelligent technology (e.g., the Internet of Things, artificial intelligence and big data) in enhancing the efficiency of railroad logistics and its challenges. Second, analyze the strategies and effects of different countries in upgrading and expanding railroad infrastructure, especially the measures in improving transport capacity and efficiency. Thirdly, in-depth studies on environmental protection practices in railroad logistics are conducted to assess the environmental and economic benefits of these practices. It is also possible to examine

how policies, regulations and market reforms support the sustainable development of railroad logistics, especially how governments promote private investment and international cooperation through policies and incentives. Finally, it examines the integration and optimization of international cooperation projects and multi-modal transportation systems, and how market demand drives innovation in rail logistics services. These research directions will not only promote the development of the rail logistics industry, but also provide valuable insights and strategic recommendations for policy makers and industry practitioners.



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APPENDIX

INTERVIEW QUESTIONNAIRE

Dear Respected Respondent,

Subject: Request for Assistance with Questionnaire Analysis

I apologize for reaching out during the evening. My name is Zifei Wang, and I am currently pursuing my master's degree in management in Logistics at the Faculty of Science at Rangsit University. I am working on a thesis titled "Opportunities and challenges for the sustainable development of railroad logistics."

As part of my research, data collection plays a critical role in ensuring the success of my thesis. I would greatly appreciate your assistance in reviewing and providing feedback on the attached questionnaire (IOC). I apologize for any inconvenience this may cause, but your expert input would be invaluable to my research, and I sincerely hope for your support.

Thank you very much for your time and consideration. This work would not be possible without your generous help.

With the utmost respect,

Zifei Wang

Master's Degree Student

Faculty of Science

Management in Logistics

Rangsit University



Content Validity Assessment Form

Title: Opportunities and Challenges for the Sustainable Development of Railway Logistics

This content validity assessment form consists of 5 parts:

1. Analysis of the current situation of China's railroad logistics industry
2. The ideal state of sustainable development of railroad logistics
3. Key Opportunities for Sustainable Development of Railway Logistics
4. Major challenges to the sustainable development of railroad logistics
5. Issues to be understood and adapted by railroad logistics service providers

Assessment Methods and Procedures

Content validity can be assessed by comparing the operational definition and questions of the variable for experts or relevant experts to consider the conformity and fill in the results of consideration. The index used to show consistency is called Index of congruence between questions and operation definition called Item-Objective Congruence Index -- IOC, which experts must evaluate with 3 levels of scores.

+1 if it's **sure** that the question **corresponds** to the operation definition of a given variable.

0 if it is **not sure** that the question **corresponds** to the operation definition of the given variable.

-1 if it is **sure** that the question does **not correspond** to the operation definition of a given variable.

All questions will be word for interviewing the expert's opinion. The 6 experts consist as:

Academic Lecture 3 person

Management in High-Speed Railway Business Company of China. 3 persons

Government Office of China Railway Jinan Business Group Co. 2 persons

Part 1: Analysis of the current situation of China's railroad logistics industry

Purpose: understand the current state of the industry and key features of rail logistics, including operational efficiencies, existing infrastructure and business models.

Questions		Rating			Opinion
		+1	0	-1	
1.	Please describe the current operational status of railroad logistics in Thailand.				
2.	What do you think are the most significant advantages and disadvantages of the current system.				

Part 2: The ideal state of sustainable development of railroad logistics

Purpose: explore expert views on the best future scenarios for rail logistics, focusing on environmental, economic and social aspects.

Questions		Rating			Opinion
		+1	0	-1	
3.	What do you envision as the ideal state of sustainable railroad logistics.				
4.	What are the key changes needed to transition from the current state to the ideal state.				

Part 3: Key Opportunities for Sustainable Development of Railway Logistics

Purpose: identify and explore opportunities to drive sustainable development in the logistics industry.

Questions		Rating			Opinion
		+1	0	-1	
5.	What are the key opportunities for promoting the sustainable development of railroad logistics.				
6.	Which of these opportunities are currently being utilized and which are being neglected.				

Part 4: Major challenges to the sustainable development of railroad logistics

Purpose: identifying key barriers to a more sustainable railroad logistics system.

Questions		Rating			Opinion
		+1	0	-1	
7.	What are the main challenges to the sustainable development of railroad logistics.				
8.	What kind of long-term strategic planning should be made in response to these major challenges.				

Part 5: Issues to be understood and adapted by railroad logistics service providers

Purpose: discuss the specific challenges and requirements that logistics service providers must address to support sustainable practices.

Questions		Rating			Opinion
		+1	0	-1	
9.	What are the key issues that rail logistics service providers need to recognize and adapt to in order to achieve sustainable development.				
10.	How can these providers be better prepared for future sustainability needs.				

Signature

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Position:

Affiliation:

มหาวิทยาลัยรังสิต Rangsit University

BIOGRAPHY

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