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An Investigation into Synergistic Strategies for Asia-Europe Container Routes and China-Europe Railway Express, with a Foundation in Resilient Supply Chains

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Abstract. With the increase in trade along the Belt and Road, the Asia-Europe Container Line and the China-Europe Shuttle have become important corridors connecting the industrial supply chains of Asia and Europe. The frequent unexpected incidents are constantly striking the resilience of the Asia-Europe supply chain. The choice of corridors for Asia-Europe supply chains has become a key factor in supply chain stability. This study, according to the theoretical framework of supply chain resilience, adopts the case study method and literature analysis method, and conducts a research on the synergistic mechanism between Asia-Europe container routes and China-Europe liner. The results of the study show that the Asia-Europe container route and the China-Europe liner face significant vulnerabilities in terms of reliability, redundancy, stability and recoverability under a single transport corridor structure. The substitution and complementary mechanism between the two channels can effectively mitigate the risks associated with the failure of a single channel and improve the resilience of the supply chain. The conclusions of the study show that the Asia-Europe supply chain should strengthen the synergistic mechanism of the sea-railway dual-channel. Specific strategies include functional cargo diversion, structural corridor backup and enhanced coupling between nodes to optimize the transport corridor layout. These approaches enhance redundancy, increase flexibility and strengthen reliability and stability to improve overall Asia-Europe supply chain resilience.

Keywords: Supply chain resilience, Asia-Europe Container Line, China-Europe express train.

1. Introduction

The Belt and Road Initiative for International Co-operation promotes maritime trade and economic development between Asia and Europe. As trade develops, the relationship between China and Europe grows stronger. The new channel of China-Europe liner was born, especially the container transport has become the main force of trade between the two places. In recent years, as the global economy has become more complex and the needs of customers have become more diversified, the demand for freight transport has grown strictly. This has imposed stricter requirements on the global supply chain network and transportation efficiency, further exacerbating the vulnerability of the

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traditional Asia-Europe supply chain. Frequent external shocks, such as the Suez Canal blockage caused by the Red Sea crisis and the suspension of the China-Europe Railway Express due to the Russia-Ukraine conflict, indicate that a single mode of transportation is no longer sufficient to meet the growing trade demands. In this background, increasing supply chain resilience and security levels has become a necessary strategy to maintain trade stability. Therefore, the research perspective on the Asia-Europe supply chain no longer focuses solely on the efficiency and cost of a single mode of transportation. Instead, it examines how the combination of China-Europe railways and maritime transportation can enhance the resilience of the supply chain. Scholars both at home and abroad have studied on container transportation and supply chain resilience in China and Europe. Cao yuhao et al. modeled both breadth-first redistribution rule (BFRR) and depth-first redistribution rule (DFRR) and found that freight redistribution is the core strategy to control the spread of cascading faults [1]. This is because cargo redistribution affects transport network resilience. Transport network resilience is in turn affected by port redundancy, and ports with sufficient backup capacity can reduce cascading effects [2]. Guo Liquan et al. evaluated the international multimodal transportation connections (IMTCS) from the Chinese mainland to Europe before and after the epidemic. They found that CR Express costs fell after the epidemic and that shippers preferred CR Express when transporting export goods to Europe [3]. This conclusion shows that shippers' preferences can change under different transport situations. However, some current studies focus on abstract mathematical models in the analysis of resilience, while neglecting case studies of actual shock events. Others analyzed the Asia-Europe route and the China-Europe liner as independent objects, lacking comparative and synergistic perspectives. This paper analyses uses literature analysis and case studies, analyzing the problems and challenges faced by the two transport corridors in terms of reliability, redundancy, stability and resilience. This paper also further explores the substitutability and complementarity of the Asia-Europe route and the China-Europe liner, as well as the collaborative mechanism of the two in the face of emergencies.

2. Current situation analysis

2.1. Status of Asia-Europe maritime routes

The container ships on the Asia-Europe route undertake the main cross-border cargo transportation tasks between the Central European regions. The main transport routes are China-Malacca Strait-Suez Canal-Europe route; China-Malacca Strait-Cape of Good Hope-Europe route; China -Bering Strait-European route. Among these routes, the Suez Canal route has the largest number of ports and carries the vast majority of oil shipments. So the Suez Canal route has become the transport route of choice for most ships. The Cape of Good Hope route has longer haulage distances and its transport costs will be increased. Although the Arctic route is the shortest, ships can only sail in the summer months and rely on icebreakers to break the ice during the rest of the year, which makes it less economically efficient. It is the long history of the ship's extreme dependence on the Suez Canal route that has led to the emergence of supply chain vulnerabilities to major shocks

2.2. Status of the China-Europe shuttle train

Since the start of the China-EU liner train in 2011, the cumulative number of trains has exceeded 120,000, and the value of goods sent has exceeded US$490 billion [4]. The China-European Union (CEU) liner has continuously increased its comprehensive competitiveness and become a stabiliser and accelerator of the international supply chain. At present, the China-European liner mainly

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includes three fixed frequency transport routes in the west, centre and east. The western route collects goods from the central and western regions and departs through the Alashankou or Khorgos ports. The Central Route starts in North China and leads out of the country through the Erlianhot port. The Eastern Route, on the other hand, starts in the Northeast and leaves China via Manchuria and Suifenhe. Nowadays the freight volume of the western corridor of the China-Europa liner train far exceeds that of the other two corridors. It has become the main corridor of the China-Europa liner train.

2.3. Status of sea-rail multimodal transport

Multimodal transport is now gradually becoming the dominant trend. Containers on the Asia-Europe route have the advantages of high transport carrying capacity, low transport costs and better infrastructure. It is disadvantages are low transport timeliness and channel stability needs to be strengthened. The China-Europe liner has the advantages of short transport time and high transport safety, but at the same time its transport cost is high and the flexibility of route selection is low. This shows that there are differences between Asia-Europe routes and China-Europe trains in terms of reliability, time fluctuations and risk resistance. The two channels, by combining the cost-effectiveness of sea transportation and the high timeliness benefits of railways, not only can reduce the overall costs and improve logistics efficiency, but also can enhance the flexibility of transportation routes and the resilience of the Asia-Europe supply chain. But there are also many problems with sea-rail multimodal transport, such as the lack of a systematic coordinating mechanism for dual channels, complex operational processes; inadequate infrastructure; and inefficient customs clearance. These problems can lead to increased uncertainties in transport such as port congestion, equipment breakdowns, and extreme equipment, creating a cascading effect that reduces transport efficiency.

3. A analysis of supply chain resilience

Supply chain resilience mechanisms are characterized by four dimensions: reliability, redundancy, robustness and recoverability [5]. Both Asia-Europe routes and the China-Europe liner have the problem of vulnerability in a single channel.

3.1. Reliability

Reliability is the basis of the resilience evaluation metrics and refers to the probability of maintaining normal operation of the port system in the event of a sudden emergency [5].

The Asia-Europe route is subject to a variety of uncertainties, such as extreme weather or port congestion and geopolitical conflicts, due to the long transport times and distances involved. So the timeliness and reliability of transport on the Asia-Europe route is low.

The reliability of the China-Europe liner has improved compared to the Asia-Europe route. This is because of the short transport time of the China-Europe liner, which is less affected by natural factors and has higher security and risk resistance. But the track change delays generated by the China-Europa trains can also reduce reliability. Due to the different gauges of the Chinese-European railways, it is necessary to change the rails twice between Belarus and the European Union countries after leaving the country via Korgos, which makes the operation process complicated. When the freight volume of the China-Europa train exceeds the maximum limit it can bear, it is very easy to cause the collapse of the import and export bank operation and reduce the reliability of transport. As

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a result, both the Asia-Europe route and the China-Europe liner have the problem of insufficient reliability, and the probability of the route or the port successfully resisting the uncertainty risk on the surface is low.

3.2. Redundancy

Redundancy refers to the ability of a transport network to cope with external changes through support means and back-up resources, which includes physical redundancy, path redundancy, and functional redundancy [6].

Low redundancy on Asia-Europe routes is reflected in low route redundancy, high risk concentration and limitations in substitution routes. Once the key node, the Suez Canal, is damaged, ships will have no alternative routes and will be forced to take the Cape of Good Hope route or the Arctic route instead. Ships rounding the Cape of Good Hope will inevitably lead to higher container ship rates and higher voyage costs, undermining supply chain resilience. Ships travelling around the Arctic route are limited by seasonal characteristics. Ships can only sail in summer and need the assistance of icebreakers in winter, which is not economically viable

The low redundancy of the China-Europe liner is reflected in the over-concentration of key corridors. Despite the fact that three corridors in the West and Middle East have now been developed for China-EU trains, most of them still rely on the single corridor of Russia-Belarus-Poland transport. In September 2025, the Polish government closed the commercial crossing with Belarus for 13 days [7]. This has left a large number of trains stranded at the Polish border, causing huge economic losses. And compared to traditional maritime transport, the functional redundancy and physical redundancy of the China-Europe liner train is also flawed. At present, the sources of goods for the China-Europe Railway Express are limited and it can only transport some bulk commodities. It is unable to carry hazardous goods or liquid goods. Moreover, the infrastructure at the major border ports lacks the capacity for effective diversion, and the matching efficiency between goods sources and trains is not high. During peak cargo flow periods, there is a high risk of equipment failure. Thus, the lack of backup routes is a common reason for the lack of redundancy in Asia-Europe routes and China-Europe trains. The China-Europe liner train is also deficient in functional and physical redundancy due to a single source of cargo and inadequate infrastructure.

3.3. Stability

Stability refers to the ability of a port to resist, absorb and counteract damage or adverse events under continuous changes and uncertainties within the system [5]. The instability of the Asia-Europe route is mainly characterized by weak cost resilience and unstable capacity deployment. Shipping rates are sensitive to volatility and can fluctuate dramatically due to fuel prices as well as environmental regulations. At the same time, in order to adapt to changes in the market demand for goods, shipping companies will constantly adjust the volume and schedule of shipments. This can easily lead to an imbalance between supply and demand, resulting in short-term port congestion and a drop in route punctuality. According to data provided by the Shanghai Shipping Exchange, there has been a fluctuating decline in the punctuality of routes. The composite punctuality index of the Asia-Europe route was 42.56 on 9 December, a decrease of 2.56% compared with the previous period, the punctuality of arrival service decreased by 3.49% compared with the previous period, and the punctuality of receiving and dispatching cargo service decreased by 10.03% [8].

The China-Europe liner train crosses several countries and has a very limited number of import and export ports (only three lanes) in the course of transport, which makes the supply chain more

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vulnerable to external disruptions than the Asia-Europe route [9]. During an entire supply chain transportation process, a disruption of a certain city would cause the goods that should have been processed at this node to be redirected to other nodes or transported by other means of transportation. This situation is likely to overload other nearby cities (nodes), triggering a series of congestion and cascading failures [10]. Therefore resistance to external disturbances is an important indicator of stability. Once the supply chain is destabilised, serious cascading failures can be triggered.

Consequently, the ability to withstand external disturbances becomes a critical metric for assessing the overall stability of the system. Should the stability of the supply chain be compromised, the result could be severe cascade failures.

3.4. Recoverability

The concept of resilience pertains to the capacity of a system to expeditiously revert to a state of normal operation [5].

The Asia-Europe route mainly faces the problems of slow recovery and high recovery costs. When a certain node fails, it will take a very long time to clear the congested ships. Their recoverability varies according to the time resolution of supply chain disruptions [11]. Long-term disruptions such as the New Crown epidemic and the Russian-Ukrainian conflict, where the transport network relies heavily on structural adaptation and gradual reorganization to absorb external pressures. For short-term shocks such as the Suez Canal blockade, on the other hand, the shipping network mainly uses local redundancies and alternative paths to achieve rapid functional recovery.

There is a high degree of uncertainty about the recoverability of the CEE. This is because when the supply chain is restored is not dependent on the operator, but is more often limited by cross-border agreements, diplomatic consultations, and customs negotiations. Recovery is particularly slow in times of political instability. As a result, there have been supply chain disruptions on the Asia-Europe route and the China-Europe liner, both of which will take longer to repair.

4. Suggestion

Based on the above analysis, any issue with reliability, redundancy, stability or recoverability will undermine the resilience of the supply chain and even trigger cascading failures. Therefore, maritime shipping and the China-Europe Railway Express need to utilize an alternative and complementary mechanism to address the issue of sudden disruptions in the supply chain. And how to correctly redistribute the load has become the key to enhancing the flexibility, security, reliability of the path, as well as whether the complementary advantages can be achieved.

4.1. Diversion of goods supply

Rational allocation of cargo not only improves port resilience and thus buffers against volume and price fluctuations in a single corridor, but also improves the reliability and stability of the overall supply chain operation. Zhou Xiaoyang et al. found that shippers have different route preferences for goods with different timeliness by using a generalized total cost approach. If there is a disruption in the supply chain, shippers are more willing to pay transport costs for goods with a high time value. For goods with low time value, shippers are more likely to choose to wait [12]. Due to the different seasonal and fragile nature of cargo, the demand for cargo fluctuates greatly throughout the year,

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making it difficult for some underdeveloped ports or nodes to maintain efficient operations. In this paper, goods are categorized into high-value and high time-sensitive, high-value but low time-sensitive, low-value but high time-sensitive and low-value and low time-sensitive categories based on the heterogeneity of goods. During peak demand periods, the China-Europa train mainly carries high-value and time-sensitive cargoes, easing the pressure on shipping schedules. High-value but low time-sensitive goods and low-value but high time-sensitive goods can be assembled in advance by rail at a transit point and then transported by sea to their destination. Traditional maritime transport mainly carries low-value and low time-sensitive bulk cargoes. Therefore, based on the functional and complementary synergy mechanism between maritime transport and the China-Europa liner, it is possible to reduce the failure rate of a single corridor.

4.2. Structured channel backup

Based on the fact that China-Europe maritime transport is highly dependent on the Suez Canal and China-Europe freight trains are concentrated in the Western Corridor, both of which face a high risk of single-node failure. Thus channel backup can largely solve the problem of path redundancy and also reduce the probability of overloaded node operation and avoid cascading effects. Koçak and Saim Turgut analyzed the cost-effectiveness and profitability of six different Arctic shipping routes using the Fuzzy Analytical Hierarchy Process (FAHP). They found that Arctic shipping routes are more economically efficient than passing through the Suez Canal during the summer season [13]. At the same time, Li Zhiyuan et al. also point out that with the trend of decreasing Arctic sea ice, the cost of Arctic shipping routes will continue to decline. Meanwhile , the carbon emission reduction brought about by the shortened path can also promote the development of green shipping [14]. Therefore, from the perspective of future development, the Arctic route is an excellent choice for corridor backup. In order to avoid passive search for alternative corridors after the crisis, the government should take the initiative to establish backup corridors, strengthen strategic cooperation with Russia and continuously optimize the Arctic corridors. In the event of a systemic shock to one of the corridors (CEM or CEL), the other corridor, together with the Arctic route, automatically becomes a back-up corridor to keep the supply chain essentially trans-shipped. Therefore, the key to structural corridor backup is the establishment of a switchable emergency corridor portfolio mechanism as a way to improve supply chain resilience.

4.3. Enhancing regional node connectivity to boost transshipment capacity

Cheng Jiannan found that China's New Western Land and Sea Corridor (NWLC) has relatively weak adaptive capacity and resilience in the face of key port failures compared to disruptions in maritime transport corridors [15]. At the same time, it has been found that some key nodes are more stable in the face of supply chain shocks, but once disrupted can trigger a more serious GSC collapse, and functional resilience is more difficult to repair than physical structures [7,11]. Therefore the resilience of key nodes and the flexibility of response between nodes becomes critical to the speed of recovery of the entire supply chain. Wang bing et al. established a dynamic hierarchical intermodal transport network and found that high topological coupling not only opens up European trade channels but also reduces cascading failures [9]. However, it has also been noted in the literature that too high a level of co-operative transshipment can also exacerbate risk propagation and increase port congestion rates [10]. This leads to the conclusion that good port co-operation mechanisms should both ensure risks are manageable and reduce shippers' losses and allow for the smooth transshipment of goods. At the supply chain resilience level, increasing node coupling also

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improves the recoverability of failed nodes and enables resource reallocation. Once the supply chain is disrupted, nearby ports can quickly respond and collaborate with each other, and the faulty nodes can promptly obtain emergency resources. After the shock is recovered, the contingency resources will be evenly distributed to nodes with lower load capacity to prevent unexpected situations.

5. Conclusion

This study takes containerized Asia-Europe routes and China-Europe liner routes as the object of research, and through case studies and literature analysis, it is found that Asia-Europe supply chains show obvious vulnerability when they are highly dependent on a single transport corridor, especially in the four aspects of reliability, redundancy, stability and recoverability. In terms of reliability, Asia-Europe routes are susceptible to uncertainties such as port congestion and extreme weather, while China-Europe trains suffer from delays in changing tracks. In terms of redundancy, the Asia-Europe maritime route lacks backup lanes and there are limitations in substituting routes, while the China-Europe liner is too centralized in terms of key lanes, making the system lacking in redundancy. In terms of stability, Asia-Europe routes are subject to sharp fluctuations in tariffs and market demand, while the China-Europe liner crosses multiple countries and is more likely to trigger a cascade effect. In terms of recoverability, the Asia-Europe route has a slow recovery time, while the China-Europe train suffers from an uncertain recovery time. Based on the above problems, this study proposes three synergistic and complementary mechanisms: cargo diversion, structural corridor backup, and improving regional node coupling. Diversion of goods of different natures can act as a buffer during peak demand periods, improving supply chain reliability and stability. Channel backups are used to improve path redundancy by avoiding passive search for alternatives. Increasing regional node coupling is a way to improve supply chain recovery by increasing inter-port transshipment capacity and response flexibility. This study not only enriches the application of supply chain resilience theory in trans-regional transport corridors, but also provides specific optimization suggestions for Asia-Europe supply chain synergy mechanisms and effective theoretical support for policy makers. However, this study still has some limitations. Although synergistic strategies are proposed, there is a lack of effect analysis on the implementation of specific strategies, which can be further validated and improved in the future through more empirical studies and data modelling.

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