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An Analysis of the Significant Value and Significance of Lanzhou Hub for "Full-Load Outbound, Empty-Return" Containers of China-Europe Railway Express

Yongquan Yang

Freight Department of China Railway Lanzhou Bureau Group Co., Ltd, Lanzhou, Gansu 730000, China

Abstract: The China-Europe Railway Express serves as a vital logistics corridor within the Belt and Road Initiative, yet it currently faces an imbalance where outbound trains operate fully loaded while return trips run empty or partially loaded. Analysis of the causes behind the empty container issue and its impact on operational costs, capacity utilization efficiency, and resource turnover reveals that trade imbalances create significant disparities in cargo volumes between outbound and return trips. Additionally, traditional point-to-point transportation fails to effectively resolve the return of empty containers. As a land port-type national logistics hub, Lanzhou can transform the cost of empty return containers into regional logistics network resources through a solution combining "a coordinated collection, distribution, transfer, and utilization system + multimodal transshipment + intelligent dispatch matching." Practically speaking, the Lanzhou hub can demonstrate its characteristic functions and competitiveness by reducing regional industrial and corporate logistics costs, enhancing container circulation efficiency and network resilience, and promoting industrial and hub economic development in Northwest China. Compared to other hubs, Lanzhou's "cross-shaped" railway network offers flexible adaptability to distribution structures and dual functionality of "network consolidation + regional distribution," providing a feasible solution for achieving balanced and sustainable development of the China-Europe Railway Express.

Keywords: China-Europe Railway Express; Lanzhou Hub; Return-trip Logistics; Empty Container Utilization.

1. Introduction

The National Development and Reform Commission noted in its report "The Belt and Road Initiative: Progress, Contributions, and Outlook" that as the Belt and Road Initiative continues to deepen, the China-Europe Railway Express has evolved into a flagship project and iconic brand of the joint construction, becoming a new land transport artery traversing the Eurasian continent and forming a major international logistics corridor spanning Asia and Europe [1]. Since the inaugural China-Europe freight train departed in 2011, its operational scale and transport capacity have steadily expanded, its route network has become increasingly comprehensive, and its operating frequency has grown rapidly. Particularly, the western corridor via the Alashankou and Khorgos ports in Xinjiang has shouldered increasingly heavy international freight responsibilities, playing an irreplaceable role in the Belt and Road Initiative.

During the rapid development of the China-Europe Railway Express, the persistent issue of "heavy outbound, empty return" has remained a key constraint on sustainable growth. Influenced by China's 47% trade surplus with Europe [2], the rate of empty containers on return trips remains stubbornly high. Furthermore, the cargo resources for return trips suffer from prominent problems such as a monotonous product mix and a low proportion of high-value-added goods [3], hindering the balanced development of both directions. This "one-way flow" results in wasted transport capacity. The accumulation of costs associated with empty container transportation, loading/unloading, and storage also increases the expense of acquiring empty containers, thereby raising the operational costs of the China-Europe Railway Express [4]. The empty container issue has now become a core constraint on the development of China-Europe freight trains. Effectively addressing the empty container problem on return trips and improving train utilization rates have become critical challenges requiring urgent solutions from operators and government departments. Lanzhou has established a large-scale ring-shaped hub connecting 11 major railway lines, featuring passenger traffic in the south and freight in the north. This structure better supports the core transportation network in Northwest China [5], providing a solid foundation for the collection and distribution of China-Europe freight trains. This hub attracts cargo distribution for China-Europe freight trains and stimulates the clustering of Lanzhou's commerce and trade industries. It is poised to become a comprehensive transshipment and consolidation hub for China-Europe freight trains in Lanzhou, integrating logistics, supply chain management, foreign trade, and industrial functions [6]. This development will effectively alleviate the "heavy-outbound, empty-return" container dilemma.

This paper adopts a practical approach, leveraging the advantageous conditions of the Lanzhou hub. It conducts a detailed study on strategic methods and implementation plans for utilizing return empty and loaded container resources of China-Europe freight trains. It explores the operational mechanisms of key solution strategies, including the coordinated system for collection, distribution, and transshipment at the Lanzhou hub, multimodal transport distribution, and intelligent scheduling. It analyzes the positive impact of the hub on the economic development of Northwest China and its role in promoting the sustainable development of the China-Europe Railway Express in the region. Through this in-depth study of the Lanzhou hub, the paper enhances understanding of the operational patterns of China-Europe freight train collection and distribution, as well as empty container allocation methods, providing valuable lessons for empty container resource allocation across

national hub nodes. It also offers insights for other hub developments, refining the existing hub layout of China-Europe freight trains and advancing the high-quality development of the national network.

2. Organization of the Text

2.1. Analysis of the Causes Behind the Issue of Empty and Partially Loaded Return Trains in the China-Europe Railway Express.

The "heavy outbound, empty return" phenomenon of China-Europe freight trains stems primarily from the long-standing structural trade imbalance between China and Europe. China exports large quantities of machinery, equipment, and daily consumer goods to Europe, while European exports to China consist mainly of smaller, high-value items such as precision instruments, automotive parts, and luxury goods. These products command higher prices but occupy significantly less space and volume compared to the bulk commodities China exports to Europe. According to data from China's General Administration of Customs, China's exports to the EU reached $501.3 billion in 2023, while imports amounted to only $281.8 billion, resulting in a trade surplus of $219.4 billion. This export-driven trade pattern creates ample container resources for outbound trips but leaves return trips facing empty containers. As shown in Figure 1, the number of outbound trains consistently exceeded inbound trains from 2017 to 2023, highlighting the pronounced "heavy outbound, empty return" phenomenon.

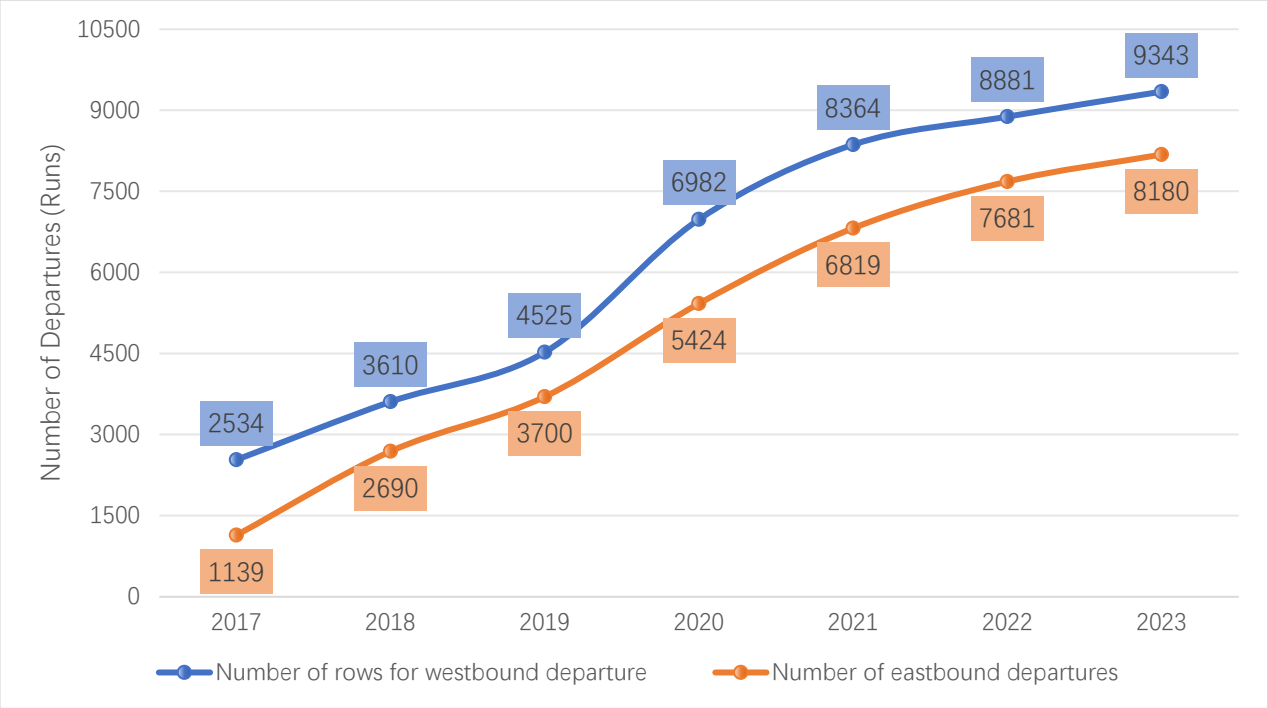


Fig 1. Schematic Diagram of Outbound and Inbound Train Services for the China-Europe Railway Express, 2017–2023

The imbalance in cargo supply will lead to increased costs in the repositioning and return of empty containers. After being unloaded in Europe, a large number of containers, if not replenished with cargo, can only be returned in an empty state or transferred to other regions. This process incurs a series of expenses such as road and rail transportation, loading and unloading, storage, and container leasing. Especially in Europe, the repositioning of empty containers is relatively scattered, with freight rates essentially on par with loaded containers, offering no price discounts, which will further increase operational costs. The return journey of empty containers also leads to idle capacity, slowing down the turnover rate of containers. According to the "China-Europe Train Development Report (2021)", the cargo loading rate of China-Europe trains on the outward journey can reach over 98%, and the number of return trains accounts for about 80% of the outward trains [7]. However, the value and loading volume of goods on return trains are relatively low, which can easily lead to structural capacity imbalance. The long period of empty container detention or transportation without cargo can easily cause deviations in the relationship between supply and demand of transportation capacity, even leading to severe shortages when container supply is tight.

The phenomenon of "heavy containers going out and empty containers coming back" is a specific manifestation of the structural imbalance in China-Europe trade. This "outward heavy and inward light" trade pattern also leads to an imbalance in the quantity of goods on the outbound and return trips of the trains, increases the cost of empty container allocation, and results in waste of railway capacity and reduced container turnover efficiency. Therefore, there exists a negative cycle of mutual causality between the issues of trade pattern, high cost of empty container allocation, and idle capacity, which restricts the development quality of China-Europe trains. Hence, "heavy containers going out and empty containers coming back" is not merely a simple transportation issue, but also a problem of trade pattern, operational cost, and resource utilization efficiency.

2.2. Utilization Strategy for Empty Heavy-Duty Vehicles at Lanzhou's Return-Leg Transit Hub.

The Lanzhou Hub for Return-Leg Transshipment of China-Europe Railway Express (referred to as the "Lanzhou Hub") is responsible for the functions of "collection, distribution,

and dispatch" of empty and loaded return-leg container resources. In facilitating the return flow of empty containers, it transforms the costs associated with empty container returns into valuable resources for the regional logistics network.

(1) Integrated Collection, Distribution, and Reuse System with Localization Priority

The Lanzhou hub employs an integrated collection, distribution, and reuse system to incorporate empty return containers, establishing an integrated "unloading-reuse" approach. This integrates European empty container returns into a digitally managed "empty container pool," utilizing intelligent matching algorithms to prioritize the "unload-and-load immediately" principle under the localization priority framework. This implementation fulfills the directive outlined in the "Gansu (Lanzhou) International Land Port 14th Five-Year Development Plan and Long-Term Goals for 2035" to "enhance hub distribution functions and drive regional economic growth" [8]. It secures export cargo sources for Gansu and neighboring northwestern provinces (Qinghai, Ningxia, Xinjiang, etc.), reduces enterprises' logistics and time costs, and boosts the vitality of outward-oriented economic development in the northwest region.

(2) Multimodal Transport and National Distribution Network

Building upon market demand in Gansu and surrounding regions, the Lanzhou hub leverages its core node advantage to prioritize multimodal transport models centered on rail corridors supplemented by road feeder services. Rail corridors primarily handle medium-to-long-distance bulk container shipments, while road feeder services ensure precise "last-mile" delivery. This development approach has gained academic recognition. Li Xiaohan [9] constructed a multimodal transport route model using genetic algorithms. For goods with varying value and time-sensitivity requirements, combined modes such as "rail consolidation – China-Europe freight train" and "road consolidation – China-Europe freight train" represent optimal solutions. The core logic relies on rail for trunk transportation, matched with corresponding feeder and distribution methods. Compared to conventional standalone transport modes, these combinations better reduce costs while enhancing delivery timeliness and reliability. This provides a reference basis for the subsequent empty container transfer at the Lanzhou hub, which adopts a rail-as-primary, road-as-supplement approach. This firmly establishes the Lanzhou hub's pivotal role in national empty container allocation.

(3) Information Platform and Intelligent Dispatch

To achieve seamless loading/unloading and multimodal transport, the Lanzhou hub requires information-driven and intelligent dispatch. The hub aggregates diverse data through an empty container data-sharing platform, leveraging big data and AI technologies for precise supply-demand matching of empty containers, then adjusts operations based on these results. Zhang Ning et al. illustrate this through a major shipping company's intelligent dispatch "M System." Based on maritime operations, this system employs deep learning and multidimensional data analysis to automatically generate empty container dispatch plans. It has elevated overseas return trunk line capacity utilization to 99.6%, thereby reducing operational costs and enhancing overall efficiency [10]. For the Lanzhou hub, this serves as a successful model for advancing intelligent dispatch. Its practical application fully demonstrates the capability to upgrade traditional operational hubs through digital transformation.

2.3. The Practical Significance of Utilizing Empty and Lightweight Container Cars at the Lanzhou Hub.

The report on the "14th Five-Year Plan for the Development of Gansu (Lanzhou) International Land Port and the Outline of Long-Term Goals for 2035" indicates that by 2035, the Lanzhou hub must be developed into a modern international port with global competitiveness, featuring functions of "international transshipment, bonded logistics, and port logistics"[8]. This lays the foundation for a significant leap in the operational volume of the Lanzhou hub and strategically establishes Lanzhou's position as a national hub for the allocation and recycling of empty container resources. To meet these development demands, while ensuring efficient organization and management of both empty and loaded vehicle flows at the Lanzhou hub, it is crucial to fully leverage returned empty container resources. Effectively revitalizing return empty containers—transforming idle "empty vehicles" into productive "loaded vehicles"—will yield significant and far-reaching practical benefits across all sectors.

2.3.1. Multi-dimensional Demonstration of Hub Core Value: Synergistic Enhancement of Cost, Efficiency, and Industry.

Traditional transportation models often impose high costs on China's inland export enterprises, particularly those in the northwest region, due to empty container transfers. As a national logistics hub designated by the National Development and Reform Commission and the Ministry of Transport, Lanzhou possesses inherent distribution capabilities along international logistics corridors. It can accommodate unused empty containers returning from Europe and Central Asia, thereby shortening the distance domestic enterprises must transport empty containers. This reduces overall logistics costs and time expenditures for businesses, delivering significant economic benefits to regional enterprises while enhancing the cost competitiveness of local products in international markets. Simultaneously, by repurposing empty containers on return trips to organize cargo, the initiative successfully transforms unused "empty vehicles" into productive "loaded vehicles" carrying actual goods, generating bidirectional transportation benefits for the trains. This aligns with the broader trend of high-quality development for China-Europe freight trains nationwide. According to the China-Europe Railway Express Development Report 2021, the volume of outbound and return trips has become increasingly balanced in recent years, with the annual comprehensive container utilization rate reaching 98% [7]. The growth in two-way cargo volumes helps spread fixed costs, thereby reducing transportation costs per unit of cargo. This further enhances the market competitiveness of the train services, gradually forming a virtuous cycle of "cost reduction and volume increase".

The Lanzhou hub plays a crucial role in enhancing the operational efficiency and resilience of the national logistics network. Strategically positioned at the "center connecting six regions and radiating to eight directions," Lanzhou serves as a vital national container circulation regulator. It redistributes and reuses the large volume of empty containers entering via the western corridor according to regional supply and demand requirements, thereby improving container turnover rates and balancing national empty container resources. In the event of port congestion or disruptions, Lanzhou can swiftly transition

into an inland emergency supply center, ensuring container availability for export enterprises and thereby strengthening the resilience of the national logistics chain.

Through its efficient container logistics services, the Lanzhou hub profoundly empowers regional economic and industrial development. According to the 2023 Performance Evaluation Report on Strengthening the Lanzhou-Xining National Comprehensive Freight Hub Chain, the hub generated an economic contribution of 678.963 billion yuan in 2023, with container throughput growth reaching 22.6% and supporting 214,500 jobs[11]. This transformation signifies an upgrade from a single logistics corridor to a modern hub economy characterized by integration, platformization, greening, and the fusion of industry and urban development. It fosters a virtuous cycle of hub economic growth and indirectly validates the theoretical essence of hub economics: "an emerging economic model where accelerated resource aggregation driven by the interactive synergy between hubs and industries enhances circulation efficiency and facilitates industrial transformation and upgrading, thereby promoting high-quality development of industrial chains and clusters" [12].

2.3.2. Unique Hub Function Positioning and Advantages.

Different hubs exhibit distinct functional divisions in container yard scheduling. The Chongqing region primarily organizes high-value cargo for outbound shipments. However, this export-oriented "unidirectional logistics model" faces challenges with accumulated empty containers on return trips. To address this imbalance-induced backlog, Lanzhou can coordinate regional empty container allocation—redirecting containers accumulated in southwest hubs (like Chongqing) to cargo origins such as Xinjiang. This cross-regional container allocation not only alleviates operational pressure on hubs like Chongqing but also balances container flows between northwest and southwest regions, enhancing the national logistics network's efficiency and resilience. Lanzhou's capacity for empty container scheduling and cross-regional allocation exemplifies a theory emphasizing how hub nodes enhance overall efficiency and coordination in international logistics networks through integrated functions (cargo consolidation, transshipment, and scheduling).

In terms of regional reach and cargo organization, Lanzhou's four-directional railway hub—with the east-west Lanzhou-Xinjiang and Longhai railways connecting Xinjiang to inland regions, and the north-south Baotou-Lanzhou and Lanzhou-Qinghai railways linking North China to the Qinghai-Tibet area—forms a rare transportation hub in Northwest China capable of "four-directional distribution." As illustrated in the schematic diagram of Lanzhou's hub railway lines (Figure 2), This structure enables scenarios like container transshipment to Tibet and bulk commodity transport between Xinjiang and North China to effectively bypass transshipment issues caused by single-channel reliance, fully leveraging the land port hub's advantages in trunk-feeder connectivity and regional distribution. In contrast, Xi'an's functional focus on cross-regional trunk transportation proves less adaptable than Lanzhou's "cross-shaped" structure for handling the flexible distribution of multi-directional, multi-commodity flows within Northwest China.

With the rapid development of China-Europe freight trains under the Belt and Road Initiative, transportation cooperation between the Lanzhou transport hub and ports/border crossings has become increasingly integrated. As shown in Figure 3, the container throughput and return empty container rate at the Lanzhou hub steadily increased from 2017 to 2023. This trend will impact empty or partially loaded containers returning from Europe. Research by Wei Hairui [13] suggests that connectivity can be enhanced by strengthening cooperation between inland ports and seaports and expanding China-Europe Railway Express routes. This also indicates that Lanzhou and border ports can establish an "end-to-end" cooperation model spanning the entire international logistics chain. Border ports serve as the starting point for consolidating and distributing international cargo flows, while Lanzhou, as the endpoint, handles the redistribution and resource integration of empty containers after their return. This cooperative model establishes a workflow where border ports consolidate cargo flows, followed by reintegration and redistribution through the Lanzhou hub. Such "end-to-end" collaboration can facilitate deeper integration of other inland provinces into global supply chains.

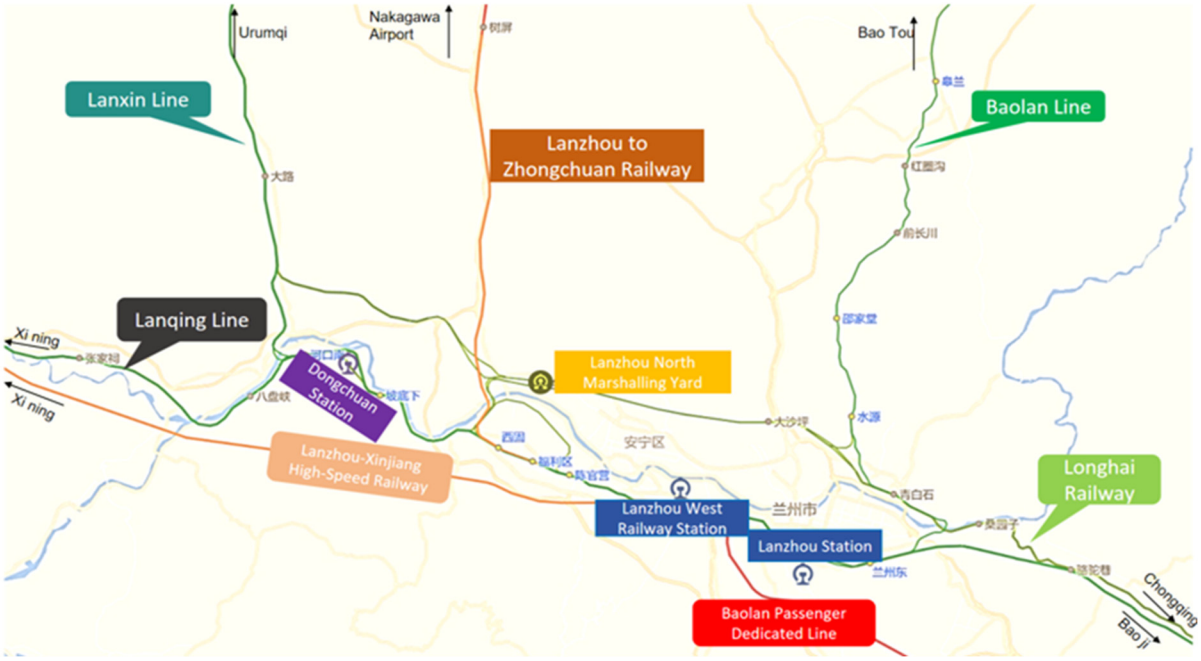


Fig 2. Schematic Diagram of Railway Lines at Lanzhou Hub

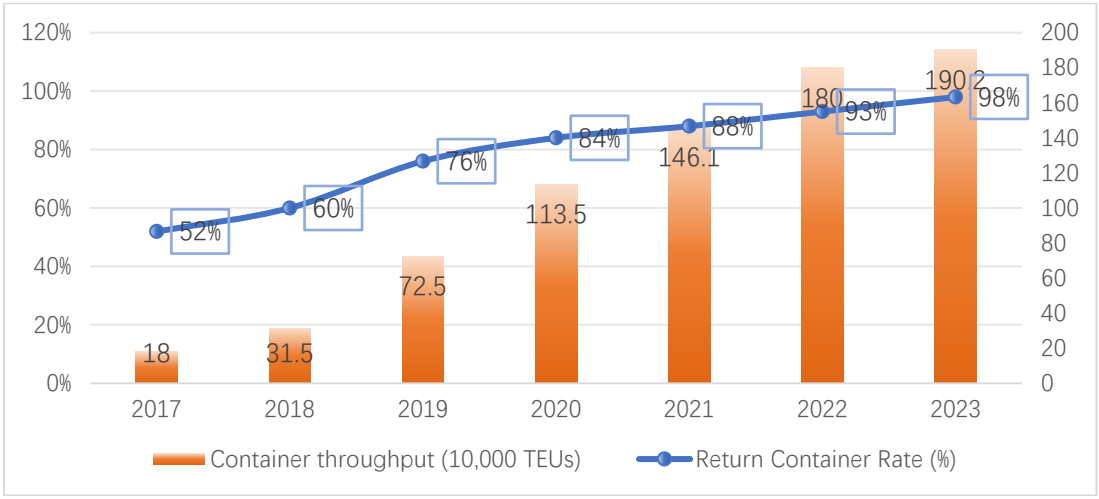


Fig 3. Trends in Container Throughput and Return Empty Container Rate at Lanzhou Hub, 2017–2023

3. Conclusion

This paper analyzes the strategies and value of the Lanzhou Hub in addressing transport capacity imbalances through efficient utilization of empty and loaded containers, based on its functional systems. Key conclusions are as follows:

(1) By establishing a utilization strategy comprising a "coordinated collection-distribution-transfer system + multimodal distribution + intelligent dispatch platform," the Lanzhou Hub has transitioned from a traditional point-to-point logistics model to a regional circular dispatch hub. This successfully converts the cost burden of return empty containers into strategic resources, boosting container utilization rates and freight train operational efficiency. It provides a replicable node solution for addressing capacity resource allocation challenges in China-Europe freight trains.

(2) The Lanzhou Hub's effective utilization of empty and loaded containers significantly impacts the logistics network. Prioritizing nearby container supply and allocating surplus empty containers reduces corporate container usage costs and overall logistics expenses. Its unique geographic position also effectively balances domestic empty container supply and demand while enhancing the resilience of the national logistics network. This enables the Lanzhou hub to evolve from a single logistics model into a modern hub economy characterized by integration, platformization, green practices, and industry-city synergy. It further drives exports of specialty products from the Gansu-Qinghai-Ningxia region, fostering a virtuous cycle of hub-based economic development.

(3) With the rapid expansion of China-Europe freight trains under the Belt and Road Initiative, Lanzhou's unique "four-directional" rail network and strengthened port collaborations demonstrate distinct advantages in empty container scheduling and cross-regional resource integration. This further refines functional division and coordination among China-Europe train hubs, aligning with green logistics and dual carbon goals.

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