A Study of Chinese and German "Super Air Carriers" in the Context of Integrated Transport Hubs: Development Model and Regional Impact

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Introduction

The year 2023 marks the 5th anniversary of promoting the Yangtze River Delta (YRD) integrated development as a national strategy. Over the past five years, the YRD region has continued to push for economic and transport integration and set a vivid example of Chinese modernization at the regional level. On the one hand, Shanghai as a regional integrated transport hub has been constantly upgraded, driving the transport network expansion in the YRD region. Meanwhile, Shanghai has made vigorous efforts to build a world-class "Super Carriers" with global competitiveness and services, construct a hub-and-spoke and city-to-city hybrid route network with shuttle services, and gradually establish a modern aviation industrial system covering the entire industrial chain.

In recent years, Shanghai has taken steps to push forward the high-quality development of "Super Carriers" and transport hubs. At the end of 2018, the Civil Aviation Administration of China (CAAC) explicitly proposed to build world-class "Super Carriers" in the *Outline of the Action Plan for Building China's Strength in Civil Aviation for a New Era*.[1] Upholding the "Super Carriers" model, China Eastern Airlines Co., Ltd (CEA) has since made active efforts to foster an aviation ecosystem by fully participating in global cooperation and getting deeply involved in the YRD regional transport integration, and acted as the "main force" of building Shanghai into an international opening-up hub. In 2021, Shanghai released the *Overall Plan to Build the Hongqiao International Opening-up Hub*[2] and the *14th Five-Year Plan for the Central Business District of Hongqiao International Opening-up Hub*, leading the transport hub construction into the "fast lane." An accessible and convenient integrated transport gateway has been created, and a rail transit system spanning the entire YRD region has been put in place, which consolidates the infrastructure for building "Super Carriers" in civil aviation. In

[1] Circular of the Civil Aviation Administration of China on Printing and Issuing the Outline of the Action Plan for Building China's Strength in Civil Aviation for a New Era. CAAC, http://www.caac.gov.cn/XXGK/XXGK/ZFGW/201812/t20181212_193447.html, accessed on October 15, 2023.

[2] Circular of the National Development and Reform Commission on Printing and Issuing the Overall Plan to Build the Hongqiao International Opening-up Hub [J]. State Council Gazette of the People's Republic of China, 2021, (07): 79–84.

August 2023, the National Development and Reform Commission (NDRC) issued the *Policies and Measures to Promote Hongqiao International Hub for Opening up at a Higher Level*, putting forward higher standards for YRD transport integration.

CEA and Deutsche Luft Hansa AG (Lufthansa) are "Super Carriers" in the civil aviation sector of China and Germany, respectively. They have played a crucial role in building international shipping centers and made great contributions to transport and economic development in the YRD region and Frankfurt-Rhein-Main metropolitan region. Given this, by comparing the important roles played by CEA and Lufthansa as "Super Carriers" in local economic and transport development, Chinese and German "Super Carriers" models in the context of air-rail intermodal transport hubs are summarized, including evolution, experience and achievements. This is of vital practical significance for further raising the level of China's transport services and enhancing the competitiveness of regional economies. Moreover, Frankfurt and Shanghai are considered the forerunner and latercomer in air-rail intermodal transport hubs respectively. A comparative study of the successful practices in building "Super Carriers" and regional integrated transport hubs will give valuable lessons and implications for advancing transport infrastructure and regional interconnectivity within the framework of the Belt and Road Initiative (BRI).

1. Evolution of Transport Patterns in Regional Urban Spatial Structure in the Context of Globalization

The spatial structure of human activities has always been dominated by "axes" throughout history. In other words, human activities have been carried out mainly along various transport routes, from rivers and post roads in ancient times to railways and highways in modern times and to high-speed railways and expressways today. Such transport routes have become different levels of development axes, through which human settlements are interconnected. The center point where multiple axes is likely to evolve into a large metropolis, regarded as the focus of further development. The hinterland along the axes or at the endpoints is dotted with towns and villages radiated from the center

point.

With the rapid development of rail and air transport, two new trends have arisen in Chinese and German settlement structure since the 1970s—suburban urbanization and decentralization. On the one hand, on the periphery of some big cities, the settlements within 20 to 40 km away from the core city have been rapidly urbanized to form highly concentrated urban agglomerations with the help of dense intra-city and inter-city rail transit. On the other hand, the less affected hinterlands of small center points have interacted more frequently with larger central hubs by air and rail, and strengthened functional links with each other based on their respective advantages. This gives rise to a regional network of cities that is mutually beneficial in terms of economic structure and infrastructure.

At the same time, human mobility has been fundamentally boosted by the stronger ties between countries and the refined division of labor in the context of globalization. Traffic is on the rise as a result of larger distance between places of residence and work, wider application of just-in-time (JIT) manufacturing (reducing inventories through transport of primary and final products by road and rail), and more frequent mobility for leisure purposes among many factors. Global air traffic has also surged, driven by increasingly globalized supply chains and growing demand for long-haul travel. Airports have thus come to prominence in urban network and spatial development. The availability of sound air transport infrastructure becomes a new measure of the competitiveness of a city or region. Cities with accessible air and rail transport infrastructures have evolved into key nodes in the regional network of cities or even gateways to the global network of cities, known as global and world cities. Where possible, the aggregation of air, rail and other transport infrastructures at the micro-spatial level to integrate two basically complementary modes of transport, i.e., air-rail intermodal transport, can undoubtedly improve and enhance connectivity within and between city networks. Better interconnectivity facilitates more rational division of labor in economic activities and more efficient aggregation and allocation of economic resources. It also allows core cities as air-rail intermodal transport hubs to further expand the capacity and scope of influence, thereby reshaping the regional urban spatial structure of economic activities at a broad level.

Against the background, world-class "Super Carriers" have emerged in civil aviation and gradually assumed the responsibility for developing globalized regional air transport networks. Carriers generally refer to enterprises that specialize in passenger and cargo transport by sea, rail, road, air, etc. "Super Air Carriers" are top-notch air transport enterprises with superb global services, innovation capability and influence.

Germany is early to explore the "Super Carriers" model. In January 2013, the Federal Cabinet adopted the Aerospace Strategy of the Federal Government developed by the Federal Ministry of Economics and Technology, aiming to accelerate the development of an efficient, safe, clean and competitive aerospace sector by bolstering the common understanding and joint effort of policymakers and stakeholders in the domains of industry, science and technology, education and economy.[3] The strategy clearly stated that the Federal Government would improve the internal structure of the aerospace sector and increase financial and technological investments in civil aviation enterprises. Remarkable results have been reaped since this strategy was implemented, as manifested in the rise of Frankfurt hub into a major European transport hub and Lufthansa into a world-renowned airline.

At the end of 2018, CAAC issued the *Outline of the Action Plan for Building China's Strength in Civil Aviation for a New Era*,[4] mapping out the way to the goal of turning the nation into an aviation power. The Outline put forward the goal of "building world-class Super Carriers" and made it clear to encourage joint reorganization and mixed ownership transformation of airlines, increase routes and flights allocated to main base airlines and foster world-class "Super Carriers" with global competitiveness and services. Global mergers and acquisitions (M&A) and strategic cooperation are encouraged, which makes use of capital to build a modern aviation industrial system covering the whole industrial chain and create top-tier airline groups in both service quality and

[3] Zhao Qinghua, The Aerospace Strategy of the German Federal Government Aiming at Making Germany's Aerospace Industry More Efficient, Competitive, Safer and Cleaner (i) [J], Global Science, Technology and Economy Outlook, 2013, 28 (11): 3–7.

[4] Circular of the Civil Aviation Administration of China on Printing and Issuing the Outline of the Action Plan for Building China's Strength in Civil Aviation for a New Era. CAAC, http://www.caac.gov.cn/XXGK/XXGK/ZFGW/201812/t20181212_193447.html, accessed on October 15, 2023.

enterprise size. The Outline also called for efforts to build a hub-and-spoke and city-to-city hybrid route network while actively developing air shuttle services. Shanghai and Frankfurt have grown into air-rail intermodal transport hubs with the strong support of "Super Carriers" CEA and Lufthansa on top of air-rail intermodal transport infrastructure. They represent the core nodes in respective hinterlands, i.e., the YRD region and the Frankfurt-Rhein-Main region, and moreover, as gateways to the world, profoundly affect the economic activities of these regions as well as their economic ties with the outside world. With regional integrated transport hubs and "Super Carriers" getting complete and perfect, Shanghai and Frankfurt set a paradigm of modern transport for regional urban spatial structure in the context of globalization.

2. "Super Carriers" Lufthansa and Frankfurt Integrated Transport Hub

Frankfurt is in the vanguard of regional integrated transport hubs with Frankfurt Airport (FRA) as the centerpiece. FRA is one of the most important transport hubs on the European continent and is home to the headquarters of Lufthansa and Lufthansa Cargo. With an annual cargo throughput of more than 2 million tons, FRA is rightly the largest cargo airport in Europe and one of the top 10 worldwide, hitting a cargo traffic record of 8,822 tons on February 6, 2021. FRA has also long ranked among the world's top 20 by passenger traffic. It secured the 4th place in Europe[5] before the COVID-19 outbreak as more than 60 million passengers arrived, departed or transited through this gateway each year, noticeably more than 70 million passengers in 2019, with a new daily passenger record of 241,228 set on June 30. Via this air-rail intermodal hub of international influence, 91.7% of the passengers traveled across borders and more than half (50.4%) took connecting flights in 2022. Given that 220 and 250 trains arrive per day at Frankfurt's long-distance and short-distance train stations respectively, travelers can also reach all parts of Germany and Europe through the extensive rail network.

[5] It slid to the 5th place in 2020 due to COVID-19 among many factors.

2.1. Transport foundation: Frankfurt transport hub creates carrying conditions for "Super Carriers"

2.1.1. Evolution of Frankfurt aviation hub

Located 12 km southwest of Frankfurt city center, FRA covers an area of about 24 km^2, including the main part in Frankfurt and some parts in the surrounding cities of Rüsselsheim am Main, Mörfelden-Walldorf and Kelsterbach.

FRA's establishment is inextricably linked with Frankfurt's unique position in the world aviation history. From July 10 to October 17, 1909, the International Airship Exhibition (Internationalen Luftschiffahrt-Ausstellung, ILA) was held in Frankfurt, which brought together more than 360 national and international companies and designers to present their flying machines and attracted nearly one million visitors. This event secured a proper place for Frankfurt in German aviation scene. The same year, Deutsche Luftschiffahrts-Aktiengesellschaft (DELAG), the world's first airline, was founded in Frankfurt. It opened an airfield on the ILA Rebstock site for the commercial operation of Zeppelins in 1912, which is later known as the Frankfurt-Rebstock Airport (Flughafen Frankfurt-Rebstock). It was from this airport that the first German airmail flight took off in 1912.[6]

After the founding of Deutsche Luft Hansa AG in 1926, German civil aviation sector grew so rapidly that the Frankfurt-Rebstock Airport in the city center fell far short of aviation demand. In view of this, the Frankfurt Municipal Administration (Magistrat) decided in 1930 to build a new airport to the southwest of Frankfurt. Frankfurt Rhein-Main Airport and Airship Port (Flug-und Luftschiffhafen Rhein-Main) was completed in 1936, known as FRA's predecessor. This airport was requisitioned by the German Luftwaffe after the outbreak of World War II and occupied by the US Army after the end of the war until 1946 when aviation services were resumed.

FRA saw its aviation business revitalized amid the post-war reconstruction boom in Germany. This time-honored airport is conveniently located near

[6] Portal of Gesellschaft zur Bewahrung von Stätten deutscher Luftfahrtgeschichte (GBSL), http://www.luftfahrtstaetten.de/luftfahrtstaetten/frankfurt-rebstock.html, accessed on November 20, 2023.

Autobahn A3 and A5 and Bundesstraße 43. A great opportunity of development befell as the Federal Government decided in 1957 to expand FRA to handle jets, the first of its kind in the country. In 1960, FRA became the second largest airport in Europe only after London Heathrow Airport, with 36 airlines, 8,100 flights, 2.17 million passengers, 46,900 tons of cargoes and 11,900 tons of airmail. In an effort to adapt to the new situation, a new terminal was planned to give the airport an annual capacity of 15 million passengers, which was further raised to 30 million passengers in 1967. The construction began in 1965 and the new terminal was put into use on March 14, 1972, known as Terminal 1 at FRA.

FRA is managed by Fraport AG, founded in 1947 under the name Verkehrsaktiengesellschaft Rhein-Main (VAG). Following the airport name change, the company adopted the name Flughafen Frankfurt/Main AG in 1954. It was a public enterprise, with the Federal Government, the State of Hessen and the City of Frankfurt accounting for 25.867%, 45.242% and 28.891% of the shares, respectively. The company was renamed Fraport AG Frankfurt Airport Services Worldwide in 2000, and listed on the Frankfurt Stock Exchange in 2001 with partial privatization. In October 2005, the Federal Government sold all of its shares, and Hesse and Frankfurt still held 51.31% together, with other considerable shareholders including Lufthansa, GAM, Lazard and BlackRock.

2.1.2. Air-rail intermodal integration at Frankfurt hub

Given the huge passenger traffic at FRA, the necessity of linking the airport to the rail network to alleviate pressure on overland transport was highlighted in the *Program for the Recovery of the German Transport System (Programm zur Gesundung des deutschen Verkehrswesens)* launched by the Federal Government in 1967. In 1971, the number of passengers at FRA surpassed 10 million. It was expected that the passenger volume would hit 24 million in 1980 and 30 million by 1985 and that 30–35% of passengers and airport staff would be handled by rail. In 1968, the Federal Railway Directorate Frankfurt am Main (Bundesbahndirektion Frankfurt am Main) was entrusted with the task of air-rail network planning. On April 18, 1969, Deutsche Bundesbahn and

Flughafen Frankfurt am Main AG reached an agreement on connecting the airport to the rail network. On March 14, 1972, FRA train station was put into use, with 96 trains carrying 12,500 passengers per day on weekdays during the summer. By the end of 1979, the expanded train station was able to deliver 20,000 passengers per day. In 1982, Lufthansa Airport Express linking Düsseldorf, FRA and Stuttgart was opened as an alternative to short-haul flights within 300 km. In 1985, under the impetus of the plan IC 85 of Deutsche Bahn, FRA was connected to the long-distance rail network InterCity, and offered long-distance train services thereafter, thus giving rise to an initial air-rail intermodal transport hub. In 1988, FRA train station served a total of 7.5 million passengers, about half of whom were air travelers. Railway transport not only reduced the traffic pressure around the airport, but also effectively consolidated and enhanced the locational advantage of FRA. In 1988, the number of FRA air passengers increased to 25.2 million.

As the advantages of air-rail intermodal transport became prominent, the existing infrastructure of airport and train station lagged increasingly behind the new situation. To this end, new terminal construction commenced on June 12, 1990. The entry into service of Terminal 2 on October 24, 1994 raised FRA's capacity to 54 million passengers. Groundbreaking for Terminal 3 took place on October 5, 2015, with delivery scheduled for 2026. In addition, the new Frankfurt dedicated long-distance train station (Fernbahnhof) was opened in 1999 in response to pressure on rail capacity, and the original train station was changed to a regional train station (Regionalbahnhof), primarily for short-distance trains. The full-ledged rail transport system laid the foundation for FRA's role as a major multimodal cargo transport hub (Multimodaler Verkehr). In this way, FRA has become an air-rail multimodal transport hub consisting of Terminal 1, Terminal 2, Freight Terminal (Frachtterminal), regional train station and long-distance train station.

With the relevant planning and financial support of the European Commission's Trans-European Transport Networks (TEN-T), the Federal Government of Germany has continuously improved the ease of rail access to FRA for European cities by optimizing link lines. The airport has basically realized full connectivity with the European backbone rail network, sharply reducing the time of travel by rail to major European cities. In 2015, the time of

rail travel to Cologne and London in the northwest was cut by about half compared to 2000 and the time to Paris and Milan in the southwest, Munich and Vienna in the southeast and Copenhagen and Warsaw in the northeast was shortened by about two hours. FRA has been recognized by the Airports Council International (ACI) as the best airport for hub connectivity almost every year since 2009, making it a true "European Gateway."[7]

2.2. Synergetic development: Lufthansa is closely related to the development of Frankfurt air-rail intermodal transport hub

Air transport, as an important part of aviation hub, gives a great boost to the development of regional transport ecosystem. In Germany, Lufthansa has rendered tremendous support for Frankfurt air-rail intermodal transport hub in terms of hardware (infrastructure) and software (network technology), from the introduction of direct flights to the inauguration of Lufthansa Airport Express.

Lufthansa started early and ran parallel to Frankfurt air-rail intermodal transport hub. The airline we know today does not originate from Deutsche Luft Hansa AG established 1926. Rather, the predecessor is Aktiengesellschaft für Luftverkehrsbedarf (LUFTAG), which was founded in Cologne on January 6, 1953 and adopted the current name in 1954. On April 1, 1955, the new Lufthansa launched regular flights between the cities of Hamburg, Düsseldorf, Cologne/Bonn and Frankfurt and the city of Munich, with Hamburg Airport (Heimatflughafen) its main base. With the advent of jets, Lufthansa moved its main base to FRA in 1960, the first airport in Germany to be able to handle jets, and played an important role in FRA's development thereafter.[8] In 1977, Lufthansa set up its wholly owned subsidiary German Cargo Services GmbH in Kelsterbach near Frankfurt, paving the way for FRA towards an important cargo airport.

Since then, Lufthansa has accelerated its efforts to build up the global aviation network, giving some support and stimulus to FRA's development. In

[7] Portal of the Airports Council International, https://www.aci-europe.org/air-connectivity.html, accessed on November 18, 2023.

[8] Portal of Airliners.de, https://www.airliners.de/grundsteinlegung-fur-neue-lufthansa-hauptverwaltung-in-koln/9272, accessed on November 7, 2023.

cooperation with other airlines in the Star Alliance, Lufthansa has opened direct flights between FRA and almost all major airports in the world. It has also introduced more feeder airlines to FRA by means of codesharing. These efforts significantly enhance FRA's status as an air gateway.

At the same time, Lufthansa has made an important contribution to air-rail intermodal integration at Frankfurt hub. On the one hand, Lufthansa Railway Express addressed the transport accessibility predicament for Frankfurt hub. Before FRA was connected to German long-distance rail network, cities a little farther away from the airport (within 300 km) did not have direct rail access to the airport, while the distance between the two places was not so far as to accommodate profitable air routes. The lack of convenient modes of transport from such cities to the airport for international flights to the rest of the world severely limited FRA's radiation radius and capacity. For this reason, Lufthansa, in cooperation with Deutsche Bahn, opened Lufthansa Railway Express on March 28, 1982, which linked Düsseldorf, Cologne, Bonn and Stuttgart to FRA. Passengers to the airport could check in with their baggage at these train stations. The train carried more than 65,000 passengers the year of its opening. Before it ceased operation in 1993, this service better filled the gap of air-rail intermodal service caused by disconnection to the long-distance rail network. The operation provides valuable early experience for the development of FRA air-rail intermodal transport.[9]

On the other hand, Lufthansa, in conjunction with FRA and Deutsche Bahn, has optimized and upgraded the air-rail intermodal online service, effectively stimulating passenger traffic at Frankfurt hub. On March 1, 2001, the three parties jointly unveiled AIRail, which achieves in the true sense the "one-ticket-fits-all" service, including air and rail combined ticket, integrated flight and train schedule and benefit and risk sharing. Currently, AIRail covers almost all of Lufthansa's target airports in Germany and has been extended to Austria and Switzerland, with 24 cities connected to the system and 240 trains per day to and from the airport.

[9] Portal of Lufthansa, https://www.lufthansagroup.com/de/chronik.html, accessed on October 8, 2023.

2.3. Regional impact: Impact of Frankfurt hub and "Super Carriers" Lufthansa on the hinterland

Frankfurt is connected to the world by air at one end and to Europe by rail at the other end. Relying on air-rail intermodal transport, Frankfurt hub has grown into an important transport hub connecting Europe to the world. Frankfurt/Rhine-Main as its hinterland has been benefited from the hub development. It is one of the 11 officially recognized metropolitan regions in Germany, with Frankfurt as its core and spanning the three states of Hessen, Rheinland-Pfalz and Bavaria. Frankfurt/Rhine-Main has about 5.9 million inhabitants in an area of 14,755 km^2, only after the metropolitan regions of Rhineland-Ruhr and Berlin/Brandenburg. From the perspective of transport geography, Frankfurt/Rhine-Main is well situated, sitting at the center of the European continent and Central Germany and noticeably the Blue Banana. The Blue Banana stretches from the Irish Sea to the Mediterranean Sea, i.e., from north-west England through central United Kingdom to northern Italy. Among the countries and areas covered are Greater London, Lille (France), Benelux, Rhineland-Ruhr and Frankfurt/Rhine-Main (Germany), Alsace-Moselle (France), Basel and Zurich (Switzerland), and Milan, Turin and Genoa (Italy). The Blue Banana is the most densely populated and most international metropolitan areas in Europe, which is economically and culturally advanced and rich in intellect, capital, media, transport and infrastructure. It is inhabited by 110 million people and home to more than 20 of Europe's global and world cities and almost all of the European Union's central institutions.

The impact of "Super Carriers" Lufthansa and Frankfurt hub on the economic development of Frankfurt/Rhine-Main is most directly reflected in the massive jobs added by the hub itself. Around 500 companies and organizations located in Frankfurt hub employ around 80,000 people, of whom nearly half work for Lufthansa and about a quarter for Fraport. Taking into account the upstream and downstream sectors that serve these companies and organizations, Frankfurt hub offers jobs to almost 120,000 people, whose consumption creates about 60,000 job opportunities through the spillover effect. As the largest workplace in Germany, Frankfurt hub benefits nearly 180,000 people,

directly or indirectly, functioning as a major engine of economic growth in Frankfurt/Rhine-Main.

More importantly, Frankfurt hub further sharpens the locational advantage of Frankfurt/Rhine-Main within Germany, Europe and especially the Blue Banana by giving full play to intermodal air-rail transport. On the one hand, hundreds of airlines operate flights at FRA, with more than 1,000 flights taking off and landing every day. There are direct flights between FRA and more than 300 airports of more than 100 countries, which makes it easy for local companies to join competition on a global scale. On the other hand, by rail, it takes less than ten minutes to get from FRA to Frankfurt city center and generally less than four hours to get from FRA or Frankfurt Train Station to the most important cities in Germany or the Blue Banana. In other words, FRA is connected to the world by air and has rail access to a wide area of Central and Western Europe, including Germany, Benelux, France, Switzerland, Austria, the Czech Republic and Poland. For German and European companies that are export-oriented or committed to operating on a global scale, this airport serves as a gateway to the various markets worldwide. For companies from outside of Europe, Frankfurt/Rhine-Main with Frankfurt and FRA as the center offers an ideal gateway to the German and European markets.[10]

The areas surrounded by Frankfurt hub are the heart of Frankfurt/Rhine-Main, including Frankfurt, Darmstadt, Wiesbaden and Mainz. The European Central Bank (ECB), as well as more than 1,900 credit and investment banks are based in Frankfurt; Darmstadt and Wiesbaden are home to the headquarters or main offices of many insurance companies, while the internationally renowned accounting firm KPMG has relocated its European headquarters from London to Frankfurt. Frankfurt-led city cluster has emerged as an important international center for high-end services, in which the role of FRA cannot be ignored. For high-end services such as finance and auditing, regular and secured client contacts on a global scale are essential to opening up and maintaining overseas markets. FRA with its air-rail interconnectivity undoubtedly provides a solid guarantee for global business. In addition, transport accessibility underpins Frankfurt/Rhine-Main's role a major trade fair

[10] Portal of Frankfurt Airport, November 20, 2023, https://www.fraport.com/de/konzern/ueber-uns.html, accessed on October 7, 2023.

center. Frankfurt plays host to many influential international trade fairs, including Automechanika Frankfurt, Frankfurter Buchmesse, IMEX Frankfurt, ACHEMA, Heimtextil, EMO and IFFA, as well as seven of the 20 most important national trade fairs in Germany. Wiesbaden, Offenbach and Darmstadt are also important host cities of trade fairs.

Manufacturing companies are more widely distributed throughout the rest areas of Frankfurt/Rhine-Main. Thanks to the accessible and dense rail and road network, most areas of Frankfurt/Rhine-Main are less than half an hour away from Frankfurt city center or FRA, and see Europe and the rest of the world reachable via the extensive air and rail network of Frankfurt and FRA. Frankfurt/Rhine-Main contributes to 10% of Germany's manufacturing output with 6% of the population. In addition, advanced transport infrastructure is conducive to the local logistics sector. Logistics companies such as DB Schenker, Lufthansa Cargo and JF Hillebrand have flourished along with local industries while supporting the development of local businesses.

Industrieparks Höchst and Automotive Cluster RheinMainNeckar are typical examples of Frankfurt hub's contribution to hinterland economic development. Sitting about 6 km north of FRA, Industrieparks Höchst is one of the largest industrial parks in Germany. It covers an area of 460 hectares and employs about 22,000 people. Since its operation in 1997, this park has attracted a variety of companies, largely from chemical and pharmaceutical industries, based on the advantages in capital flow and international logistics enabled by air-rail intermodal transport at FRA. Currently, there are more than 90 companies in the park, involving a total investment of 85 billion euros from pharmaceutical, biotechnology, chemical, plant protection, food additives and service industries. Among them are multinational giants such as Sanofi, Würth-Gruppe, Merck KGaA, AkzoNobel, BASF SE, Cabot Corporation and Bayer AG, as well as many innovative service providers such as CloudHQ.[11]

Automotive Cluster RheinMainNeckar, with Rüsselsheim and Darmstadt at its core, is one of the world's most important automobile industrial centers. Many European companies have sites here, such as Adam Opel AG, Pirelli Deutschland AG, Siemens VDO, Delphi Deutschland, TE Connectivity,

[11] Portal of Industrieparks Höchst, https://www.infraserv.com/de/unternehmen/ueber-uns/geschichte/, accessed on November 22, 2023.

Continental Teves AG and Man. Foreign companies such as Lear Corporation, Suzuki, Hyundai and Kia have also settled in this cluster, with Honda, Hyundai, and Mazda setting up their European research & development centers here. Totally 54,000 people are employed by this cluster, covering all aspects of automobile industrial chain from production, design, research & development and service.[12] Besides, the choice of South Korean companies illustrates indirectly the locational advantage of Frankfurt/Rhine-Main. Apart from numerous automotive companies, Samsung Electronics has placed its German headquarters in Schwalbach am Tanus in the region of Frankfurt/Rhine-Main. Together, these South Korean companies provide around 5,000 jobs and form Europe's largest South Korean community in Frankfurt and Frankfurt/Rhine-Main.

Thanks to Frankfurt hub and "Super Carriers" Lufthansa, Frankfurt has risen into one of Europe's most international cities in finance, business and trade fairs. As the flow of people and trade in Frankfurt is facilitated by the "Super Air Carriers" , German export-oriented enterprises come to nest in Frankfurt/Rhine-Main, so do the German or European headquarters of multinational enterprises. These enterprises, which are attracted by Frankfurt hub, create numerous job opportunities and produce a spillover effect energizing the economy of Frankfurt and Frankfurt/Rhine-Main.

[12] Portal of Automotive Cluster RheinMainNeckar, https://www.automotive-cluster.org/english/about-the-cluster, accessed on November 20, 2023.

3. "Super Carriers" CEA and Shanghai Integrated Transport Hub

As an emerging international air traffic center, Shanghai regional integrated transport hub has been developing rapidly by giving full play to its own advantages while drawing on the experience of transport hubs worldwide. Against this backdrop, CEA seizes the development opportunities brought by this hub to vigorously promote a "Super Carriers" model in civil aviation. Efforts have been made to construct and optimize the air-overland integrated travel network and upgrade and improve aviation products and services, radiating and driving the economic development of the YRD region in its hinterland. CEA has embarked on a road with Chinese characteristics for building a "Super Carriers" model and regional integrated transport hub.

3.1 Transport integration: Shanghai transport hub paves the foundation for "Super Carriers" development

3.1.1. Globalization of Shanghai aviation hub

Shanghai aviation hub comprises Hongqiao hub and Pudong hub, which grow gradually from two mainline civil airports respectively, namely Shanghai Hongqiao International Airport (SHA) and Shanghai Pudong International Airport (PVG). Among them, SHA is located in Changning and Minhang districts and closer to the city proper. Completed in June 1921, the airport opened the Shanghai-Chengdu route in May 1929 and launched the first flight on July 8 with Nanjing as the destination. In 1963, it was designated as an international airport based on the reconstruction and expansion in the early years of the new China founded after the War of Resistance Against Japanese Aggression and the War of Liberation. On April 29, 1964, SHA inaugurated the first international route after the liberation of Shanghai, i.e., from Shanghai to Dhaka, the capital of Pakistan (now the capital of Bangladesh). In 1995, Shanghai handled by air 11.08 million passengers (the third largest in China) and 370,000 tons of cargoes (the second largest in China) to become a major player in China's air transport. It was expected that by 2005, the air passenger and cargo throughputs would reach 33 million passenger trips and 1.2 million

tons, respectively.

In 1996, the demand for air passenger and cargo transport in Shanghai surged beyond the capacity of the newly expanded airport SHA, while further airport expansion was unlikely due to its location in a densely populated area. To this end, the Chinese Government decided in the Ninth Five-Year Plan to build a new international airport focusing on international services in Zhuqiao Town, Pudong New Area in the process of developing and opening the new area, based on the principle of pooling all resources to build a large hub airport.[13] PVG was officially opened on September 16, 1999 and launched international flights on October 20. Shanghai has since ushered in a period of rapid airport development. The Shanghai Municipal Government set, in its Tenth Five-Year Plan, the goal of building an aviation hub (hub airport) in the Asia-Pacific region with PVG as the mainstay and SHA as a supplement.[14]

In 2004, Shanghai issued the *Strategic Plan of Shanghai Aviation Hub*, which clearly defined the functional orientation of Shanghai aviation hub. It was committed to building an air gateway connecting China with the rest of the world and a core hub in the Asia-Pacific based on a comprehensive network of domestic and international air routes, with a view to turning the city into a pivotal node in the global aviation network. The same year, Shanghai's passenger volume and cargo and mail throughput by air reached 35.96 million trips and 2.25 million tons, respectively, equivalent to 15% and 35% of the national total, of which the international passenger and cargo traffic accounted for 40% and 68% of the total in China, respectively. Shanghai's airports became the most important gateway and aviation hub for traveling abroad, with PVG climbing to the 14th place globally by cargo and mail throughput.

After more than a decade of development, SHA's passenger volume came to 45.67 million trips in 2019, ranking 7th in mainland China and 46th in the world, while its cargo and mail throughput was relatively limited to be about 428,400 tons. At the same time, PVG's passenger volume exceeded 76.1 million trips, securing the 2nd place after Beijing Capital International Airport in China and

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[13] Outline of the Ninth Five-Year Plan (1996-2000) for National Economic and Social Development and the Long-range Objectives to the Year 2010 (Adopted at the Fourth Session of the Eighth National People's Congress on March 17, 1996).

[14] Outline of the Tenth Five-Year Plan for Economic and Social Development of Shanghai Municipality.

the 8th place globally. With a cargo and mail throughput of 3.6242 million tons, PVG rose into the second largest cargo airport in China after Hong Kong International Airport and the third largest worldwide. In total, Shanghai handled by air 120 million trips of passengers and 4.058 million tons of cargoes in 2019, ranking 4th and 3rd in the world, respectively. China's first "one city, two airports" urban airport system has taken shape, with air travel accessibility leading in Asia.

On the basis of the construction of Shanghai aviation hub, fast economic growth of the YRD region has brought new opportunities and challenges for Shanghai's urban development. The Shanghai Municipal Government continues to update and enhance transport infrastructure on top of its aviation hub, and in particular, endeavors to build an integrated transport hub centering on air-rail intermodal transport. Intercity air shuttle routes and regional rail transit network featuring "one core, two belts" have been extended to the YRD region, gradually shaping a regional comprehensive transport network that radiates from Shanghai to the neighboring cities.

3.1.2. Emergence and development of Shanghai air-rail intermodal transport hub

From aviation hub construction to air-rail intermodal integration, Shanghai has carried out adequate exploratory practice in a top-down approach. In 2006, the Shanghai Municipal Government decided to build a high-speed rail hub, known as Hongqiao Railway Station, on the west side of Terminal 2 at SHA, in a bid to foster a transport super hub—Hongqiao Integrated Transport Hub. Based on the airport and railway station, the planned hub integrates various modes of transport, including air, high-speed railways, inter-city railways and urban highways in the YRD region. On July 1, 2010, Hongqiao Railway Station was put into operation with the opening of the Shanghai-Nanjing intercity high-speed railway. Located at the junction of the Beijing-Shanghai and Shanghai-Kunming trunk railways, this station is connected to the Beijing-Shanghai high-speed railway and Shanghai-Wuhan-Chengdu passenger-dedicated high-speed railway in the north and to the Shanghai-Kunming high-speed railway and Shanghai-Hangzhou-Ningbo

passenger-dedicated railway in the south. Backed by the prosperous YRD region and areas along the Beijing-Shanghai route, Hongqiao Railway Station has maintained a steady growth in passenger flow since its operation. In 2019, the daily average passenger volume hit 376,000 trips, carried by 620 trains, ranking 2nd among high-speed rail hubs in China. The integration of rail network enables free switch between air and rail transport for passengers traveling to and from Shanghai. A dual-core air-rail intermodal transport hub relying on PVG and Hongqiao Integrated Transport Hub has basically taken shape, which drives Shanghai's external passenger traffic and economic growth. In particular, Hongqiao Integrated Transport Hub sees a daily average of 1.2 million passenger trips on weekdays and a daily peak of about 1.4 million passenger trips during holidays and festivals. This secured world's top hub sets a paradigm for the planning and development of hub areas in China.

In 2021, Shanghai issued the *Master Plan for Building the Hongqiao International Opening-up Hub* and the *14th Five-Year Plan for the Central Business District of Hongqiao International Opening-up Hub*. It planned to improve the cross-regional rail transit network by means of newly built high-speed railways such as Shanghai-Suzhou-Huzhou, Shanghai-Zhapu-Hangzhou and Nantong-Suzhou-Jiaxing-Ningbo railways. Furthermore, it intended to upgrade the rail transit system from SHA to the entire YRD region and create a dual-core hub pattern of air-rail intermodal transport with "Zhuqiao in the east and Hongqiao in the west" based on closer linkage between SHA and PVG. By intensifying transport integration and radiation, these measures better serve the "one core, two belts" development pattern. More specifically, Hongqiao International Opening-up Hub will be built with Hongqiao International Central Business District (CBD) as the core, driving the development of the northward expansion belt to Suzhou in Jiangsu Province and the southward expansion belt to Jiaxing in Zhejiang Province, and promoting the YRD economic integration.

Building on the success of air-rail intermodal integration at Hongqiao Integrated Transport Hub, the Shanghai Municipal Government approved the *Special Plan for Building the Pudong Integrated Transport Hub in Shanghai* in 2020, and unveiled the official name of this hub, Eastern Hub, in November 2022. According to the plan, Shanghai East Railway Station will be built in the

west of PVG along with the airport expansion. This station will be connected to the Shanghai-Nantong (connecting the north-south railways along the Yangtze River) and Shanghai-Zhapu-Hangzhou railways, as well as Shanghai-Suzhou-Huzhou and Shanghai-Hangzhou inter-city railways that are integrated into the Shanghai-Nanjing and Shanghai-Hangzhou corridors. Access to the Shanghai-Zhoushan-Ningbo railway is also considered under this plan. Upon completion, the Shanghai-Nantong and Shanghai-Zhapu-Hangzhou railways will be an important part of the coastal corridors in the national network of "eight vertical and eight horizontal" high-speed railways and render a north-south passenger channel in addition to the Beijing-Shanghai and Shanghai-Hangzhou railways. Shanghai East Railway Station will be linked to PVG by three rail transit lines, namely, metro line 21, airport express, and land-side rapid transit line. With air-rail intermodal transport enabled by PVG and Shanghai East Railway Station, the Eastern Hub will stand as a large comprehensive transport complex that integrates air, national and municipal railways, urban rail transit, and other modes of transport and supports the integrated development of railway station, airport, and city.

As an air carrier based in Shanghai, CEA has a mutually reinforcing relationship with Shanghai air-rail intermodal transport hub. In recent years, CEA has been planning its reform and development within the framework of national strategies and continued to beef up its comprehensive strength while participating in, serving, and supporting the three major strategies of the BRI, the Beijing-Tianjin-Hebei Integrated Development, and the Yangtze River Economic Belt. At the North Bund International Aviation Forum 2022, CEA showcased its "Super Carriers" innovations, defining "Super Carriers" as a top-notch airline that boasts world-leading service, innovation capability and influence. More specifically, the "Super Carriers" is a flagship air carrier dedicated to building a civil aviation ecosystem and joining globalized cooperation on all fronts and characterized by outstanding strength in terms of operation, service, management, innovation, and influence. CEA aspires to build a "Super Carriers" model engaged in a higher level of international competition and cooperation as a representative of China's civil aviation

sector.[15] It consolidates Shanghai's position as a transport hub through the provision of flight services and gives strong support for building China's strength in transport and aviation and developing the Shanghai International Shipping Center. At the same time, the airline harnesses this transport hub to give synergistic power to the YRD economic globalization.

3.2. Deep cooperation: CEA and Shanghai air-rail intermodal transport hub support each other

Like Lufthansa's important role in supporting Frankfurt regional transport hub, CEA, as a "flagship" and "Super Carriers" in Shanghai's civil aviation sector, has been deeply involved in the development of Shanghai air-rail intermodal transport hub. The airline has deepened cooperation with the hub in various areas such as infrastructure, products and services, network construction, and stayed in the forefront of the hub to serve the vast hinterland by virtue of its passenger and cargo transport network.

As an aviation enterprise founded in Shanghai, CEA has always kept pace with Shanghai. It originated from the first aviation squadron established in Shanghai on January 9, 1957, i.e., Shanghai Civil Aviation Division Aviation Squadron, which was renamed the China Civil Aviation Fifth Brigade on September 1, 1965, after several name changes. In the era of planned economy, a traditional model bringing administrations, airlines and airports under unified management was implemented. On December 24, 1987, the former Civil Aviation Administration of Shanghai was split into the CAAC East China Regional Administration, CEA, and SHA in accordance with the principles of "separating government and business, streamlining administration and delegating power" in the civil aviation system. After half a year of internal trial operation, CEA officially announced its establishment on June 25, 1988. In October 1993, China Eastern Group was formed as the first large aviation group incorporated by CAAC. In 1997, CEA became the first Chinese airline listed on the stock markets of Shanghai, Hong Kong, and New

[15] Three Latest "Super Carriers" Achievements Unveiled by China Eastern Airlines and Sha nghai Airports, https://baijiahao.baidu.com/s?id=1750259930017556926&wfr=spider&for=pc, accessed on November 21, 2023.

York. On December 30, 2017, CEA completed the corporate system reform from an enterprise owned by the whole people to a solely state-owned enterprise (SOE) and adopted the name "China Eastern Airlines Corporation Limited."

In recent years, CEA has accelerated the pace towards "Super Carriers". It has made every effort to construct an accessible international aviation network, an efficient and convenient domestic aviation network, and an integrated air travel circle, which assists Shanghai air-rail intermodal transport hub in serving as a gateway to the global network of cities. In 2009, the *Opinions on Accelerating the Development of Modern Service and Advanced Manufacturing and Building Shanghai into an International Financial Center and International Shipping Center* was adopted, adding fuel to the national strategy of transforming Shanghai, CEA's main base, into an international shipping center. With the reorganization of CEA and Shanghai Airlines the same year, the Shanghai-centered global route network has been rapidly expanded. In June 2016, CEA historically launched four China-Europe routes from Shanghai to St. Petersburg, Prague, Amsterdam, and Madrid within a month in support of the BRI strategy. In December 2016, the number of passengers handled by CEA and Shanghai's airports exceeded 100 million each. China joined the United Kingdom, the United States and Japan to have an aviation hub with an annual throughput of over 100 million passengers. CEA, a round-the-clock airline mainly based in Shanghai's airports, takes a crucial part in underpinning Shanghai international shipping hub.

CEA has also stepped up efforts in the areas of intermodal transport products and services, network data sharing and air-rail direct transit, perfecting the "Super Carriers" model. As early as 2012, CEA, in junction with the former Shanghai Railway Administration, pioneered to launch air-rail intermodal transport service within the YRD region, with Shanghai's airports as the aviation hub and regional high-speed railways as the feeder. The service, open to passengers from home and abroad, was limited to intermodal ticketing and corresponding emergency response. In September 2019, in accordance with the CAAC plan to promote air-rail intermodal transport, CEA signed a strategic cooperation agreement with China State Railway Group Co., Ltd (China Railway), intending to cooperate in the areas of innovative intermodal transport

products, intermodal ticketing and integrated and comprehensive transport services. On August 25, 2020, the two sides announced that their APP platforms had been linked and "air-rail combined products" were put online. Passengers can, via either APP, purchase tickets that combine flights operated by CEA and Shanghai Airlines with high-speed trains. This tie-up enables flight and train ticket platform interconnectivity in China for the first time, facilitates train and flight information sharing and makes air-rail intermodal travel more convenient. With SHA and Hongqiao Railway Station as the core hubs, the air-rail combined products serve the national strategy of the YRD integrated development. The service supports two-way intermodal travel via Shanghai between most cities of Jiangsu, Zhejiang and Anhui provinces and CEA's domestic destinations, and soon becomes applicable to more than 30 cities across the country. In addition, dedicated air-rail combined products have been made available in Wuhan, Shenzhen, Changsha, and Kunming.

In terms of cargo transport, CEA has intensified efforts to build a convenient and efficient modern air logistics system, including expanding the air cargo transport network, constructing air logistics infrastructure, and increasing the distribution capacity of air cargo hubs. In response to the call of NDRC and CAAC, the airline joined hands with China Railway in September 2020 to establish an air-rail intermodal cargo transport network, with hub airports as the aviation center and luggage compartments of passenger trains as the backbone. The project for efficient link between rail and air freight networks is undertaken by their subsidiaries Eastern Air Logistics Co., Ltd (Eastern Logistics) and China Railway Express Co., Ltd. It harnesses CEA's extensive global passenger and cargo route network and gives full play to the safety and efficiency of air transport and the accuracy and continuity of rail transport. In 2021, they jointly launched the "air-rail direct transit" service at Hongqiao hub, connecting the belly capacities of CEA's passenger planes to high-speed railways, baggage transport railways and express trains to form an "air-rail intermodal" cargo distribution center in Hongqiao. The pair is also taking steps to realize "network-wide delivery" nationwide, in which transit cities for "air-rail intermodal transport" will be expanded to all parts of the country. The project will make full use of the global passenger and cargo flight network of Eastern Logistics and the trunk high-speed railways and luggage compartments of

China Railway to provide time-differentiated products such as next-day delivery and three-day delivery to second- and third-tier cities. In addition, the two companies will collaborate on the long-range "Pudong air-rail intermodal transport hub" project, with a view to building a globally unique and innovative air-rail intermodal transport hub in Pudong. This project will closely combine PVG's international air route network with the domestic rail cargo transport network to support an innovative mode of operation that globally air imported goods are transshipped and distributed via domestic railways and cargoes carried by domestic railways are transshipped and exported via international airport to all parts of the world.

To promote better synergies between CEA's "Super Carriers" model and Shanghai's air-rail intermodal transport hub, the Shanghai Municipal Government and CEA signed a strategic cooperation framework agreement on January 29, 2023, according to which the two sides will deepen cooperation based on the principles of "complementary advantages, mutual benefits and win-win results" to jointly pursue high-quality development. In specific, the Shanghai Municipal Government will support CEA to accelerate the creation of a globally competitive "Super Air Carriers" model. The airline will help the city improve its capacity as a world-class aviation hub, which contributes greatly to transforming Shanghai into a modern socialist international metropolis with global influence. This involves work to comprehensively strengthen the "four functions" (i.e., global allocation of resources, source of technology innovation, leader of high-end industries, and open hub and gateway), accelerate the construction of "five centers" (i.e., international economic, financial, trade, shipping, and technology innovation centers) and foster a modern comprehensive transport system. With the support of China Eastern Group, Shanghai is expected to further sharpen its advantage in multimodal transport by river, sea, land, air and rail. It will evolve into a comprehensive transport mega-hub that combines air, national and inter-city railways, urban rail transit and other modes of transport and supports railway station-airport-city integrated development.

3.3. Regional impact: Impact of CEA's "Super Carriers" model on the

YRD hinterland

The YRD region is one of the most dynamic, open, and innovative regions in China, as well as a major intersection of the Belt and Road and the Yangtze River Economic Belt. In this hinterland of Shanghai hub, Hongqiao International CBD and Pudong New Area are the core and two belts are extended therefrom, shaping a transport network of "one core, two belts." At the North Bund International Aviation Forum 2023, CEA released the "Construction of Air-Overland Integrated Transport Network in CEA-based Yangtze River Delta" and "Air Travel Health Guide" among its important achievements, and AVINEX unveiled the AviPort platform built under its leadership. These noticeable results signify the increasingly sophisticated layout of the "Super Carriers" in the YRD region and the gradual formation of synergy with Shanghai transport hub to jointly spur the YRD transport and economic development.

3.3.1 Boosting the economic vitality of Hongqiao International CBD

Transport integration is essential to coordinated and integrated development. Shanghai air-rail intermodal transport hub propels the modernization and globalization of the YRD transport network and gives a constant impetus to the development of Hongqiao International CBD and Pudong New Area. Based on its huge locational advantage and sound air-rail interconnectivity, Hongqiao Integrated Transport Hub stands as the core hub connecting Pudong hub with the YRD-wide rail system. Moreover, it continues to interact with economic resources from around the world, injecting vitality to the economic development of Hongqiao International CBD and Pudong New Area. Hongqiao International CBD is an important engine of the YRD development, delivering power to the economic and transport development of neighboring hinterland cities. By the end of 2021, there were cumulatively 56,272 legal entities in this CBD, including 2,833 foreign-invested enterprises, more than 400 enterprise headquarters and 6,600 digital economy enterprises. The headquarters economy, exhibition economy, platform economy and digital economy have developed steadily in this CBD. An industrial innovation cluster of high-end

service industries has taken shape, covering biomedicine, logistics, artificial intelligence, high-end equipment, aviation services, trade, exhibition, legal services, finance, science, and technology. The sound groundwork enables the CBD to lead the coordinated opening-up of the YRD region and support Shanghai's east-west development axis.[16] The "one core, two belts" outlined by the *Master Plan for Building the Hongqiao International Opening-up Hub* involves 14 districts and counties in Shanghai, Suzhou, and Zhejiang, with a total area of 7,000 km^2. They rendered a gross domestic product of 2.69 trillion yuan in 2022, contributing to nearly 10% of the YRD economic aggregate with less than 2% of the area. Pursuant to this plan, Hongqiao International CBD has created functional platforms based on comparative advantages and accelerate efforts to develop the "four high and five new" industries (i.e., high-level headquarters, high-traffic trade, high-end service, and high-spillover exhibition; new digital economy, new life technology, new low-carbon energy, new automobile business and new fashion consumption). The Headquarters Cluster of Yangtze River Delta Private Enterprises and the Headquarters Service Center for Yangtze River Delta Private Enterprises were also set up under this CBD, serving and supporting the YRD enterprises in bringing-in and going-out.

Given strong policy support, Shanghai's local "Super Air Carriers" has speeded up development with the help of local air-rail intermodal transport hub in infrastructure, injecting a steady stream of economic vitality into Hongqiao International CBD. First, the introduction of direct flights propels the CBD internationalization. In 2018, CEA's first Airbus A350-900 arrived at SHA in the CBD and then entered into service on international long-haul routes from Shanghai to Europe, Australia, and North America.[17] The international routes of the "Super Carriers" enable this CBD to be more quickly integrated into the world trade economy towards internationalization. CEA's first global chartered business class suite can fly for 19 hours to the maximum, which is comparable to the world's longest direct flight from Singapore to New York. Second, the

[16] Report on Development of Shanghai Hongqiao International Central Business District 2021.

[17] Debut of New Aircraft at Hongqiao Airport at the End of the Year! See Air Transport Enabled New Trade and Economic Development in the Greater Hongqiao, https://www.sohu.com/a/283089450_744115, accessed on November 20, 2013.

resumption of past flights facilitates the ties and exchanges between this CBD and the international market. In 2023, CEA will resume 75.7% of its international and regional flights offered in 2019 at SHA and 27.8% at PVG. The international and regional flights from PVG will reach 192.5 flights per week, specifically to 134.5 international destinations and 58 regional destinations.[18] Third, CEA will put into practice an advanced service concept at the East Hongqiao Center to provide business facilitation services such as express check-in and VIP pass for corporate tenants.[19] This will improve the efficiency of multinational enterprises in the CBD and make the CBD a "gate" to the world.

3.3.2. Spurring urban transport network development in the YRD hinterland

In August 2023, NDRC released the *Policies and Measures to Promote Hongqiao International Hub for Opening up at a Higher Level* to enhance the Hongqiao hub-centered interconnectivity of air and rail transport and other infrastructure. Among the proposed measures are increasing inter-city air shuttles at SHA, building Jiaxing Intermodal Transport Center and Wuhu Air Cargo Hub, and supporting Hefei to launch high-quality China-Europe railway express. They are introduced to enhance the YRD air-rail intermodal connectivity and turn it into a great thrust in the YRD high-quality integrated development.

At present, a dense and radiating integrated high-speed rail network has been basically put in place in the YRD region, with the central cities as the main node of resource allocation. The "one-day living circle" and "one-hour commuting circle" have been substantially expanded, resulting in frequent population commuting and mobility. Hongqiao International CBD has actively interacted with counties and cities on the "two belts" and deepened cooperation in industries such as aviation services, artificial intelligence, digital

[18] The 2023 Summer and Fall Flight Season Starts! Here is the Latest Route Plan of Chin a Eastern Airlines. Shanghai Observer, https://sghexport.shobserver.com/html/baijiahao/2023 /03/26/990487.html, accessed on November 20, 2023.

[19] East Hongqiao Center Business Complex Opens! CMSK and Eastern Investment Join Ha nds to Create a "Future Life Magnet" in the Greater Hongqiao, https://baijiahao.baidu.co m/s?id=1750723611915997638&wfr=spider&for=pc, accessed on November 20, 2023.

finance, life health and intelligent and connected vehicles. As the industrial linkage between "one core" and "two belts" becomes increasingly close, a functional pattern is gradually taking shape, characterized by "Hongqiao headquarter and hinterland bases," "Hongqiao trade and hinterland logistics," and "Hongqiao business and hinterland leisure." In a broad view, the YRD air-rail intermodal connectivity has further magnified the scale effect and agglomeration effect of the YRD aviation market by linking Shanghai aviation hub as a global gateway with the regional rail transit network. By the end of 2022, the operating mileage of high-speed railways in the YRD region reached 6,704.4 km, representing one-sixth of the national total. A metropolitan area within 0.5-hour to 3-hour high-speed railway from Shanghai has already been formed.[20] In terms of cargo transport, Hongqiao hub and Pudong hub boast a well-established global cargo route network and outstanding software and hardware strength in air cargo transport based on air-rail interconnectivity. They pave a solid way for enterprises from the YRD region to compete in the international arena and profoundly affects the spatial pattern of economic activities in the YRD region. In particular, high-quality air logistics prop up the continued concentration of manufacturing on the middle and high end of industrial chain.

Given transport network construction in the YRD region, CEA has firmly taken the delta as a stronghold as always. It has explored a "Super Carriers" model with all-round, three-dimensional network interconnectivity and risen into a powerful engine of influential and radiating city clusters. With priority given to capacity, route, resources and development, the airline further improves the lower delta layout involving Shanghai, Nanjing and Hangzhou and drives the development of its subsidiaries in the delta, among which China Eastern Airlines Jiangsu Co., Limited grows into a medium-sized airline.[21] Through nearly two decades of efforts, CEA has put in place a route network with Shanghai as the core hub, covering 1,074 destinations in 177 countries by 2019, and served more than 110 million passengers annually, ranking 7th in the world. The airline is also the first to explore the air-overland intermodal

[20] Statistical Bulletin on Production of Civil Aviation Airports in 2019.

[21] Tang Bing. Yangtze River Delta City Cluster and Network Layout of China Eastern Airlines in the Context of Aviation Economy [J]. Civil Aviation Management, 2017, (06): 21–22.

transport model based on the Hongqiao hub. By 2019, the bidirectional passenger intermodal transport by "air and high-speed rail" were accessible in 15 YRD cities and by "air and highway" in seven YRD cities, as well as the corresponding remote check-in services and remote baggage check-in and drop-off services.[22]

In 2023, CEA put forward the strategy of building an "Air-Overland Integrated Transport Network in CEA-based Yangtze River Delta" to further upgrade the "Super Carriers" model, which is a major achievement contributive to building Shanghai International Shipping Center. Bearing in mind the "Super Air Carriers" vision, this strategy speeds up the pace to build an air-overland integrated network for both passenger and cargo transport in the YRD region, covering "hub consolidation, network establishment, service improvement, streamlined management, vigorous innovation, and synergy creation." Specific to passenger transport, CEA is sparing no effort to foster an accessible international aviation network, an efficient and convenient domestic aviation network, and an integrated air travel circle. Its newly upgraded "Fly at Will" air ticket discount package enriches travel choices and boosts air consumption. As to cargo transport, the airline is devoting energy to developing a convenient and efficient modern air logistics system, including accelerating the expansion of air cargo transport network and the construction of air logistics infrastructure and enlarging the distribution capacity of air cargo hubs.

4. Model Similarities and Development Trends of Regional Transport Hubs and "Super Carriers" in China and Germany

Lufthansa and CEA as "Super Carriers" share many similarities in terms of impact on regional economy and transport, and both exhibit the tendency to international and integrated development, according to a comparative analysis of regional integrated transport hubs and "Super Carriers" in China and Germany. The emergence and development of "Super Air Carriers" gives a constant boost to the evolution of regional air-rail intermodal transport system

[22] Co-build a World-Class Airport Cluster in the Yangtze River Delta: Field Investigation to China Eastern Airlines by CPPCC Shanghai Committee Research Team, https://baijiahao.baidu.com/s?id=1633042098746566805&wfr=spider&for=pc, accessed on November 20, 2023.

and plays an instrumental role in optimizing industrial and supply chains and prospering regional industries while supporting the transport of high value-added products. The continued expansion of international air routes and introduction of new aircrafts smooth the way for optimizing and upgrading regional supply and industrial chains. In addition, "Super Carriers" facilitate international exchanges among enterprises and people and promote tourism and cultural cooperation and economic progress. They contribute to international economic and trade cooperation within the region by bringing in many international enterprises.

4.1. Building an air-overland integrated regional transport system

CEA and Lufthansa as leading "Super Carriers" have both realized air-overland integrated operation in their home regions. CEA combines the "Super Carriers" model with the construction of air-overland integrated transport system in the YRD region, reflecting its consistent guiding role as a SOE. The "Super Carriers" model enables air-overland interconnectivity and integration by taking advantage of transport hubs, so that passengers in the YRD region can conveniently transfer between air and land transport. In terms of transport services, CEA has advanced the integration of market products and services in the delta based on the linkage among market segments. Noticing the 144-hour visa-free transit policy adopted by Jiangsu, Zhejiang and Shanghai, CEA has put in place a comprehensive service network with uniform passenger and business service standards. As a large SOE, CEA plays a leading role in the collaboration among airports and organic integration of air and land transport and fosters an integrated transport network with higher operational quality and efficiency. In terms of route planning, CEA has rationalized long-haul and international routes involving the YRD region and allocated more flights to Shanghai hub and main base airlines to strictly restrict non-hub flights from occupying time resources. Meanwhile, CEA has clarified the position of the YRD cities, identifying Shanghai as the primary market, Nanjing and Hangzhou as key markets and Hefei as an important market, and added routes and flights to increase market density and thickness. Similarly, Lufthansa's "Super Carriers" model makes possible seamless transfer

between air and rail modes for more efficient transport through hub construction and flight schedule optimization at FRA. In particular, air-rail intermodal transport significantly improves the efficiency of cargo transport by reducing the number and time of transshipments.

While expanding their own international carrying capacity, "Super Air Carriers" have been exploring the integrated development with local transport hubs. The Eastern Hub under construction in Shanghai will connect PVG to the Shanghai-Nantong Railway and contain a 50,000 m^2 front-end terminal, enabling for the first-time seamless passenger transfer between air and rail transport. In this regard, CEA has forged strategic cooperation with Pudong New Area on pooling more route resources to build Pudong to a world-class aviation hub with prominent advantage of multimodal transport by river, sea, land, air, and rail. Unlike the Hongqiao hub, the Eastern Hub will introduce the concept of "front-end terminal" that incorporates airport functions into air-rail transfer center. Such terminal will directly provide such services as domestic and international baggage check-in, security check and inspection and quarantine clearance, making the transfer process simpler and shorter for passengers.[23] In short, "Super Air Carriers" contribute to regional transport integration by building an air-overland integrated transport system based on coordinated planning for high-speed railways and other overland transport networks and airport clusters.

4.2. Optimizing regional industrial and supply chains

"Super Air Carriers" are helpful for optimizing regional industrial and supply chains. Air transport is of importance for international trade and domestic economic activities, especially for cargo transport and industrial chain connection. With the development of aviation services, air cargo transport can better support the smooth flow of industrial chains and make logistics more efficient and less costly. Air transport is preferable, even irreplaceable in the transport of high value-added products and urgently needed goods. By

[23] Eastern Hub to Build Front-end Terminal for Seamless Transfer between Air and Rail Transport, https://baijiahao.baidu.com/s?id=1769857060723180602&wfr=spider&for=pc, accessed on November 20, 2023.

providing convenient air cargo services, the air transport sector can spur regional industrial development, upgrading and transformation.

In promoting the integrated and high-quality development of the YRD region, capacity building for international air cargo transport is crucial to safeguarding international supply chain stability and security for high-tech industries and enhancing regional innovation capability and international competitiveness. According to the *Three-Year Action Plan to Build an Aviation Industrial Chain in Shanghai* released earlier, Shanghai will, by 2035, become an aviation industrial center with global influence and foster a world-class aviation industrial cluster in collaboration with the YRD region.[24] This aviation industrial cluster, with Shanghai as the core, will stretch to the YRD region through an aviation industrial chain corridor along the G2 Beijing-Shanghai Expressway and an aviation science and innovation corridor along the G60 Beijing-Kunming Expressway. In view of this, CEA continues to optimize and upgrade the "Super Carriers" model by introducing new aircrafts and expanding international routes. For example, the C919 plane, a domestically produced large passenger aircraft, has been put into commercial operation on the Hongqiao-Tianfu route on a regular basis and will gradually enter into service on more routes. The potential broad market for the homegrown aircraft will stimulate the optimization and upgrading of aviation industrial chain and accelerate the development of aviation ecosystem in the YRD region.

Lufthansa's "Super Carriers" model based on air-rail intermodal transport has also made FRA one of the busiest European cargo hubs with surging cargo traffic. With a noteworthy focus on cold chain logistics, the airline provides efficient and reliable cold chain logistics services for food and pharmaceutical industries in the Frankfurt region. Besides, air-rail intermodal transport facilitates cross-border e-commerce in the region by quickly taking cargo to all parts of Europe in cooperation with rail carriers.

4.3. Facilitating interregional economic and trade flows of international

[24] Homemade Aircraft "Flying to the Sky" Quickens the Aviation Manufacturing Industry C hain Layout in the Yangtze River Delta, https://new.qq.com/rain/a/20230529A03MVM00?no -redirect=1, accessed on October 20, 2023.

enterprises and people-to-people exchanges

By driving regional flows of people and logistics, "Super Air Carriers" contribute to international cultural and tourism cooperation within the region and channel many international enterprises and human resources to regional economic development.

Air travel becomes more preferred by tourists because of rapidity and convenience. With the growth of tourism demand, the development of "Super Air Carriers" has created more opportunities for the tourism sector. Air routes and flights added by airlines enable various regions to better develop and utilize respective tourism resources, thus boosting prosperity in tourism and upgrading the regional economy. CEA and Lufthansa as "Super Carriers" boast a network of flights to many places around the globe, which prompts more international tourists to choose Shanghai and Frankfurt as their destinations. Under the "Super Carriers" model, the international flights and passenger traffic of the two airlines have been on the rise, stimulating the development of regional cultural and tourism industries by bringing in more tourists and economic resources. Tourists from different countries and cultures also inspire the innovation of cultural and tourism services and products in the YRD and Frankfurt regions, which is conducive to regional industrial upgrading and internationalization.

Taking advantage of the well-developed transport hubs and "Super Air Carriers" from China and Germany, international companies are pouring into the YRD and Frankfurt regions and promoting bilateral economic and trade cooperation between the two regions. As one of the earliest cities to open German air routes, Shanghai plays a significant role in the interactions between China and Germany. Before the COVID-19 outbreak, there were 12 direct flights from Shanghai to Germany, operated by CEA, Air China, and Lufthansa. Among them, CEA and Lufthansa operated eight and four direct flights to and from Frankfurt, respectively. These flights facilitate and support economic and trade cooperation between the two sides. As a transport hub connecting Germany with the YRD region, Shanghai has attracted numerous German companies. As of 2019, of the 5,200 German companies operating in mainland China, 41% were in Shanghai. Many German companies have set

up their regional headquarters and research & development centers in Shanghai, which is of great significance for the stable growth and high-quality development of the municipal and national economy. Shanghai air-rail transport hub will also produce a radiation effect that promotes the economic and trade ties between the rest of the YRD region and Germany.

Frankfurt, as the first German city to launch direct flights between China and Germany, also takes an important position. It is a major destination of all direct flights from Chinese cities to Germany, including Beijing, Shanghai, Guangzhou, Chengdu, Qingdao, Nanjing, Shenyang, and Shenzhen. Prior to the COVID-19 outbreak, Frankfurt saw 69 direct passenger flights to and from China per week, operated by CEA, Air China, China Southern Airlines and Lufthansa, as well as 61 cargo flights per week. Up to present, more than 850 Chinese companies and organizations have settled in and around Frankfurt. Being an important global financial center and home to the ECB headquarters, Frankfurt provides a gateway to Germany and Europe for Chinese financial institutions.

Conclusion and Outlook

Regional air-rail intermodal transport hubs, which integrates "trunk air and rail transport" at a micro-spatial level, have greatly contributed to the rise of Shanghai and Frankfurt into international influential mega-cities for business and finance. As the hinterlands of the two cities, the YRD region and the Frankfurt/Rhine-Main region, have benefited from better external connectivity to become important players in domestic and international economic and trade activities. The common features of the two cities reflected in building air-rail intermodal transport hubs provide meaningful reference for other cities in transport infrastructure optimization. Shanghai, as a latecomer to air-rail intermodal integration, sets a model for improving infrastructure in developing countries based on respective national conditions while drawing on the experience of developed countries. Its success facilitated by the latecomer advantage has great implications for other developing countries.

The development of regional integrated transport hubs cannot be divorced from the deep cooperation with "Super Carriers", in addition to the airport

authority and the railway administration. The emergence and success of regional integrated transport hubs in Shanghai and Frankfurt are highly attributable to the two "Super Carriers", CEA and Lufthansa. The two airlines are devoted to building Shanghai and Frankfurt into well-connected aviation hubs, which lays a foundation for the air-rail intermodal transport. Moreover, they have been actively involved in the design and operation of air-rail intermodal transport at an early stage as the backbone of building regional integrated transport hubs.

Currently, the global civil aviation industry is on the way of steady recovery, with a quicker pace of digital, intelligent, and green transition. Future development and upgrading requires closer international cooperation and industrial collaboration. On the one hand, it is important to expand bilateral cooperation on air rights, smart aviation, and green and low-carbon development, so as to boost the world economic recovery. On the other hand, it is necessary to strengthen "aviation+" comprehensive cooperation and improve the quality and level of integrated services to meet the diverse needs for high-quality air travel.[25] The global civil aviation sector should work together to build a civil aviation community with a shared future and realize common prosperity through win-win cooperation.

To sum up, Shanghai and Frankfurt regional integrated transport hubs provide a gateway to the global network of cities for the hinterlands, i.e., the YRD region and the Frankfurt/Rhine-Main region. CEA and Lufthansa as "Super Carriers" are the key vehicles for linking the two regions to the world. Regional integrated transport hubs and "Super Carriers" are of great significance to the position of such node cities as Shanghai and Frankfurt in the global network of cities. Moreover, they have a far-reaching impact on the hinterlands, including the construction of an integrated transport system, the optimization of regional industrial and supply chains, and the facilitation of inter-regional economic and trade exchanges among international enterprises and people-to-people exchanges. The synergies between "Super Carriers" and transport hubs

[25] Achievements Unveiled at the North Bund Forum: Construction of Air-Overland Integrated Transport Network in CEA-based Yangtze River Delta and the AviPort Platform, https://sghexport.shobserver.com/html/baijiahao/2023/09/22/1132813.html, accessed on November 20, 2023.

continue to spur the high-quality economic development and strengthen the international competitiveness of the YRD region and the Frankfurt/Rhine-Main region. These two regions can thus build up their locational advantages of developing a more vibrant, open, and innovative economy and contribute to the global economic growth as an important engine.