

# Strategic Pathways for Reconstructing Civil Aviation's Ecological Niche under High-Speed Rail Transformation

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**Abstract:** The high-speed railway transformation, which has been stimulated by the expansion of the high-speed railway network, has led to a strong substitution effect for civil aviation in the short-to-medium distance transportation sector. The substitution effect is reflected in passenger diversion, a reduction in market share, a rise in niche overlap, and a reduction in the competitive edge of civil aviation. Based on niche theory, this research investigates how high-speed railway transformation affects the competitive environment of civil aviation, looking at the role of high-speed railway transformation in reconstructing the niche of civil aviation. There are three strategic steps to reconstruct the niche of civil aviation, which include optimizing the transportation network, enhancing air-rail intermodal transport, and international development with hub improvement. The goal is to promote a shift in the overall transport system from substitution-based competition to a coexistence relationship, which increases efficiency growth and sustainable development.

**Keywords:** High-Speed Rail Transformation; Civil Aviation Niche; Substitution Effect; Route Network Optimization; Air-Rail Intermodal Transport

## 1. Theoretical Basis for Civil Aviation Niche Reconstruction under High-Speed Rail Transformation

### 1.1 Transportation Niche Theory

The niche theory, which originated from biological ecology, is used to analyze the role of a species within an ecosystem, use, and coexistence with other species. In transportation research, this theory has been expanded to analyze competition and coexistence within different modes of transportation (for instance, high-speed railways, highway transport, and

civil aviation), which views the overall transportation system as a living ecosystem, with different modes occupying respective niches. By resource competition, modes of transportation are differentiated, overlap, and adjusted [1, 2]. Niche breadth defines the scope of resource use by a particular mode (for instance, passenger flow), while niche overlap defines competitive intensity with other modes. In multi-mode competition, niche differentiation increases the overall efficiency of the system. In relation to the overall transportation system within the country, the theory of a new branch niche applies as a tool to analyze substitution and complementary development within high-speed railways and civil aviation. The growth of high-speed transportation has led to an increase in the overlap of short- and medium-distance passenger transport, which has caused civil aviation to modify its niche orientation toward long-distance flights, hence contributing to the overall development of different modes within the transportation sector [3].

The dynamic development process of the transportation niche theory is illustrated in Figure 1. In the initial stage of high-speed railway development, a significant overlap of the high-speed railway and air transport niches led to a competitive situation, specifically regarding short- to medium-range routes. This competitive force, in turn, reinforced the development of a differentiated niche structure with increased resource attributes of civil air transport infrastructure, including route optimization, intermodal transportation, and globalization, which finally led to a coexistence relationship with a reduced overlap of niche attributes and optimized niche scope, thus ensuring overall efficiency of the entire transportation system.

### 1.2 Characteristics of High-Speed Rail Transformation

The China high-speed railway upgrade is marked by the acceleration of network size, self-developed technologies, and intelligent

operation modes. The high-speed railway has been developing quickly since the launch of the Beijing-Tianjin Intercity High-Speed Railway in 2008, becoming the longest and most heavily used high-speed railway in the world with design speeds of 200-350 km/h, connecting large urban clusters and economic corridors [4]. Over the entire course of the upgrade, China has changed from relying on technologies from others to developing technologies on its own via introduction, digestion, absorption, and

reinnovation, thus realizing a complete industry chain and standard system. In terms of the upgrade, China has changed from a single railway transportation mode to a full transport hub, with a focus on air-rail intermodal transportation, multimodality, and intelligent operation modes. This upgrade promotes economic integration and interconnectivity, but also meets challenges of debt and capacity optimization [5].

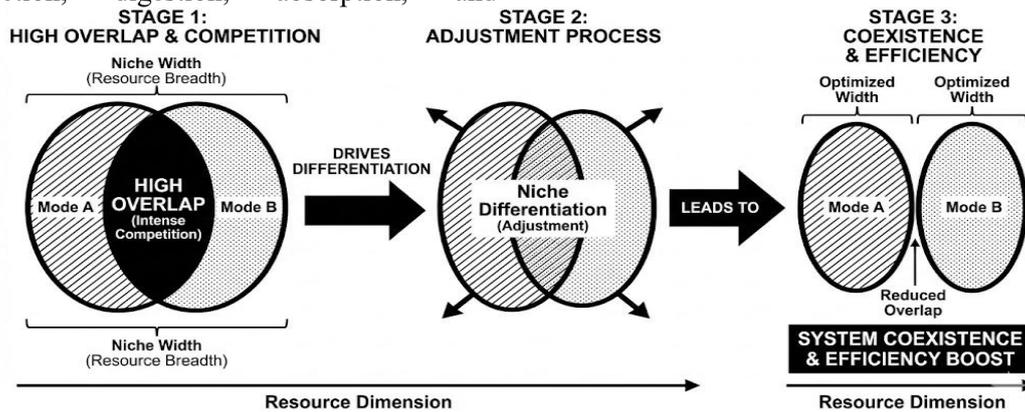


Figure 1. Dynamic Evolution Process of Transportation Niche Theory

### 1.3 Necessity of Civil Aviation Niche Restructuring

The cutting-edge development of high-speed rail (HSR) technology has generated a strong substitution effect on civil air transport, especially on short- to medium-distance routes, which has led to a decline in air passenger traffic. In this respect, the reconstruction of a niche has appeared as a necessary condition for the healthy development of air transportation [2, 3]. It has been revealed that the demand for air transportation, which has a distance of 500-800 km, is reduced significantly following the implementation of high-speed rail, with some routes reporting over 50% declines in air passenger traffic.

The rationale for carrying out niche reconstruction in civil aviation is linked to the need to respond to changes in the competitive environment within the transportation system, optimize resource allocation efficiency, and make way for low-carbon growth. Through the maximization of long-haul international air routes, hub optimization, and strengthened intermodal collaboration, civil aviation is capable of realizing niche differentials, enhancing overall competitive power, and promoting overall cooperation within the transportation system [1].

## 2. Impact of High-Speed Rail Transformation on Civil Aviation Niche

### 2.1 Substitution Effect of High-Speed Rail Expansion

The development of the high-speed rail (HSR) network has a significant substitution effect on civil aviation, mainly reflected in the redistribution of passenger flows on short-medium routes. Owing to the properties of high frequency, high punctuality, and prolonged overall travel time, HSR has been shown to possess significant competitiveness on routes with a distance of 500-1000km, thereby leading to a significant reduction in passenger traffic, flight frequencies, and available seats on corresponding air routes [6][7]. The result of empirical research has shown that, following the launch of HSR services, air routes with short-medium distances suffer a significant decline in demand, with the East Asian region being particularly hit hard by a sharp drop in passenger traffic on parallel air routes, but a complementary relationship is likely to exist in long-distance air routes. The substitution effect of HSR network development gradually strengthens, especially in the China market, with a significant substitution effect on short-medium routes, but the HSR service launched on longer

routes has prompted an increase in air passenger demand. This phenomenon helps optimize transportation modes, but at the same time, increases competitive pressure on civil aviation, especially on routes with short-medium distances, forcing a decrease in air flight frequencies or capacity [8]. In summary, HSR development has reinforced the substitution effect of short-medium passenger transport, contributing to a low-carbon transformation and efficient resource use in the overall transportation system.

## 2.2 Changes in the Competitive Landscape

The rise of high-speed rail (HSR) has triggered a change in the competitive relationship between HSR and civil aviation from a local rivalry to overall competition, with a significant change in the spatial and temporal dimensions. It has changed from a spatial relationship that favored aviation in short, medium, and long distance routes to a situation where HSR dominates short and medium routes, with a competitive relationship on parallel routes, although aviation still has a dominant position on long routes [9]. In a spatiotemporal relationship, the high density of schedules offered by HSR, with reduced travel times, has played a significant role in changing passenger travel behavior. Although this impact was limited when aviation experienced a rapid expansion growth process, in later phases, the negative impact has been increased, thereby playing a significant role in changing the competitive environment from point-to-point rivalry to network rivalry, with a need for cooperation from aviation on long-distance international routes, making air-rail intermodal cooperation necessary [7]. The competitive environment thus changes, making the overall connectivity more efficient while making the aviation network more vulnerable, especially when cities are not within the hub area [7]. In the long run, the rise of HSR thus promotes a changing relationship that promotes overall coexistence, thereby supporting regional development [10].

## 2.3 Impact on the Market Share of Civil Aviation

The growth of high-speed railways has significantly reduced the market share of civil aviation, especially on parallel routes with short to medium distances. Findings from empirical research show that after the establishment of

high-speed railways, the passenger demand for air transportation is significantly reduced, especially as the negative impact worsens after more than two years of establishment. The factors that significantly affect this situation are increased passenger frequency and reduced travel times [9] [10]. The existence of market-share differences is observed, and the establishment of the four vertical and four horizontal networks has significantly impacted the demand for air transportation in the central and western regions. The impact on the civil aviation market share cumulates, and improvements in high-speed railway infrastructure increase the substitution rate, hence leading to changes in the concentration of the air transportation market. This phenomenon aids in the shift of civil aviation market share to long-distance international routes, hence promoting low-carbon travel, but to mitigate the potential losses, hub optimization and intermodal transportation are required [6]. The growth of high-speed railways rearranges markets and enhances the sustainability of the overall transportation system.

## 3. Strategic Path of Civil Aviation Niche Restructuring

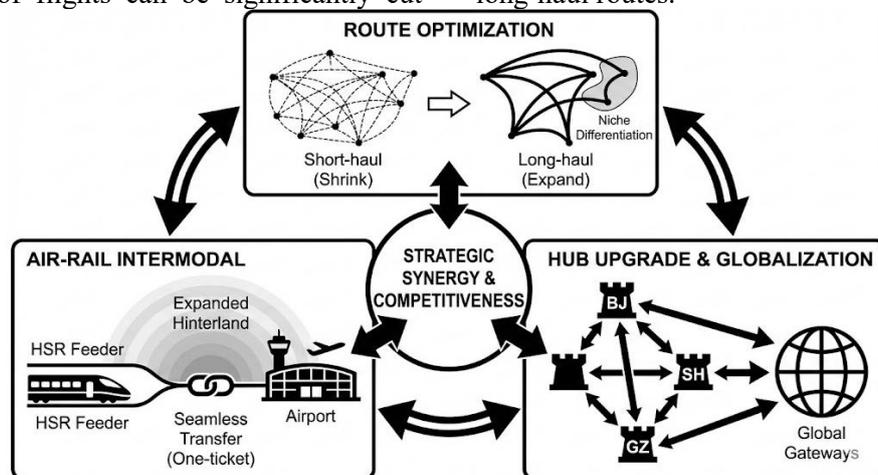
In figure 2, a strategic path approach is adopted in reconstructing the strategic niche of civil aviation with the assistance of high-speed railway transformation. The strategic path approach focuses on optimizing routes to accomplish niche distinction with decreased short-haul transport and increased long-haul transport. The approach is built on intermodal transportation, combining air-rail transportation, with high-speed railway transportation utilized as a feeder service from which inland transportation capabilities are expanded. In addition, hub renovation and international growth are the focuses that govern the strategic path approach, with the enhancement of worldwide gateways of hub airports included.

### 3.1 Route Network Optimization

In relation to the accelerated modernization of high-speed railways, the most pivotal part of the competitive niche positioning of civil aviation is involved in optimizing the air routes network. In other words, civil aviation's most potent strategy to counter overlap rivalry from high-speed railways is to actively cut back services on short- and medium-haul routes, hence redeploying the

available operating capacity on long-haul routes within the country as well as globally. In particular, on routes that are less than 800 km, the number of flights can be significantly cut

back, with the resulting available operating capacity deployed on routes in excess of 1000km, especially inter-regional trunks and international long-haul routes.



**Figure 2. Strategic Path Framework for Civil Aviation Niche Restructuring under High-speed Rail Transformation**

Meanwhile, the route network optimization should be connected with a hub-and-spoke system, which strengthens the role of hub airports as feeders for the corresponding feeder routes. Regarding second- and third-tier airports that are heavily impacted by high-speed railways, a small number of feeder routes may be retained for the purpose of hub connectivity, but not to maintain fierce competition on trunk routes with high frequencies. In addition, the adjustment of seasonal routes, night routes, and routes with other conditions may provide additional enhancement for the network resilience and resource allocation efficiency. In sum, the route network optimization moves civil aviation from a "comprehensive coverage" to a "key breakthrough" path, thereby sharpening its competitive edge in the medium-to-long distance routes, with a niche restructuring path towards high-end, high-efficiency channels.

### 3.2 Development of Air-Rail Intermodal Transport

Air-rail intermodal transportation is a distinct means by which the air transport sector can cope with the competition from high-speed rail transport systems and find complementary ecological niches. The air transport sector can thus develop a longer hinterland by enhancing cooperation with high-speed rail systems and developing them as a feeder service for short- to medium-haul air transportation. This can be realized by developing a close physical connection between airports and high-speed

railway terminals, as well as check-in, ticketing, and timetabling.

In terms of implementation, airlines, together with railway departments, are encouraged to provide air-rail intermodal services, such as "one ticket to the end" solutions, to entice fare-sensitive passengers. Meanwhile, with regard to the development of megahubs in China, such as Beijing Daxing, Shanghai Hongqiao, and Guangzhou Baiyun, constructing comprehensive transportation hubs can assist in providing passengers with a seamless air-rail transfer service. This service has the effect of offsetting the threat of substitution of short-to-medium-haul air transportation by high-speed rail, while stimulating traffic growth in the civil air transportation sector, especially transit air traffic.

In the long run, the progressive development of air-rail intermodal transport is anticipated to facilitate the establishment of a multimodal transportation system, which will result in supplementary transportation resources and improved efficiency. Via intermodal collaboration, civil aviation is recasting their competition with high-speed trains into a network extension advantage, thereby remodeling their ecological niche as a leader in long-distance transportation and gateways to international transportation systems.

### 3.3 Internationalization and Hub Enhancement

Overseas development and the improvement of

hub competitiveness are strategic focuses for the ecological niche reconstruction of civil aviation. In the face of the challenges imposed on the short-range and medium-range markets within China by high-speed rail, civil aviation should quicken the process of capacity transfer to the international sector, which would result in a greater density of international routes, especially on the Belt and Road Initiative routes, as well as major routes in Europe, the Americas, and Australia. This goal can be achieved by launching international long-haul routes, as well as increasing frequencies on existing routes, which in turn would promote the position of Chinese carriers in the international air transportation system.

At the same time, hub enhancement supports the internationalization plan. The priority tasks are to enhance international aviation hubs in Beijing, Shanghai, and Guangzhou, optimize air rights, slots, and transfer facilities, further optimize sixth freedom rights use, as well as increase the number of international transit passengers. In addition, promoting cooperation with international airline alliances, developing code-sharing cooperation, and complementarity, as well as improved accessibility worldwide, are vital elements.

Hub enhancement also requires corresponding infrastructure improvement, including the construction of new international terminals, improved efficiency in customs clearance, and development of air logistics. Through the use of a two-engine strategy that takes a combination of internationalization, hubs, and development, civil aviation is capable of developing a niche position in long-haul transportation, as well as stemming the decline in the domestic market, to progress from a regional transportation sector to a global transportation sector with a high-end international gateway.

#### 4. Conclusion

The development of high-speed rail has led to a paradigm shift in the competitive arena of the comprehensive transportation system in the country. By extending the scope of development and upgrading technologies, it has delivered a high level of substitution impact on civil aviation in short- to medium-haul routes, which has been reflected in passenger diversion, reduced market share, and overlap of niche opportunities. In this backdrop, the niche reconstruction process in civil aviation appears to be an inevitable

strategic consideration for ensuring the sustainable development of civil aviation. By applying the principles of niche theory, this research provides a comprehensive perspective on the nature of the high-speed rail shift and the implications of such a shift on civil aviation, which are divided into three strategic paths: Route Network Optimization, Air-Rail Intermodal, and Internationalization/Hubs in Civil Aviation.

These strategic paths are interrelated with a synergistic effect on each other, with the aim of the first path facilitating niche differentiation by means of capacity shift to longer haul markets, while the second path reconstructs competition with a complementary extension of the network hinterland; thus, with the third path, civil aviation cements its preeminent position in international air transportation, from a competitive rivalry within the broad domestic arena to notability within the international transcontinental hub gateway position.

In summary, the transformation of the civil aviation system is also aimed at not only offsetting the effect of high-speed railway systems but also ensuring efficiency in the use of resources. In the future, with the improvement of high-speed railway systems, as well as the implementation of civil aviation strategies, there is a potential transformation from rivalry to complementarity within the two sectors, resulting in a new transportation system that is efficient, green, and sustainable, providing a strong impetus for regional economic integration and the construction of a transportation giant.

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