Economic and Policy Analysis on High-Speed Rail and Interactions with Air Transport

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Abstract

High-speed rail (HSR) has substantial differences from conventional trains, both in its role in the economy and in its relationship with other transport modes. This thesis focuses on HSR development and its interactions with airline. First, this thesis offers a comprehensive framework for evaluating the impacts of major government initiatives on the spatial transformation of transport and regional systems (Chapter 2). We further study the Chinese HSR by reviewing its network evolution and projecting its future development. Second, we conduct a macroeconomic comparison between HSR and Low-cost carrier (LCC) in Japan and Western Europe (Chapter 3). The findings reveal that Japan and Europe have both promoted HSR as the government key project, but the European government has a more liberal attitude towards its aviation sector compared with the Japanese government. Third, we summarize all the existing air-rail partnerships around the globe and investigate the potential driving forces behind different partnership levels in such intermodal cooperation with an econometric model (Chapter 4). We find that the location of the train station has the largest impact on the partnership level. In particular, if the train station is located within the airport, the air-rail cooperation is more likely to end up with a high partnership level. Finally, major results, contribution, limitation and future research directions are discussed in Chapter 5.

Keywords: High-speed rail, Airline, Cooperation, Competition

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Chapter 1 Introduction

Rail industry has experienced rapid development in the past few decades due to the significant technological breakthroughs in train speed. High-speed rail (HSR) is the primary beneficiary of increased train speed. HSR has substantial differences from conventional trains and plays a key role in the competition with both road and air transport. Because of high speed, large volume, comfortableness, convenience, and high punctuality, HSR has attracted more and more passengers. Now, HSR services have been adopted by many countries and become the dominant transport mode on many corridors, serving millions of passengers every day. Many countries such as India, Thailand, and United States, are seriously considering the feasibility of HSR development and some of their HSR projects are even under construction.

With the expansion of HSR network worldwide, there are numerous examples showing that airlines suffer from competitive pressure from HSR. For example, the Paris-Bruxelles and Nagoya-Tokyo routes experienced a withdrawal of airlines right after the entry of HSR (Givoni, 2006). On the other hand, it is also believed that HSR, in some cases, can be an effective way to relieve the increasing airport runway congestion subject to capacity constraints (Jiang & Zhang, 2014) and mitigate harmful environmental issues (D'Alfonso et al., 2015).

1.1 HSR Development

In 1964, the first HSR, Shinkansen, began operation on the route between Osaka and Tokyo with a speed of 210 kilometers per hour (kph) in Japan. Since then, HSR network expanded to Europe. France was the first country in Europe to introduce HSR service (TGV) and completed the very first route from Paris to Lyon in 1983. In 1988, the first Italian HSR (ETR 450 Pendolino train) came into service, followed by the German HSR (ICE) in 1991. The Spanish HSR (AVE) commenced operation shortly after ICE in 1992 when the route between Madrid and Seville started running. HSR was then introduced to many other European countries including Belgium, Netherlands, and United Kingdom. The ultimate goal is to develop a trans-European HSR network, allowing all the countries to be connected by a cross-border HSR network.

In the early of 2000s, several East Asian countries offered HSR services. In 2004, South Korea started its HSR service. They have announced that most of the major cities will be connected with each other within 90 minutes by HSR (Railway Gazette, 2011). Taiwan HSR began operation on the Kaohsiung-Taipei corridor in 2007. However, it was not until the construction and operation of Chinese HSR that this term has regained the world's attention. By the end of 2015, China has already had the world's longest HSR network with over 23,000 km in service, more than the rest of the world's high-speed lines (HSLs) combined. According to the National Development and Reform Commission (NDRC), by 2020, the Chinese railway network will be 150,000 km in total, including about 30,000 km HSLs. This development is an extraordinary achievement especially considering the fact that it is started only less than a decade ago and still in the middle of network expansion today.

HSR networks of major countries can be found in table 1.1. We can see that as of February 2017, the HSLs of major countries were 35,435 km in total, of which 21% in Europe and 79% in Asia. The extension of the HSR network worldwide is still ongoing and could reach more than 80,000 km by 2030-2035 (UIC, 2015). A new dimension and perspective for HSR must be developed and performed in order to meet the challenge for operator, industry, and authorities.

Table 1.1 HSR networks of major countries (as of February 2017)

Country	In service (km)	Under construction (km)	Planned (km)	Total (km)
China	23,914	10,730	1,525	36,169
Japan	3,041	402	179	3,622
South Korea	657	120	49	826
Taiwan	354			354
France	2,142	634	1,786	4,562
Germany	1,475	368	324	2,167
Italy	981	67	221	1,269
Spain	2,871	1,262	1,327	5,460

Source: UIC-International Union of Railways (2017)

1.2 Interactions between Airline and HSR

As train speed has increased significantly over the years, HSR has long been regarded as a substitute and competitor of airlines, especially for routes between 400 km and 1,000 km where airlines usually lose ground to HSR, being either pulled out of markets or into big decline in the market share (Rothengatter, 2010). The existing literature focuses initially on the competition mode between airline and HSR and more recently on their cooperation mode. For example, Givoni & Banister (2006) explore the potential for airline and HSR to integrate and cooperate under the hub-and-spoke network. The following sections briefly discuss the competition and cooperation modes between airline and HSR, respectively.

1.2.1 Competition

HSR is more likely to be the transport mode with lower generalized cost due to the shorter door-to-door travel time when taking into consideration the access time, security checks, and boarding of air transport. Such features make HSR be a strong competitor to airlines. The introduction of HSR services resulted in the decrease in market share of airlines (Gonzalez-Savignat, 2004). The existing consistently shows that the competitiveness of HSR largely depends on travel distance with medium-distance routes being more efficient than short- or long-distance routes (Milan, 1993; Capon et al. , 2003). In fact, there are numerous examples of the negative impacts of HSR on airlines, which lead to the decrease in airfares, frequencies, market shares, and passenger demand. Table 1.2 offers several examples of such negative impacts. However, the results may be different when low-cost carriers (LCCs) are involved in the competition. In spite of the fierce competition from HSR, the presence of LCC provides air transport with more protection from such competition.

Table 1.2 The negative impacts of HSR on airlines

Study	Country	Impacts
Bergantino et al. (2015)	Italy	In 2012, with the reaction of Trenitalia and the entry of NTV, the air market share reduced to 26%, while the rail market share reached 68%.
Cheng (2010)	Taiwan	Air market share decreased from 24% to 13% after the introduction of HSR.
Dobruszkes (2011)	Germany	Lufthansa gradually reduced its service when the Cologne-Frankfurt route began operation.
Fu et al. (2012)	China	In 2010, Airlines' daily frequency on Wuhan-Guangzhou route was reduced from 32 to 17.
Givoni & Dobruszkes (2013)	South Korea	Air Market share decreased from 42% in 2004 to 17% in 2008.
López-Pita & Robusté (2005)	Spain	The market share of domestic airlines reduced from 89% to 36-47% on Madrid-Barcelona route.
Vickerman (1997)	France	Air traffic of Lyon-Paris route reduced 50% after the introduction of HSR services.

1.2.2 Cooperation

Looking at the cooperation cases, we find that there exist various partnership levels. Some cooperation is very advanced with numerous features including coordinated scheduling, dedicated carriage, and integrated ticketing (e.g., the AIRail service offered by Deutsche Bahn and Lufthansa). Some cooperation is basic and nothing more than an emergency back-up strategy for extreme cases (e.g., the reproduction agreement between Air Canada and VIA Rail). More cases have a partnership level that is in between these two extremes.

However, little attention has been devoted to the cooperation between airline and HSR compared to the competition mode. Exceptions include Grimme (2006) investigates the cooperation case of AIRail, which is an integrated ticket and baggage handling service provided by air carrier (Lufthansa), airport (Frankfurt), and rail operator (Deutsche Bahn). As noted by Clewlow et al. (2012), HSR might serve as a complementarity by offering short-distance travel in support of longer-distance airline travel. They prove the possibility of HSR being successful feeders for international airline travel by analyzing the case at Paris-Charles de Gaulle and Frankfurt Airport. Jiang et al. (2017) investigate two intermodal relationships in airline-HSR cooperation: an international one where the networks of airline and rail do not overlap and a domestic one where they partially overlap. Their findings show that these two relationships may end up with different partnership levels under various conditions. However, the study for cooperation still remains largely under-researched.

In the existing literature, there are two main reasons for supporting air-HSR cooperation: the mitigation of environmental pollution and the relief of airport congestion. For example, Jiang & Zhang (2014) discuss that airline-HSR cooperation will reduce traffic in the HSR-accessible market. Pfragner (2011) illustrates the development of the cooperation case at Frankfurt airport could lead to a reduction in carbon emissions by 174,900 t per year.

1.3 Primary Research Questions and Objectives

Motivated by the rapid development and expansion of HSR networks worldwide, the fierce competition between airline and HSR, and the interesting airline-HSR cooperation cases, this thesis tries to answer three primary research questions:

(1) What are the main impacts of the development of the Chinese HSR network on transport and regional systems?

(2) What are the development patterns caused by the competition between HSR and LCC in different markets?

(3) What are the driving forces behind different partnership levels in air-rail cooperation?

Starting with the overview of the above three question, this thesis has the following four objectives:

(1) To investigate the general situation of HSR development around the world.

(2) To capture the full picture of the airline-HSR relationship.

(3) To help policy makers develop effective approaches in transport planning that may have an effect on regional systems.

(4) To offer a valuable reference for other countries those are considering the option of building their own HSR networks or planning to improve the performance of their airline industry.

1.4 Structure of the Thesis

The rest of the thesis is structured as follows. Chapter 2 provides an overall perspective of

Chinese HSR development patterns and predictions on its future development. Afterwards, in chapter 3, a macroeconomic comparison between LCC and HSR in Japan and Western Europe has been conducted. Chapter 4 summarizes all the existing air-rail partnerships around the globe and investigates the potential driving forces behind different partnership levels in such intermodal cooperation with an econometric model. Finally, brief summary with general discussions and implications for further study are discussed in chapter 5.

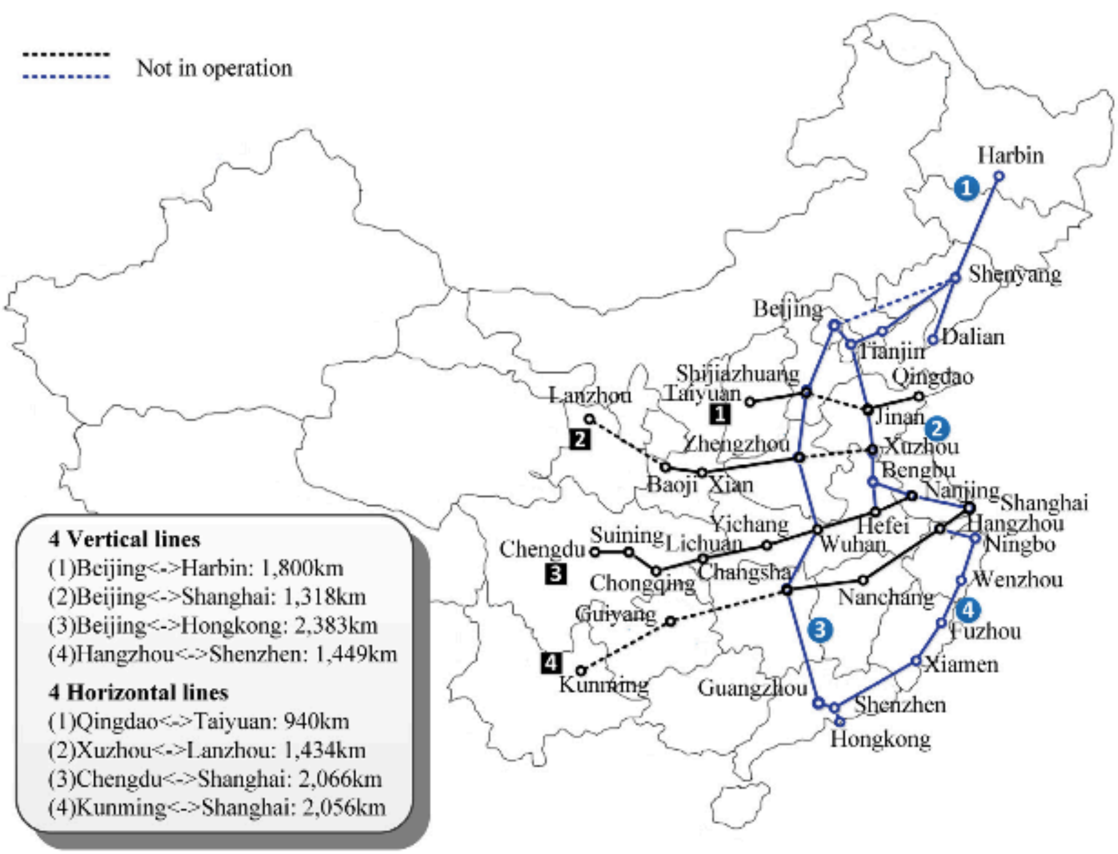
Chapter 2 The Development of Chinese High-Speed Rail: the Transformation of Transport and Regional System

There have been considerable efforts by the governments of many countries and regions to engage remote or peripheral regions within national or continental networks, notably transport investments and institutional changes. In some cases, this has led to spatial transformation in both the transport and regional systems. However, the impacts of government initiatives on the transformation of transport and regional systems are currently under-researched, and this chapter attempts to address this deficiency. It consists of a relevant case of HSR development in China. By doing so, this chapter offers important contribution through establishing a comprehensive framework on the impacts of major government initiatives on the spatial transformation of transport and regional systems.

2.1 Review of Chinese HSR Network Development

It has been more than half a century since Japan launched the first modern HSR 'Shinkansen' on the Tokyo-Osaka route in 1964. HSR has now been regarded as a common transport mode in countries like France, Italy, Spain, Germany, South Korea, and Taiwan, serving millions of passengers every day. However, it was not until the construction and operation of Chinese HSR that this term has regained the world's attention. The operation of the route between Guangzhou and Wuhan on December 26, 2009, marked that China railway transport entered a new high-speed era. Travel time has been reduced from 12 to 3 hours because of the launch of the network with over 23,000 km in service, more than the rest of the world's HSLs combined. According to NDRC, by 2020, the Chinese railway network will be 150,000 km in total, including about 30,000 km HSLs. With a system comprising four horizontal and vertical lines (as shown in Figure 2.1), China's HSR served 80 million people in 2014, and is expected to serve 90% of the population by 2020. With the commitment of the Ministry of Railway, the Chinese HSR network has expanded at an unprecedented speed and scale.

Figure 2.1 HSR network in China



Source: Fu et al. (2015)

The Chinese government plays a key role in HSR development from the beginning design stage to the later expansion plan. In China, the HSR network has been encouraged and financially supported by the Chinese government, and in turn, the opening of HSR has significantly positive impacts on regional economic which are often regarded as important factors in planning and decision-making for policy makers. A major indicator of regional economic impacts is the effect of transport-induced agglomeration on business productivity. According to an empirical analysis report by World Bank (2014a), the estimated agglomeration effects of HSR on various second-tier and third-tier cities are substantial. As shown in table 2.1, they are about 0.55% of total gross domestic product (GDP) in Jinan per year, 1.03% in Dezhou, and 0.64% in Jilin. Although economic factors are critical to the decision on whether the government should invest in HSR projects, the rationale for the investment goes far beyond them. In fact, it is the combination of political and strategic factors, normally related to regional development objectives, that determines the feasibility of building a HSR network. The development of Chinese HSR network is an excellent example to show the impact of the government initiative on spatial transformation as many previous studies have proven this point. A list of literature on the impacts of HSR on spatial transformation is shown in table 2.2. Apart from the studies mentioned in table 2.2, we further discuss two examples in the following, i.e., the announcement of ten megacity regions and the 4 trillion RMB stimulus package, to illustrate the impact of the Chinese government initiative on infrastructure development and spatial transformation.

Table 2.1 Regional economic impacts of HSR on cities

City	Agglomeration effects	
	Increase in GDP	Benefits (RMB in billions)
Jinan (Beijing-Shanghai HSR)	0.55%	3.65
Dezhou (Beijing-Shanghai HSR)	1.03%	3.59
Jilin (Changchun-Jilin HSR)	0.64%	2.39

Source: World Bank (2014a)

Table 2.2 Studies of the impacts of HSR on spatial transformation

Sources	Main impacts
Cao et al. (2013)	Redistribution of demographic and economic activities
Guo et al. (2016)	An indirect effect on the pollution distribution among cities
Wang et al. (2012)	Enlargement and transformation of tourism market space
	Intensified market competition on a larger scale
	Redistribution of urban tourism centers
Yin et al. (2015)	The spatial penetration of HSR can be improved by the integration between HSR and other transport modes.
Zheng & Kahn (2013)	Trigger the development of surrounding second-tier and third-tier cities

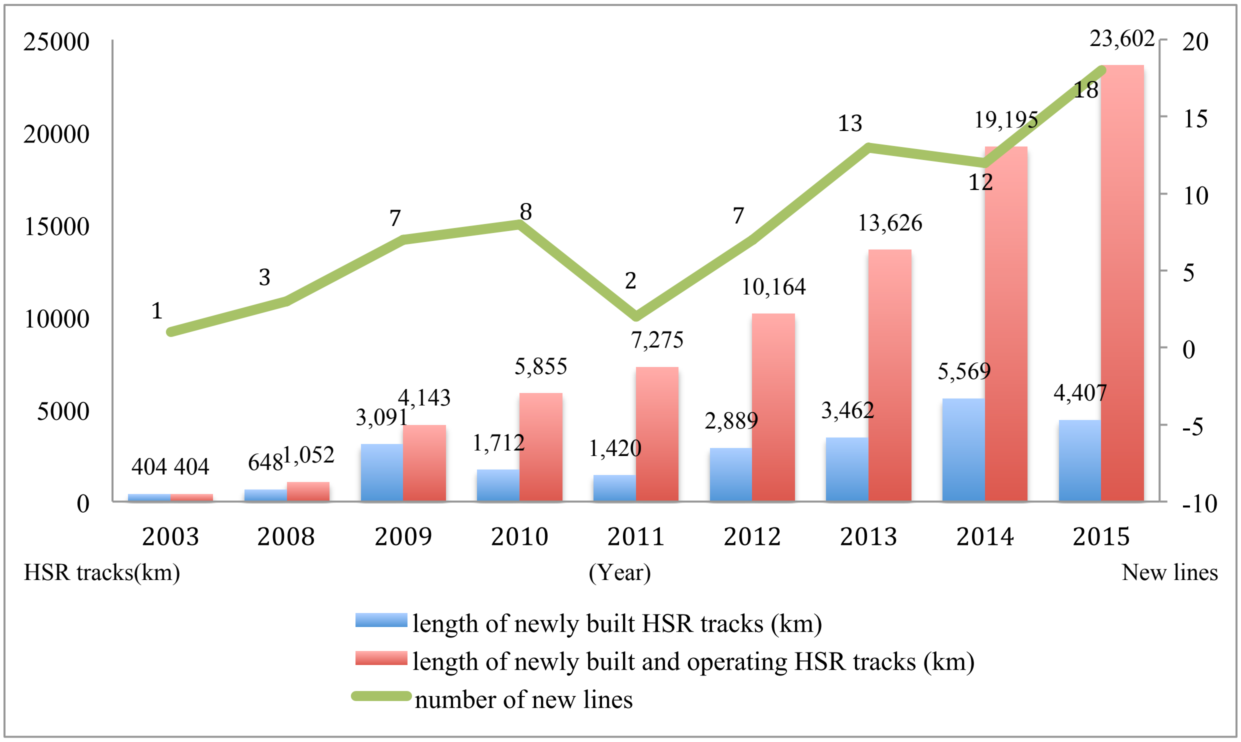
2.1.1 Ten megacity regions

In 2007, NDRC announced ten megacity regions, including seven in inland China and three along coastal economic zones, which are expected to become engines of domestic economic development. The idea of megacity regions refers to an economic concept embodied in geographical location. It links multiple centers and sub-centers and then integrates them in a hierarchical order via essential communication and transport infrastructures (Hall & Pain, 2006). The productivity of these ten megacity regions is more than half of the whole country. For example, in 2005, the GDP of these ten megacity regions accounted for about 53% of the total output and their population was about 35% of the total population in China (Xiao & Yuan, 2007). In fact, the development of the Chinese HSR network has been closely related to this spatial development strategy. HSR enables the formation of polycentric agglomerations of urban areas, i.e., the megacity regions. On the one hand, the spatial development strategy facilitates the exchange of information, economic, technological, and labor flows along HSR corridors, which would have positive effects on regional development from urban centers. On the other hand, the Chinese HSR network is expected to link all megacity regions, unify the whole national economy, and eventually achieve the goal of reconfiguring urban economic geography both regionally and nationally. The cross-boundary HSR network development is likely to stimulate the integration of Chinese regional economy, while the development of transport infrastructure would enable local governments to break fixed administrative boundaries and hence optimize their policies. As a result, the lower value-added activities are expected to shift from coastal areas to the western parts of China, and then the booming coastal economic zones would focus on developing high value-added services. The rapid development of the Chinese HSR network in parallel with the improvement of the regional competitiveness would decrease the level of regional uneven development.

2.1.2 4 trillion RMB stimulus package

From 1978 to 2008, the market share of road rose from 29.9% to 53.8%. The market share of aviation experienced the similar trend, increasing from 1.6% to 12.4%. However, the market share of rail has dropped from 62.7% to 33.3% (Fu et al., 2012). An important reason for this situation has been the capacity constraint of the rail industry. The capacity increase had not met traffic growth over these years. However, such capacity constraint has been largely alleviated due to the fact that the Chinese government increased its investment in infrastructure development, especially in HSR infrastructure. In 2008, the Chinese government announced an economic stimulus package of 4 trillion RMB (585 billion USD), including 1.5 trillion RMB (225 billion USD) on public infrastructure (e.g., railway, road, and airport construction). Since then, the importance of infrastructure development has been further emphasized. The Chinese HSR network is no doubt one of the main beneficiaries of this stimulus package. Table 2.3 shows the progression of the Chinese HSR network, which partially indicates that the stimulus package has a positive effect on the expansion of the Chines HSR network. As shown in Table 2.3, the Chinese government built new HSR lines every year, indicating that China adopted a simultaneous instead of sequential plan for the construction of multiple HSR corridors at the same time. Besides, we can see that the growth of HSR lines was relatively slow from 2003 to 2007. However, the development of HSR lines started to become faster at the beginning of 2008 right after the announcement of the stimulus package. The speed of growth has experienced a dramatic increase since 2011, causing the total length of HSR lines to more than triple within 4 years. We suppose that this phenomenon was largely due to the financial crisis in 2008. With a weakened global demand, China had to transform itself from an export-driven economy to rely on investment for GDP growth.

Table 2.3 The progression of the Chinese HSR network



Source: Chinese Ministry of Railways (2016)

2.1.3 Government support

In the period when the Chinese government began to plan the large-scaled HSR project, there was no shortage of financial resources. This is the main reason why the Chinese HSR network can be built and has achieved substantial success in such a short period of time. However, according to the China Railway Corporation, which is a state-owned HSR operator, about two-thirds of its debt was from HSR construction, and most of the HSR corridors are not profitable. Even though the Chinese HSR network is not profitable, the government still invests billions of dollars every year in its development since being unprofitable does not mean that it is unnecessary to build. In fact, there are a lot more indirect benefits of HSR, including spatial transformation. This is also the case in Spain, where the first HSR line began operation along the corridor between Madrid and Seville in 1992. It now has the longest HSR system (2,515 km) in Europe due to the fact that the Spanish government has regarded the HSR development as a priority in its transport policy. Spain was the only country in Europe that started to build the HSR network from a less populated city (Seville) since the main objective of HSR development is to promote economic growth in poor regions. This case also perfectly proves the impact of the government initiative on spatial transformation. Also, the Spanish HSR is not financially viable. Even in corridors with high passenger demand, the HSR system still needed to receive huge public subsidies from the government in order to maintain daily operations (Albalate & Bel, 2012). By contrast, other countries, such as the US and Canada, are still hesitant about or even shied away from HSR investment. Indeed, the US government faces far more obstacles in HSR development than the Chinese government does. In April 2009, they announced the blueprint for the construction of a national HSR system, but the debate about the costs and benefits of building a HSR system in the US still remains to be a controversial issue, and some policy makers did not think that it is socially profitable to do that. Moreover, labor costs are low in China, and it is not much of an issue to acquire land when the government owns all the lands. However, this is difficult to achieve in the US. From this point of view, we can conclude that it is very difficult to develop HSR without government support, and as a result, there would be no spatial transformation caused by HSR development.

Even though the political and economic centers, i.e., the capital region, the Pearl River Delta region, and the Yangtze River Delta, did enjoy the priority in the development of the Chinese HSR network, its evolution is relatively even in China, especially in eastern and southern parts of China (Jiang et al., 2016). This is in stark contrast to countries where a radial network was developed and centered on particular cities (e.g., Madrid and Paris in Spain and France, respectively). The cost advantage is another unique characteristic of the Chinese HSR network. According to Ollivier et al. (2014), the Chinese HSR network has been accomplished at a relatively low unit cost that is at most two-thirds of that in other countries. They further argued that the relatively low labor cost and the large scale of the HSR network planned in China are the two main reasons for this cost advantage. Besides, this cost advantage is also closely related to the Chinese government initiative, i.e., the huge investment in building viaducts and bridges. In fact, the Chinese HSR network prefers to lay track on viaducts so as to mitigate harmful environmental effects and to minimize the use of fertile land and resettlement costs. The estimated cost of viaducts for a double track line ranges from RMB 57 to 73 m/km (World Bank, 2014b). Such costs can be kept low due to the standardization of the design and construction process for casting and laying bridge beams on viaducts. Therefore, the spatial patterns of HSR network development, as well as the government initiative, play an essential role in gaining competitive advantages of the Chinese HSR.

The Chinese government has promoted HSR as the key project since it has not only construction and operation contributions but also positive effects on economy, society, culture, and environment. China with its vast land area and densely populated cities in central and eastern provinces is an optimal country for HSR development. Cities with high population densities along the corridors, suffering from road and air congestion, are more likely to ensure the financial viability of HSR operations. Some important metropolitan areas linked by HSR are also important aviation destinations, and hence these two modes are competing with each other, especially in short-haul to medium-haul markets. For example, HSR traffic volumes were significantly larger than air traffic volumes in the market between Shanghai and Beijing in 2009 (Fu et al., 2012). This is understandable since the majority of Chinese people still regard air transport as a 'luxury transport mode' because of the relatively low average income. In this case, the government is now building new lines over greater distances and expanding the HSR network to the less-developed and less-populated western regions in order to solve these problems to some extent.

2.2 Looking to the Future: HSR and Regional Development

The Chinese HSR network development is an extraordinary achievement, especially considering that it started only less than a decade ago and is still in the middle of network expansion today. Looking to its future development, we hereby make four predictions:

(1) HSR services are likely to affect the spatial distribution of employment and population.
(2) An integrated HSR network with other transport modes, especially airlines, is to be expected.
(3) HSR Freight will connect major Chinese logistics sites, and regional impacts of this new logistic mode are going to favor established and large locations.
(4) The long-distance international HSR services will begin operation and have positive effects on regional development, but the impacts may be less than we conventionally expect.

2.2.1 Spatial distribution of employment and population

Since the busiest HSR line, the Beijing-Shanghai line, started operation in 2011, we can conclude that HSR is helping to create a deeply connected economy. The advent of HSR has started to change the life and work, especially in Beijing, Shanghai, and Guangzhou (three megacities in China located in the northern, central, and southern part of the country, respectively). Now, each of these three megacities is developing commuter corridors in order to reduce commute time. Many people start to live within one hour of megacities by HSR because of the high real estate prices in these cities (The Economist, 2017). In the foreseeable future, more people will enjoy the benefits of urban agglomeration while not suffer from high level of traffic congestion, pollution, and rents, because HSR enables passengers to access megacities without living within its boundaries. Besides, the introduction of HSR facilitates firm fragmentation and firm sorting depending on their unique requirements for megacity access. HSR services provide the possibility that firms locate their headquarters in major cities and send other activities to surrounding low-cost cities. For example, after the launch of Tianjin-Beijing HSR line which only takes half an hour in travel time, several large firms keep their headquarters in Beijing while transferring their manufacturing factories to Tianjin. As a result, the lower value-added activities are expected to shift from megacities to (nearby) low-cost cities, while the headquarters in megacities will focus on developing high (or even higher) value-added services. This trend is likely to be adopted by more and more companies with the expansion of the HSR network towards second- (*erxian*) and third-tier (*sanxian*) regions. Therefore, it is expected that HSR will have increasing impacts on the spatial distribution of employment and population.

2.2.2 An integrated HSR network

In China, air transport is not fully deregulated and well-developed: some remote areas can yet be reached by air. Although airport connectivity has improved in general, its density will not likely be sufficient in the coming decades, considering the country's huge population. Hitherto, almost every major Chinese airport faces runway capacity shortages, resulting in increased delay and congestion. In this case, the government is now building new lines over greater distances and expanding the HSR network to the less-developed and less-populated western regions so as to solve these problems. Simultaneously, in some particular cases, governments encourage the cooperation between airline and HSR by providing connections between nearby cities and airports. The hub-and-spoke network adopted by most major airlines makes such airline-HSR complementarities possible. In China, there are several airline-HSR cooperation cases, mainly aim at reducing airport runway congestion subject to capacity constraints. For example, the Beijing-Tianjin HSR line helps transfer passengers from Beijing Capital International Airport to Tianjin Binhai International Airport, and all travel costs between Beijing and Tianjin will be subsidized by the airport. Most of these cases connect regional spaces to main transport infrastructures so as to reinforce the secondary transport networks. We believe that there will be more and more such cooperation cases in the future. Such a more integrated transport system is likely to change the spatial structure of the whole network, and the reinforcement of secondary transport networks can modify the urban hierarchy of the spatial system. In the existing HSR network, the political and economic mega-centers enjoyed the priority in the development process, so there is a big city bias in impacts. However, we also perceive that a more integrated HSR network with other transport modes will help to relieve such a bias since it enables more currently underdeveloped regions to be integrated into the network. By doing so, the HSR network grants access to regional population, and finally, decreases the level of regional uneven development.

2.2.3 HSR freight

At first, Chinese HSR lines are only passenger-dedicated lines, and then passenger-freight mixed lines are introduced in recent years. According to the State Post Bureau, China’s express delivery volumes exceeded 30 billion in 2016, rising by 53%. Nowadays, China is the world's leader in terms of express delivery volumes. In October 2016, HSR Express services launched on trial to offer customers high-end door-to-door small parcel express service. We expect the HSR Express to become a new logistics mode and connect the major Chinese logistics sites due to the surging demand for express delivery and the rapid development of e-commerce in recent years. The infrastructure and technological improvements made by HSR freight will lead to increased freight capacity, which creates new and growing routes to trade and business. At the same time, more and more firms may shift from offline trade to online trade. This will be a stimulus to boost intraregional trade.

In recent decades, the role of transport, and the scale and location of transport activities, have been reshaped by a complex set of interfirm linkage associated with the global production network. Saxenian (2002, 2006) showed that communities play an important and complementary role in the development of global production network, and emphasized the 'transnational elite community', which has the tactical knowledge and skills to create new responses within the industry and in its related infrastructure. They have proved that there are now several forces operating within and through transport infrastructure and logistics services at a global scale that reinforce the ideas that regional impacts of transport systems favor established and large locations. According to this discussion, we believe that regional impacts of HSR freight are going to favor established and large locations.

2.2.4 Long-distance international HSR services

As part of the One belt One Road (OBOR) initiative, China plans to connect its HSR lines to 17 countries in Asia and Eastern Europe. Additional rail lines will be built into Russia as well as South East Asia, in what will likely become the largest transport infrastructure project in history. In this case, China plans to install 81,000 km (50,000 miles) of HSR lines, involving 65 countries. This is essential to border regions where are peripheral and remote areas, and suffer from incomplete hinterlands. With this improved connectivity between different regions, a new intercity relationship is going to be expected.

In most cases, HSR is regarded as a short- or medium-distance transport mode. However, these long-distance international HSR services are now gaining more attention, and may even revolutionize the concept of HSR. They are likely to facilitate the exchange of information, economic, technological, and labor flows along these international HSR corridors. These new corridors may pose positive effects on regional development from urban centers and reconfigure urban economic geography both regionally and nationally due to the fact that the primary cities in OBOR initiative are underdeveloped northwestern cities. This indicates that the Chinese government provides an opportunity for peripheral areas initially disadvantaged by distance from the core areas. The cross-nation HSR network is likely to stimulate the integration of Chinese regional economy.

However, even the cross-border network has been seen as a priority of the HSR future development strategy in terms of the OBOR initiative, problems of jurisdictional segregation, competition between various countries may prevent the creation of new services which could transform regional performance. For example, the Kashgar-Gwadar economic corridor connecting western China and Pakistan passes through some of the world's most vulnerable and conflict-ridden territories. Moreover, the relationship between central and local governments may pose threats to the construction of these international HSR lines. Although agreement and consensus have been reached between central governments, local governments who will implement the whole project may be not willing to cooperate will foreign investors, and ignore the central government's policies. Therefore, the expansion of the Chinese HSR network worldwide in parallel with the improvement of the regional competitiveness may decrease the level of regional uneven development, but the real impacts may be less than we conventionally believe, given that international projects covering so many countries may be promising at the beginning but will be difficult to pursue.

The above suggests that HSR can be an important transport mode to improve equality of intercity accessibility and the external agglomeration economies. In the future, a more mobile workforce and newly accessible markets, a more integrated HSR network, and a new logistic mode are going to be expected. Such large-scale implementation of HSR network cannot be achieved without government support. On the other hand, new and major government initiatives (e.g., OBOR) may generate fewer impacts than we have initially hoped for on the spatial transformation of transport and regional systems when other countries are involved.

2.3 Concluding Remarks

This chapter offers a comprehensive discussion on the impacts of the government initiatives on the transformation of transport and regional systems. By investigating the HSR network in China, it offers interesting examples explaining such impacts, and therefore filled this gap. It illustrates the major reason why the Chinese HSR network has achieved extraordinary success, namely the Chinese government always financially supports and encourages its development and expansion. At the national level, we argue that government initiatives are very likely to have positive impacts on the transformation of transport and regionals. However, at the international level, such impacts may be more limited. Our analysis suggests that government initiatives on transport and regional systems can be highly diversified based on physical locations, economic and social systems, institutional, and even cultural issues between various countries.

The regional focus in this study may have its own limitations and the results may not reflect the situation of transport systems in other countries. Despite such, it offers a solid theoretical foundation and practical reference for the implementation of other government initiatives in the future. Moreover, we recognize that governments and related public sectors play pivotal roles in the spatial transformation of transport infrastructure programs. Thus, our analysis contributes valuable food for thought on what the right approach should be for policy makers when initiating major investments under diversified circumstances, and how success should be assessed. The insight gained from this chapter can help policy makers to develop effective approaches in transforming transport and regional systems, improving their efficiency, and therefore facilitating the development of international trade and the global economy. Otherwise, the substantial money and time may be wasted throughout implement process.

However, one thing that we need to emphasize here is the approach of how government initiatives are presented. Although new and major government initiatives are always regarded as the locomotive for transformation, the actual impacts remain a vivid debate among politicians, industrial practitioners, and scholars. Given the persistence in economic differences between regions and countries within the OBOR network, there is a real possibility that some countries may reject this initiative. Moreover, the new institutional settings created by the new government initiatives may not be suitable to all the involved regions due to diversified institutional and political histories and systems. The spatial transformation of transport systems caused by the government initiatives may make some of involved regions' transport infrastructures uncompetitive, and because of this, they may reject the initiatives in order to protect self-interests. Such initiatives might induce a competition effect among neighboring regions for potential regional investors. In this case, governments need to consider the extent of spatial competition and implement mechanisms, which help prevent such behaviors. Therefore, we strongly advise policymakers to be very careful on the arts of presenting new and major initiatives. If the initiatives are presented too aggressively, they may not get the desired results that they look for.

Chapter 3 Low Cost Carrier and High-Speed Rail: A Macroeconomic Comparison between Japan and Western Europe

3.1 Introduction

Over the past decades, the commercial aviation industry has undergone significant changes. Among all the disruption factors, two might have important impacts: LCC business model within the industry and HSR as a strong substitute and competitor. On the one hand, the advent and growth of LCC have revolutionized the way in which airlines do business. Formed as a result of liberalization, LCC has successfully implemented the idea of "cost minimization" and stripped the industry back to its essential. The LCC model was first introduced in the US and pioneered by Southwest Airlines in the early 1970s. Despite the success of Southwest Airlines in America, the spread of LCCs around the world was relatively slow. It was in the mid-1990s when this phenomenon was ultimately implemented in certain Europe and many other parts of the world. The advent of LCCs has beneficial impacts on passengers, airports' traffic[1] and their financial performance, and tourism to a certain extent. For instance, the number of travelers at Charleroi airport increased from 20,000 in 1997 to 1.27 million in 2002 since Ryanair began to operate there in 1998, and only 2.3% (29,505) of the total 1.27 million travelers were non-Ryanair travelers (Barrett, 2004). However, there is a little ex-post evidence to support that aviation

[1] The traffic unit in this chapter refers to passengers only, since the passenger side of transport is the main focus of this chapter.

liberalization has truly contributed to the growth of tourism business, and the positive impacts of LCCs on tourism are normally restricted to tourist destinations newly served by such airlines (Dobruszkes et al., 2016). On the other hand, due to increased train speed, HSR has now been regarded as a *de facto* substitute and effective competitor for airlines, especially for travel time within 2-2.5 hours (Dobruszkes et al., 2014) or up to 3 hours (Fröidh, 2008). However, HSR services are no longer a good substitute for aircraft services when the travel time becomes longer. Therefore, travel time, which largely depends on the distance of routes and the speed of HSR, plays a critical role in the competition between HSR and LCC.

HSR is already a common transport mode for millions of passengers every day in various countries, including China, Japan, Italy, and France, etc. Many countries including India, Malaysia, and Thailand, are seriously considering the construction of their own HSR networks, and some of them even have had a clear schedule on the table. With this growing popularity, HSR has become one of the biggest threats for airlines. Several examples support that airlines have been forced to leave or decrease short-haul routes.[2] For example, Givoni (2006) concludes that the entry of HSR results in a withdrawal of aircraft on routes of about 300km (e.g., Paris-Bruxelles and Nagoya-Tokyo). More recent cases include several Chinese domestic routes such as Wuhan-Nanjing, Nanjing-Shanghai, and Zhengzhou-Xi'an. Significant decreases in airfares due to the entry of HSR services are also very common. For example, the Xiamen-Wuhan route experienced a 80% drop in airfares after the operation of HSR services

[2] Short-haul routes generally refer to travel time up to 3 hours or the market range less than 500km.

(CAPA, 2013). Although the global aviation industry is still likely to continue to grow at a fast pace despite of the success of HSR on given routes, intermodal competition and the development patterns of airline networks may experience some major changes.

These two phenomena are particularly relevant for a few reasons. First, one of the main advantages of HSR compared with airlines is its much lower ticket price. This is true in most of the cases but may not hold in the markets where LCC exists (Casas Esplugas et al., 2005).[3] Second, HSR is a formidable competitor for the airlines only for short-haul markets (Milan, 1993; Rothengatter, 2011), while short-haul markets are basically the bread and butter for most LCCs.[4] Overall, compared with traditional full-service carriers (FSCs), it is fair to say that LCC is in a more fierce competition with HSR. More interestingly, the interactions between LCC and HSR show different patterns in different markets. For example, despite of being the continent of one of the world's most extensive HSR networks, Europe still has a very strong LCC sector which maintains a sufficiently high level of competitiveness in the face of HSR competition. In fact, LCCs are so strong in Europe that the HSR operators start to copy its business model, creating "low-cost high-speed rails", with OUIGO in France as a notable example (Delaplace & Dobruszkes, 2015). Recently, another low-cost high-speed rail service "IZY" between Paris and Brussels, operated by Thalys, began operation on 3rd April 2016. One of the main differences

[3] One example is the Paris-Köln market, which is served by both Thalys HSR and the LCC Germanwings, with the LCC offering better schedules as well as lower fares.

[4] In fact, whether the LCC business model can be successfully transferred to the long-haul markets is still a largely open question (e.g., Francis et al., 2007; Morrell, 2008; Wensveen & Leick, 2009), but in reality, very few successful cases have been observed.

between OUIGO and IZY is that IZY uses main stations (e.g., Brussels-South, the biggest rail station in Brussels) while OUIGO uses secondary stations (e.g., Marne-la-Vallée in Paris). Clewlow et al. (2014) also find that European air traffic experienced a significant increase because of the expansion of LCCs while HSR substitution has led to a modest decrease in system-wide air travel demand. On the other hand, as the first country to develop HSR system, Japan's LCCs seems to be struggling for survival and further development. We have observed limited expansion of LCCs in Japan after the domestic liberalization in 1997. Skymark Airlines made a profit only in 2004, whereas both Air Do and Skynet Asia Airways operated at a loss (Murakami, 2011). Zhang et al. (2008) identify that highly regulated domestic market, scarcity of open-skies agreements, and lack of secondary airports are the main reasons why Asian LCCs lag behind European counterparts. Therefore, without a broader view of case comparisons, we probably won't be able to capture the full picture of this LCC-HSR relationship.

Understanding such, in this paper, we fill this gap by providing a case comparison for the development of LCC as well as HSR in both Japan and Western Europe via a comparative research analysis, which is widely used in social sciences. The essential objective of such method is to search for variances and similarities (Mills et al., 2006). The search for variances focuses on differences so as to have a better understanding of specificities. In this way, the comparison not only reveals differences among social entities but also discovers unique aspects of a particular entity that would be hard to detect otherwise. Those searching for similarities, on the other hand, pay more attention to universality or general processes across various contexts. Therefore, we can find the largest difference between Japan and Western Europe via such methodology. Several papers also applied this methodology to study different topics in the transport industry. For example, Oum & Yu (1994) apply a comparative analysis to investigate the economic and financial performance of railways of 19 countries. Oum et al. (2003) compare the productivity performance of 50 main airports in North America, Asia Pacific, and Europe by applying a comparative analysis. It should be noted that this methodology has its limitation, as well documented by literature (e.g., Peterson, 2005; Mills et al., 2006). In particular, it is very hard to take into account the complex diversity among countries/regions under comparison. However, it can serve as a useful first step in presenting a particular problem. With this in mind, we do not attempt to reach definitive conclusions with this paper. Instead, the focus is to open up a particular research venue and point out a few possible directions for utilizing more sophisticated methodologies in the future. Some of the potential future research will be discussed in the concluding remarks.

Admittedly, the comparison between Japan and Western Europe may raise some concerns, as it is likely to be biased to compare a single country with a region. However, it should still be on solid ground given that the Single European Act has already united the whole European Union into a single aviation market, while the integration of the Trans-European high-speed rail network (TEN-R) has also been successful and ongoing. In fact, with respect to European LCCs, it is very hard to define their "home country", with big players like Ryanair and Wizz Air having much larger operations in other European countries other than the ones where their headquarters are. In contrast, HSR is more local by nature and shows distinctive features across different European countries. To capture the characteristics of both sectors, we focus mainly on four Western European countries, i.e., Italy, France, Spain, and Germany, which have the longest HSR lines within Continental Europe and have been widely regarded as the exemplars of European HSR system.

The rest of chapter is organized as follows. Section 3.2 reviews the previous literature. Section 3.3 details the LCC-HSR interactions in both Japan and Western Europe. Section 3.4 compares the two cases and offers explanations for the differences. Section 3.5 contains concluding remarks.

3.2 Literature Review

As major transport modes, LCC and HSR have gained increased attention in the literature. In recent years, a wide range of studies have addressed various issues of these two modes. For example, the study of Mason & Morrison (2008) shows that there are essential differences in airlines' business models even though they are all considered as LCCs, and they also discuss how these different business models affect airlines' profitability. Connectivity, which is one of the elements of airlines' business models in Mason & Morrison's paper, has also been discussed in the study of Li et al. (2012). They find that the adoption of a dual-hub strategy has lead to the decrease of network connectivity. Graham (2013) points out that the governance model of airports and their sizes play an important role in the airline-airport relationship, and the findings show that small airports have more flexibility to address the LCC customers because the formal economic regulation rarely influences small airports. Some literature also discusses the liberalization of LCC (Graham & Shaw, 2008; Mason et al., 2011; Hanaoka et al., 2014), the evolution of LCC (Miyoshi, 2012), and the comparison between LCC and incumbent airlines (O'Connell & Williams, 2005; Fu et al., 2006).

As for the literature of HSR, Levinson et al. (1997) study the full costs of HSR infrastructure, which refers to the sum of the social and private costs, and they conclude that the cost of HSR is more expensive than that of airline services. De Rus & Nombela (2007) suggest that local conditions, which hold the key to demand levels, and the degree of congestion of other transport modes determine whether the investment in HSR infrastructure is socially profitable. In particular, they found that a 500km HSR corridor would produce net social benefits if it serves 8-10 million passengers per year. Some papers also investigate the environmental impact of HSR (Van Wee et al., 2003; Chester & Horvath, 2010; Chang & Kendall, 2011), accessibility of HSR network (Hou & Li, 2011; Jiao et al., 2014), and future development of HSR (Cheng, 2010).

Surprisingly, despite the strong connection, very few direct comparisons have been made between LCC and HSR. Instead, most of the existing studies on the interactions between airlines and HSR are very general, with the focus on the FSC sectors. Some of them are ex-post analyses, while others are ex-ante[5]. For example, Gonzalez-Savignat (2004) applies the ex-ante analysis to indicate that HSR services will decrease the market share of airline industry. By contrast, Park & Ha (2006) apply ex-post analysis to study the air-HSR competition and get the similar result. They find that in South Korea, the entry of HSR negatively impacted the domestic air transport industry. Adler et al. (2010) use a game theory setting to analyze air-HSR competition and encourage the development of a Trans-European HSR network. Yang & Zhang (2012) show that if HSR operator aims at maximizing a weighted sum of profit and welfare, both airfare and HSR fare decrease with increase in the weight on welfare. Fu et al. (2012) take China as an example to analyze the impact of the entry of HSR on its airline industry and state that travel time, cost efficiency, and network connectivity are the main factors that make HSR service competitive. Jiang & Zhang (2014) show that the air-HSR cooperation reduces traffic in the HSR-accessible markets. Albalate et al. (2015) conclude that when airlines are subject to competition from HSR, flight frequencies do not suffer from a significant decrease while the number of seats provided by airlines decreases. Some recent contributions have investigated the response of an airline to HSR competition in terms of its network choice and market coverage (Jiang & Zhang, 2016), the determinants of partnership level in air-HSR cooperation cases (Jiang et al., 2017), as well as the effects of air-rail competition on social welfare and environment (D'Alfonso et al., 2015; 2016). Almost exclusively, these studies incorporate features of FSC instead of LCC in their analysis.

[5] Ex-ante analysis plays an essential role in evaluating projects and assessing the priority of projects. However, ex-ante forecasts are largely wrong. As noted by Preston & Wall (2008), in 1998, the London & Continental Railways predicted the there would be 25 million HSR passengers in Cross-English Channel market in 2006. However, there were only 9.9 million passengers in 2012.

To our best knowledge, only two papers have attempted to study the interactions between LCC and HSR specifically. Casas Esplugas et al. (2005) discuss the response of European HSR network towards the entry of new LCCs. They believe that HSR will still dominate the markets but will feel substantial competitive pressure from LCCs. Chantruthai et al. (2014) compare the cost structures of LCC and HSR in a case study of the southern corridor in Thailand and conclude that HSR still has cost advantage even when competing with LCCs.

3.3 LCC and HSR in Japan and Western Europe

3.3.1 Background information of LCC in Japan

As the earliest two LCCs in Japan, Air Do and Skymark Airlines entered Tokyo-Sapporo and Tokyo-Fukuoka routes respectively in 1998, which was mainly due to the liberalization of the Japanese aviation market. Skymark Airlines also offered services from Osaka to Fukuoka and Sapporo. Both of them adopted the low fare strategy: Air Do's airfares were 36% below the incumbent airlines' airfares, and Skymark Airlines offered tickets at half the normal price (Yamaguchi et al., 2001).[6] In this case, incumbent airlines suffered a decreased in passengers. They had to offer discount tickets and upgrade their frequent flyer programs in order to compete with LCCs. Due to these effective measures incumbent airlines had regained the same level of demand as that of the previous year by March 1999 (Yamaguchi & Yamasaki, 2009). Because of

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[6] However, the low fare strategy remains to be a controversial issue. Miyoshi (2015) conclude that the aviation liberalization in Japan actually increased fares since airlines offered "high-yield products" rather than "high-productivity products".

such competitive forces, passenger demand experienced a growth of 9.4% on the Tokyo-Sapporo route and 16.3% on the Tokyo-Fukuoka route (Yamaguchi, 2007). Solaseed Air[7] then entered the market in 2002 along with the promulgation of new Civil Aeronautics Law, which partially liberalized airfares and the domestic air market. It started operation on the Tokyo-Miyazaki route first, and then expanded to the Tokyo-Nagasaki route and the Tokyo-Kumamoto route. In 2006, StarFlyer began operation between Tokyo and Kitakyushu, followed by the Tokyo-Kansai route in 2007.

In 2012, Peach Aviation, AirAsia Japan[8], and Jetstar Japan entered the market. Japanese domestic air traffic experienced an increase due to their operations. For example, the traffic of the Osaka-Sapporo route rose by 20% from 2010 to 2012. The domestic air traffic in 2012 was higher than it had been in approximately five years (Wu & Hayashi, 2014). Kansai International Airport provides carriers with several discount strategies, such as the off-peak discount and the promotional discount, which are the main reasons why Peach Aviation recognizes Kansai as its base airport. These discount strategies represent the collaboration between airport and airline. Vanilla Air commenced its first flight on the Narita-Okinawa route and the Narita-Taipei route in December 2013. Spring Airlines, which is a Chinese LCC, followed the Southwest model to

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[7] Skynet Asia Airways was rebranded as Solaseed Air in July 2011.

[8] AirAsia Japan operated as a joint venture between AirAsia and All Nippon Airways from August 2012 to October 2013, and it was the first LCC to be based at Narita International Airport, which indicated that it aimed at connecting the Unites States and Southeast Asia within the AirAsia group network. However, AirAsia decided to withdraw its investment, and then AirAsia Japan became fully owned by All Nippon Airways in June 2013. One of the main reasons was that AirAsia Japan had the lowest load factor compared to Peach Aviation and Jetstar Japan.

reduce maintenance and management costs, and invested in Spring Airlines Japan and held 33% of the total share of Spring Airlines Japan. Spring Airlines Japan commenced operation in 2014. However, its development is full of challenges and difficulties. For example, Spring Airlines Japan reduced its flight frequencies of the Narita-Takamatsu route from 7 to 4 weekly flights due to the low load factor.

3.3.2 Background information of HSR in Japan

The first modern HSR " Shinkansen" began operation on the Tokyo-Osaka route with the speed of 210 kph in 1964 in Japan. The Sanyo Shinkansen started operation in 1972 and extended to Fukuoka in 1975. Since then the network has been developed and expanded rapidly. The Joetsu and Tohoku Shinkansen started offering services in 1982, followed by Yamagata Shinkansen in 1992, and Akita and Hokuriku Shinkansen in 1997. The newest Kyushu Shinkansen opened in 2004. The Shinkansen network now has a total length of approximately 2388km comprising of eight Shinkansen lines operated by Japan Railways. The Shinkansen is best characterized by its punctuality and safety. There have been no passenger fatalities since it began operation, and the average delay time is within one minute. Although the network was designed to offer services for both passengers and freight, it is mainly passenger-oriented. The Tokaido Shinkansen is the busiest and oldest among all Shinkansen lines. It carried 143 million passengers in 2012, accounting for 42% of all Shinkansen passengers (Smith, 2014).

3.3.3 Background information of LCC in Western Europe

In Europe, the entry of LCCs has significantly displaced the market share from FSC, forcing them to adjust their strategy so as to compete with LCCs. The market shares of LCCs in several intra-European markets are even higher than 50%. One example is that LCCs accounted for 54% of the international seat capacity and 51% of domestic seat capacity in Spain in May 2013 (OAG, 2013). The fierce competition in the aviation industry has made many European LCCs become hybrid, changing the traditional low-cost model and following some characteristics of FSC (Klophaus et al., 2012). They also point out that the strategy of European LCCs is to focus more on route expansion instead of increasing existing routes' flight frequency. The low-cost model has developed since the European Union started to liberalize its internal market in the 1990s. Ryanair, the pioneer LCC in Europe, commenced operation in 1985, and then transformed itself from a traditional airline into a LCC in 1991. At that time, it put particular emphasis on providing services in the leisure passenger market between UK and Ireland. Now it is the largest and busiest airline in Europe. The main competitor of Ryanair is easyJet, which was established in 1995 in the UK. Both of them are leaders in the European LCCs market. Several other LCCs have also been established in the 1990s, such as Norwegian Air Shuttle in Norway, and Virgin Express in Belgium. A large number of LCCs commenced operation since 2000, especially between 2002 and 2004. However, the failure rate of these newly emerged LCCs is also very high.

3.3.4 Background information of HSR in Western Europe

HSR system has been developed in Europe for more than 30 years, and the route expansion is still ongoing. The entry of HSR in Europe significantly influenced the market share of airlines, resulting in the extensive competition between HSR and airline. France was the first country in Europe to introduce HSR service and completed the very first route from Paris to Lyon in 1983. The total travel time was decreased from four and a half hours (by car) to two hours. Since then, France extended HSLs in every direction from Paris. The first Italian HSR, ETR 450 Pendolino train, came into service in 1988. After that, the Rome-Naples route began operation in 2005, followed by Laveno-Modena and Novara-Turin in 2006. The motivation behind the construction of Italian HSR was that the relatively short distances between major Italian cities make it difficult to ensure the intermediate stopover for airlines. In Italy, HSR sometimes uses upgraded conventional tracks (e.g., Florence-Rome), and the spare capacity is used to transport freight at night. German HSR ICE started operation in 1991, and it connects all major cities in Germany as well as several foreign countries, such as Denmark and Belgium. The AVE in Spain commenced operation shortly after ICE in 1992 when the route between Madrid and Seville started running. Spain gave a priority to develop HSR in its transport policy, and hence, it currently has the longest HSR network (2515km) in Europe. TGV, ETR, ICE, and AVE are the main representatives of modern European HSR. Now, the main goal of European Union is to develop a trans-European HSR network, allowing countries to be connected to each other by a cross-border HSR network.

3.4 Comparisons and Discussion

3.4.1 Comparisons between Japan and Western Europe

Table 3.1 shows a basic comparison between Japan and Europe. The number of LCCs emerged in Europe is much larger than that in Japan, even on a per capita basis. The European LCC sector is also much more volatile compared with its Japanese counterpart. The total failure rate of LCCs in Europe is 58.8%[9], compared with the much lower 22.2% in Japan. In fact, if we count the number of survived LCCs on a per capita basis, Japan has an even higher value. However, this direct comparison neglects the different development stages of LCCs in these two regions. If we break down the failure rates of LCCs, it is 73% between 2000 and 2006 in Europe, during which 48 LCCs emerged and only 13 of them are still operating. The failure rate before 2000 is 48%. In other words, the European LCCs were at early stage of development before 2000, and hence the competition was less intensive. Then the market gradually became too competitive and saturated after 2000, forcing the weaker LCCs to leave the market. Comparatively speaking, the development of LCCs in Japan largely lags behind that in Europe.

[9] The LCCs' failure rate in this paper was calculated from International Civil Aviation Organization Database (2016a). Available at: https://www.icao.int/sustainability/Documents/LCC-List.pdf.

Table 3.1 Basic comparisons between Europe and Japan

Basic comparison	Europe	Japan
Area (1000km^2)	10,180	378
Population (million)	742	126
Number of LCCs emerged	85	9
Number of LCCs survived	35	7
LCCs' failure rate	58.8%	22.2%
Number of LCCs emerged/population	0.115	0.071
Number of LCCs survived/population	0.047	0.056
Length of HSR (km)	7316	2388
Length of HSR/population	9.86	18.95

Source: International Civil Aviation Organization Database (2016b).

Table 3.2, in which we compare the major LCCs in Europe and Japan in a more detailed fashion, also supports this idea. The major LCCs in Europe almost dominate their Japanese counterparts in every aspect. For example, as the pioneer of European LCCs, Ryanair carried 81.7 million passengers in 2014, which is 11% of total population in Europe. By contrast, Peach Aviation, the first Japanese-based full-scaled LCC, only carried 2.9% of total population in Japan. Overall, it is fair to say that the LCC sector is much more mature and advanced in Europe compared with Japan.

Table 3.2 Comparison between major LCCs in Europe and Japan in 2014

LCC	Passenger (million)	Average load factor	Destination	Route	Aircraft	Country served
Ryanair	81.7	82.8%	180	1600	297	30
easyJet	64.8	90.1%	134	675	226	32
Norwegian	24.0	80.9%	130	402	95	34
Wizz Air	13.9	85.9%	91	308	46	36
Peach Aviation	3.63	85.9%	16	19	17	4
Jetstar Japan	5.00*	70.0%	12	20	20	2

* Jetstar Japan carried 5 million passengers since it began operation in July 2012.

Source: Companies' annual reports and European Low Fares Airline Association (2016)

On the other hand, Shinkansen is better developed than European HSR. The last two rows of Table 3.1 shows that the average length of HSR doubles in Japan compared with in Europe. Table 3.3 tells pretty much the same story, showing that HSLs density in Japan is almost twice as high as that in major European countries. However, the length of HSLs should not be the only issue to be discussed. We should also consider about differences of the technical nature of HSR infrastructure between Japan and Europe, which may play a role in the range of HSLs. It is obvious that more than one scenario deploys and operates HSR infrastructure due to the spread of HSR technology. In Japan, HSR can run only on HSLs while mixed operations are more common in Europe. Campos & de Rus (2009) divided HSR services into four different models.

The first model is the exclusive exploitation model, and a good example of this model is Japanese Shinkansen. In Japan, the scenario is that the HSR and conventional services are completely separated, which results in the independent market organization of conventional rails and HSR. This is mainly because the HSLs were decided to be built in standard gauge (1.435m), while the conventional tracks, which were built in narrow gauge (1.067m), had limited capacity. The second model is the mixed high-speed model. In this case, passengers can have their HSR services on newly constructed lines or upgraded conventional lines. A good example is the TGV in France. The third model is the mixed conventional model, which means that conventional trains can run on HSLs. Spain's HSR AVE is the exemplar of this model. The last model is the fully mixed model. In this case, conventional trains and HSR can use both upgraded conventional lines and HSLs at their own speed, which offers the most flexibility. This model has been used by the Rome-Florence line in Italy and German's HSR ICE.

Table 3.3 High-speed rail density

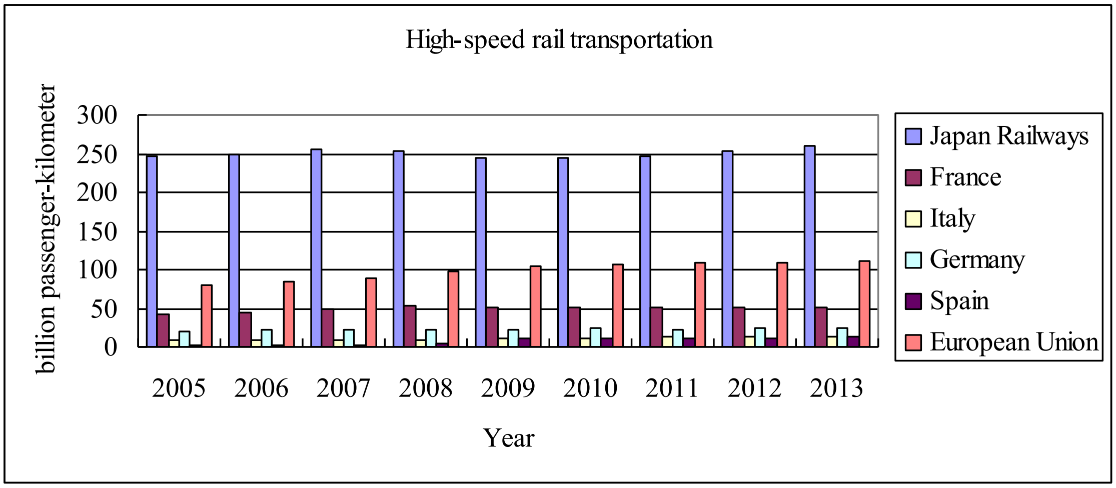
	Japan	**France**	**Germany**	**Italy**	**Spain**
Length of HSLs (km)	2388	2036	1352	923	2515
Area (1000km^2)	378	544	357.1	301.3	506
Line density (length/area)	6.32	3.74	3.79	3.06	4.97

Source: EU Transport Statistical Pocketbook (2014) and Japan Statistical Yearbook (2014)

The nature of HSR is also different in Japan and Europe. The Shinkansen services can be divided into three main types: Kodama (Normal, stops at all stations), Hikari and Sakura (Express, stops at main stations only), and Nozomi and Mizuho (Super Express, stops at very large cities only). In fact, the Nozomi and Mizuho HSR as well as Hikari and Sakura HSR have the same maximum speed and use the same type of train, but stop more on each route. In this context, Japan’s HSR services could be regarded, to some extent, as a mix of direct/fast trains, of semi-direct trains, and of stopping trains in the very large conurbation. By contrast, HSR services are more direct in Europe, especially in Spanish and French where their HSR have a radial network with few and distant stations, centered on Madrid and Paris respectively.

Moreover, Table 3.4 shows that the billion passenger-kilometers by HSR are much higher in Japan than in Europe. Although the value increases rapidly in Europe between 2005 and 2013, mainly due to the investment in infrastructure, it is again still not yet half of the Japanese level.

Table 3.4 HSR comparisons between Japan and Europe



Source: EU Transport Statistical Pocketbook (2014) and Japan Statistical Yearbook (2014)

Next, we will discuss the possible reasons behind the obvious differences between the LCC and the HSR sectors in Japan and Western Europe.

3.4.2 Geography and spatial pattern

In Table 3.1, we can see that the size of the European Union combined is much larger than that of Japan. The Single European Act that called for the liberalization of air transport was signed in 1986 and came into effect in 1987. This Act and subsequent regulations united the whole European Union into a single aviation market, changing the very fragmented situation. This creates opportunities for LCCs to compete with HSR and thrive since the competitiveness of HSR generally decreases with the increase of market distance. A larger geographical area also means more viable markets for the LCCs to shun HSR competition, given that the market density requirement for LCC is lower than that for HSR. This is clearly reflected by the fact that

European LCCs have much more destinations, shown in Table 3.2. On the other hand, it is difficult for Japanese LCCs to compete with HSR due to a small geographical area. In fact, this is the main reason why some Japanese LCCs began to offer international flights. For example, both Vanilla Air and Peach Aviation offer flights to Taiwan and Hong Kong.

The spatial pattern of the countries also matters. In particular, a country's urban system has significant impact on the development strategy of its HSR and LCC sectors. Due to the large percentage (about 75%) of mountainous terrains in land area, Japan has a high population concentration in urban areas on the plains, and most of them are heavily concentrated the Pacific shore of Honshu. Metropolitan Tokyo-Yokohama is the most populous cities in the world, with population of 35 million residents. This is why Japanese HSR operates under the exclusive corridor strategy, connecting megacities with high population density (Perl & Goetz, 2015). This spatial pattern also aggravates the development of Japanese LCCs, making it hard to compete with the HSR on the corridor as well as leaving few operable alternative markets. By contrast, although the urban systems in the Western European countries are diverse, the population concentrations are generally not as high as in Japan. In Italy, a single HSL is enough to serve a large share of inhabitants due to the linear shape of its urban system and the large percentage of inhabitants living in Milan and Rome. Both the Spanish HSR and the French HSR have a radial network with few and distant stations, centered on Madrid and Paris respectively. German's HSR network, on the other hand, is decentralized due to a more dispersed urban system and more mountainous terrains, which means that much more length of HSLs is needed so as to serve a large share of the population. Unlike Japan, all these European countries, being monocentric, bicentric or polycentric, have a relatively large number of mid-sized communities that are not connected by the HSR networks and thus provide sufficient demand for the LCCs.

3.4.3 Entry time

In Japan, HSR has been operating for more than five decades since the very first route began operation in 1964. By contrast, the first LCCs entered the market in 1998, much later than the opening time of HSR. The pioneer of Japanese LCC Skymark Airlines announced its bankruptcy in January 2015, and other LCCs have also experienced the decrease in traffic demand of some city pairs, especially for those city pairs that HSR overlaps with LCCs. The newly opened Spring Airlines Japan experienced several difficulties since its commencement in 2014. For example, the company had to reduce its flight frequencies of the Narita-Takamatsu route from 7 to 4 weekly flights due to the low load factor. As the HSR system is now very mature in Japan, it is difficult for LCCs to compete with HSR in the domestic market. On the other hand, HSR has substantially higher market shares, especially in the short-haul markets.

The European HSR started to develop around three decades ago when a large number of LCCs also commenced operation. There were 48 LCCs emerging from 2000 to 2006, but only 13 of them are still operating while 35 had ceased operation. The failure rate is 73%. The operation time of some failed LCCs is even less than one year. In contrast, the failure rate of LCCs emerged before 2000 is 48%. The competition between LCC and HSR is less intensive before 2000 because both of them are at early stage of development, and hence, these LCCs are more likely to survive in the competition. These surviving LCCs are normally the leaders of the market, such as Ryanair and easyJet. However, the market became too price competitive and relatively saturated after 2000, forcing the weak operation LCCs to leave the market. Therefore, it is difficult for the later entered LCCs to remain competitive compared to HSR.

Apparently, HSR predated LCC by a long period of time in Japan, while they emerged almost at the same time in Europe. This difference in entry points might also partially explain why HSR dominates LCC in Japan but not in Europe. If HSR has established itself in a market, it is very hard for LCCs to compete; but if LCCs have a period of time to develop, they may have a chance to survive.

3.4.4 Policy environment

One of the most important differences between Japan and Europe is the policy environments towards LCC and HSR. Liberalization has a huge impact on the airline sector. In fact, LCCs emerged in Europe as a result of liberalization. The whole liberalization process in Europe was completed gradually from 1987 to 1997. During this period, European Union implemented three air transport liberalization packages, which finally established a single aviation market for the European Union airlines. Now, Europe has established a single sky and the full air transport liberalization as well as the airport privatization. In Europe, LCCs have not only promoted a decrease of airfares but also put threats to FSC. Ryanair has beaten Lufthansa and became the largest carrier in Europe. The entry of LCCs enables more and more people to have access to air transport[10], and stimulate economic growth in both regional and national areas.

The regulatory environment and market conditions in Japan are quite different from Europe. LCC is a more recent phenomenon in Japan as a result of liberalization along with slot allocations system at Haneda airport. The process of liberalization in Japanese air transport was operated step by step from 1985 to 2000. The structural policy before the liberalization was called “45/47 system”. In 1972, the government enacted the so-called "aviation constitution", which was widely referred to the 45/47 system. Under this system, the government could allocate the domestic market to different airlines (Miyoshi, 2007). More specifically, as for the international market, Japan Airlines operated all international scheduled routes, while international charter routes were operated by both All Nippon Airways and Japan Airlines. The main reason behind such allocation was that Japan Airlines was strongly against All Nippon Airways' entry to the international market due to their inability and inexperience. In terms of the domestic market allocation, both All Nippon Airways and Japan Airlines had the right to domestic truck routes, whereas the domestic local routes[11] had been allocated to All Nippon

[10] Windle & Dresner (1995) find that the entry of Southwest Airlines onto a route resulted in a traffic increase of 200% and an average price decrease of 48% by using a data set from 1991 to 1994. Fu et al. (2010) state that most liberalization results in traffic growth because liberalization removes limits, and hence results in increased service quality and decreased price. Besides, the network configuration can be improved through liberalization. The implement of hub-and-spoke allows airlines to expand their services to new destinations as they are able to connect small markets with their hub airports. However, according to the reviewer, some studies show that LCCs rather help the middle class already flying to flow more often, the poor still flying very infrequently.

[11] The domestic trunk routes refer to all the domestic flights from Fukuoka, Okinawa, Osaka, Sapporo, and Tokyo, while the domestic local routes refer to all the remaining routes.

Airways and Toa Domestic Airlines. The main objective of this 45/47 system was to promote the co-prosperity of airlines by preventing excessive competition (Miyoshi, 2015). In 1985, the 45/47 system had been abolished, which represented the beginning of liberalization, and the new policy offered more market access. Before that, transport policies had been strictly regulated, limiting effective competition among carriers. The rules of fare setting were repealed between 1996 and 2000, and the competition promotion policy between 1986 and 1996 provided carriers with a less restrictive environment. During this process, two LCCs, Air Do and Skymark Airlines, entered the market in 1998. These two LCCs were the first new entrants in 35 years except for subsidiaries of three major airlines (Japan Airlines, All Nippon Airways, and Toa Domestic Airlines). In 2000, the Civil Aeronautics Law was substantially revised, which largely liberalized the fare approval system and license system. This revision has enabled airlines to freely set price and to operate any route they desire legally, and the only thing they need to do is to notice Civil Aviation Bureau of Japan in advance. It was in 2000 when Japan completed its liberalization. Even though Japanese officials said that the domestic market has already adopted liberalization, there are still many incomplete issues regarding liberalization. For example, Miyoshi (2015) identifies six main constraints that would hinder the fully liberalization of the Japanese aviation market. They are: (1) the highly regulated market, (2) the dominant places of All Nippon Airways and Japan Airlines in the market, (3) the mature HSR network, (4) weaknesses of LCCs, (5) high-cost and high-yield airlines, and (6) the public ownership of airports. All of them are difficult to be removed as both the airlines and government are keen to protect the market.

It was until 2012 when the first Japanese-based full-scale LCC, Peach Aviation, emerged. LCCs in Japan are now starting to expand to intra-Asia regional markets. For example, Peach Aviation provides service from Japan to Taiwan, Hong Kong, and Korea. However, the aviation regulation system across Asian countries is much more restrictive than that in Europe, which is one of the main barriers to the development of Japanese LCCs. Meanwhile, the Japanese government has begun to put particular emphasis on the airport privatization, which became both important and frequent in the 1990s, and perhaps the airport liberalization in Europe has the most notable effects. In 2011, Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) announced the plans to privatize all national airports by 2020, which aim to reform the management structure and type of ownership of Japanese airports. There are currently 97 airports in Japan, including 65 airports are owned by the government, 28 are owned by the government, and 4 (Kansai, Itami, Narita, and Nagoya) are managed by private companies (Miyoshi, 2015). Such larger number of concession deals have attracted considerable attention from the world. In November 2013, the Japanese government announced the Sendai Airport concession scheme, which represented the beginning of the bidding process. The privatization would include a long-term lease concession for the rights to manage and operate Sendai Airport, but not air traffic control, which is still managed by the government. Following that, the concession scheme of the merging of Kansai and Itami International Airports, as well as Fukuoka Airport is also under consideration. Generally speaking, a relatively more liberal aviation regulation system is being established step by step in Japan.

The highly regulated market also led to a lack of dynamic fare setting rules and revenue management. In Japan, airlines still need to notice the levels and types of fare to the government in advance, which remains a main limitation of full competition. The government policy largely protects All Nippon Airways and Japan Airlines, resulting in their dominant places in the domestic aviation market. All the LCCs, except Skymark Airlines, operate under the control of these two airlines. Therefore, there is a lack of low fare competition, which allows airlines to increase fares. For example, the highest demand route such as the Tokyo-Osaka route, HSR fare was set exactly same as air even after 2000, when the domestic aviation market partially liberalized. However, the cheapest fare was only 30 % cheaper than that of the fully flexible fare. It was the same as that of LCCs. This maintains the high yield in the domestic market. As a result, the average yield in the domestic market has increased 4% between 2002 and 2004 even after the liberalization in 2000 (Miyoshi, 2007). On the other hand, the pricing capacity and access are now fully liberalized due to the implement of The Third Package in 1993.

Another thing we want to emphasize here is about the international regulation of air transport in Japan. A few decades ago, Japanese aviation market was structurally closed to foreign entrants. It was until 1953 when the bilateral air transport agreements between Japan and US, UK, Netherlands, Sweden, Noway, Denmark, and Thailand came into force. Among all these countries, US had the most freedom to offer air services in Japan. The original agreement enabled Japanese airlines to fly between any Japanese city and three US cities, and granted them rights beyond San Francisco and Honolulu to third countries. Besides, it also allowed US airlines to fly between Tokyo and Naha and US cities with unrestricted traffic rights and beyond these cities to any third country. However, the agreement still remained to be a challenge especially to potential new entrants from both countries. In 1998, Japan and US reached a new agreement, which allowed incumbent airlines to fly between any point in Japan and US without any capacity restrictions. Currently, US has the largest number of incumbent carriers that have the right to provide air services in Japan. In 2007, MLIT began to liberalize the international scheduled air services in order to achieve the goal of Asian Gateway Initiative that is to liberalize the aviation policy and eventually achieve "Asian Open Skies". Since then, several international LCCs (e.g., Spring Airlines, Jet Star, and Tway) began to offer services to Japan.

Regarding HSR development, both the Japanese and the European governments have promoted it as the government key project because of the substantially positive effects on economy, society, culture, and environment in ways beyond mere construction and operation contributions, but they have different motivations of HSR development. As early as in 1986, long before the aviation liberalization, a reform was passed to privatize the Japan National Railway into Japan Railways. The cost of expanding the original Shinkansen network to serve less densely populated regions and smaller cities, i.e., the construction of Sanyo, Tohoku, and Johetsu Shinkansen, led to financial losses which are the underlying reason of the privatization. This privatization offered more freedom of operations and largely improved financial performance. However, the privatization does not mean that the government does not pay anymore for building new HSLs. In fact, Japan Railways companies are still highly regulated by MLIT but experience less intervention by the government compared with the Japan National Railway era. On the other hand, HSR services have remained state-owned in most European cases, but they are often managed as private firms. For example, France's TGVs are mostly operated regarding load factors and profit margins, and the market-oriented management of TGV was one key innovation that led to its development in the late 1970s. While most countries put particular emphasis on commercial achievement in terms of developing HSR network (see Dunn & Perl, 1994 for the discussion about France), some of them also attach various political purposes to the projects. In Germany, a major driving force for HSR development was political, i.e., the need to reunify east and west. This is not the issue only for Germany. In Japan, some areas such as Tohoku lines have been suffering the low demand not only for HSR as well as the air transport, but these lines are also developed due to the political reasons in Japan. In Spain, the main purpose to develop an HSR network is to promote poor regions' economic growth. This is why Spain was the only country that started HSR construction from a less populated city (Seville).

In conclusion, both Japan and Europe has promoted HSR as the government key project, but the European government has a more liberal attitude towards its aviation sector compared with the Japanese government, which may also play a role in the different development states of LCC and HSR in these two regions.

3.5 Concluding Remarks

In this paper, we apply a comparative research analysis to compare the macroeconomic development status of both HSR and LCC in Japan and Western Europe. We observe that the Japanese LCC sector seems to be lagging behind its European counterparts while both regions have strong HSR systems but the Japanese case appearing more dominant. We further analyze the possible driving forces behind this distinction. Three potential factors are investigated. First, a larger geographical area in Western Europe means that LCCs have more potential to enter the medium- and long-haul routes, which facilitates their further development. The more polycentric spatial pattern in Western Europe also provides more viable markets for LCCs where no HSR competition exists. Second, HSR predated LCC by a long period of time in Japan, while they emerged almost at the same time in Europe. This gives the extra strategic advantage to HSR in Japan instead of in Europe, since if HSR has established itself in a market, it is very hard for LCCs to compete; but if LCCs has a period of time to develop, they may have a chance to survive. Third, both Japan and Europe has promoted HSR as the government key project, but the European government has a more liberal attitude towards its aviation sector compared with the Japanese government, which discourages the LCC sector in Japan. Among these factors, we focus on the policy environment. We believe that different regulatory environments might be a major driving force why development states of LCC and HSR in these two regions differ from each other. Compared to Western Europe, the highly regulated domestic aviation market in Japan has largely discouraged the development of LCCs, resulting in the weakness of LCCs. The post-partial liberalization, i.e., the airport privatization, may change the situation, and make it possible to implement the flexible management strategy. This is the first time a macroeconomic comparison is given to the development of HSR system and LCC sector. Some conclusions should have policy implications for other countries that are currently building their HSR networks or planning to foster their LCC sectors.

This study is confined in a few ways. First, due to the lack of data, only macroeconomic comparisons are available. No specific markets are identified, thus a lack of details might potentially cause analytical inaccuracy. Second, only logical inferences are used to identify the potential driving forces behind the different development status of LCC and HSR. No statistical tests are given for these conjectures. However, we believe that this chapter serves as a meaningful first step in this research venue. When first-hand data is collected, more rigorous statistical analysis and more detailed case studies can be implemented.

Chapter 4 Partnership Levels in Air-Rail Cooperation

4.1 Introduction

HSR that developed in the second half of the 20th century has been recognized as one of the most important technological breakthroughs in the transport industry. As of April 2015, there are 29,792 km of HSLs in the world and 3,603 HSR sets in operation. HSR has been a popular transport mode, carrying 1,600 million passengers per year (UIC, 2017). It has mainly been regarded as the biggest threats to airlines, especially for short-haul markets where airlines usually lose ground to HSR, being either pulled out of markets or into big decline in market share. There are many examples showing that these two transport modes fiercely compete with each other. As noted by Park & Ha (2006), the operation of HSR in Korea resulted in the reduction in airline demand in domestic markets. Similarly, the introduction of HSR has decreased the number of air transport operation in Spain (Jiménez & Betancor, 2012). According to de Rus Mendoza (2012), the mix of air/rail passengers in the Madrid-Seville route changed to 16% and 84% after the opening of HSR, which was 67% and 33% respectively before HSR first operation in the early 1990s, and the numbers are expected to become 13% and 87% by 2020. In China, the introduction of HSR even led to air route cancellation in several domestic markets (Fu et al., 2012; 2014). The same situation can also be found in the market between London–Paris (Behrens & Pels, 2012). However, the competition between airline and HSR becomes less straightforward when flights are operated by LCCs (Gleave, 2006).

Although HSR is now experiencing the rapid development and in the middle of network expansion today, aviation still has its own competitive advantages especially its extensive network and ability to offer long-haul flights. Román et al. (2007) study the competition between airlines and HSR in the corridor Madrid-Barcelona and find that airlines are still the dominant transport mode with the market share close to 75% whereas the decrease in the market share of air transport due to the operation of HSR never exceeds 13%. In fact, HSR not only competes with airlines but also complement air services in some particular cases by providing connections between nearby cities and airports. The hub-and-spoke network adopted by most major airlines makes such airline-HSR complementarities possible. In a hub-and-spoke network, two flights ("legs") are connected through a centrally located hub airport as one journey from the origin airport to the destination airport. Under the airline-HSR complementarities, however, HSR can be one leg and used in cooperation with a flight to provide services. Sometimes, the complementarities are not confined with HSR. In countries, such as Canada and US, the intermodal cooperation is offered without real HSR. We can simply regard such intermodal cooperation as a special type of "code sharing" which has been widely adopted by the airline industry (e.g., Oum et al., 1996; Oster & Pickrell, 1988; Ito & Lee, 2007). Under a code sharing agreement, connecting flights being operated by two separate airlines with each offering one leg of a flight, and the non-operating airline is allowed to put its code on the operating airline's flight number. Policy makers also encourage and support the air-rail cooperation since it is generally believed that the substitution of air services with equivalent HSR services can help mitigate the air pollution and airport congestion (Janic, 2011). Because of such positive environmental and social impacts caused by the air-rail intermodal cooperation some studies have shifted focuses from the competition to cooperation between these two transport modes. Most of these studies are empirical works (e.g., Givoni & Banister, 2006; Albalate et al., 2015), while few analytical papers investigated this issue (e.g., Jiang & Zhang, 2014).

Despite the importance of the air-rail intermodal cooperation, there are several interesting aspects that have never been discussed by literature. First, there are considerable differences among different air-rail intermodal cooperation cases. For one thing, different partnership levels exist between different intermodal cooperation cases. Some cases are high cooperation level with features like baggage handling, coordinated scheduling, and integrated ticketing, and can be comparable to connecting flights. For instance, the AIRail service offered by Deutsche Bahn and Lufthansa at Frankfurt Airport is one of the best intermodal practice examples. By contrast, some cooperation is nothing more than an alternative back-up strategy for emergent situations. A good example can be found in the cooperation between VIA Rail and Air Canada, where they cooperate with each other only under delay or cancellation disruptions. Most partnerships lie in between these two extremes. For another, in intermodal cooperation cases, airlines can be of various types. Some cases are between domestic airlines and rail operators, whereas other cases are between foreign airlines and rail operators, and sometimes both cases exist simultaneously. In most cases, domestic airlines have higher cooperation levels with rail operators compared to foreign counterparts. Because of the diversity of various cases, we probably won't be able to capture the full picture of the air-rail cooperation cases without a broader view of case comparisons.

The above discussions lead to an important query: what are the potential driving forces causing such substantial differences between air-rail cooperation cases? The nature and implications of air-rail intermodal integration have been analyzed in previous studies from qualitative perspectives (Chiambaretto & Decker, 2012; Chiambaretto et al., 2013; Gleave, 2006). The existing literature on the airline-HSR interactions has mainly focused on their competition mode. For example, Dobruszkes (2011) study empirically the extent to which HSR may cause the decrease in the air supply. Yang & Zhang (2012) investigate the effects of air and HSR competition on prices, profits, and welfare from an analytical perspective. Some recent studies have investigated the impacts of the air and HSR competition on social welfare and environment (D'Alfonso et al., 2015; 2016), as well as the long-term impacts on how an airline would change its market coverage and network when competing with HSR on trunk routes (Jiang & Zhang, 2016). The studies on the cooperation aspect of these two transport modes are currently under-researched. To our best knowledge, Jiang et al. (2017) is the only paper that studies the partnership level in air-rail cooperation. Two intermodal relationships are investigated in their paper: a vertical one where the networks of airline and rail do not overlap, and a parallel one where they overlap partially. Their findings show that these two relationships may end up with different partnership levels under various conditions.

The rest of chapter is organized as follows. Section 4.2 identifies different air-rail partnership levels and their main features, followed by an econometric model of air-rail cooperation cases in section 4.3. Section 4.4 analyzes empirical results and the potential driving forces behind different partnership levels in air-rail cooperation. Finally, section 4.5 contains concluding remarks.

4.2 Air-rail Partnership Levels

4.2.1 The emergence of air-rail partnerships

Trying to understand the different partnership levels of air-rail cooperation, we first investigate the emergence of air-rail partnership. There are three main reasons for this phenomenon: the expansion of HSR around the global, the development of intermodal airports, and the challenges and difficulties airlines faced.

HSR has become a strong competitor and substitute of air transport because of its expansion around the world. With its growing popularity, HSR has received substantial political support in recent decades. As a result, it is now a common transport mode in countries including China, Japan, Italy, France, Spain, and Germany, serving millions of passengers per day. However, air transport is still dominant in long-distance travel, and it is still likely to continue to grow for its extensive networks. This situation calls for an intermodal cooperation between airlines and rail operators in providing an opportunity for the hub airport to transfer transport modes. Under this scenario, the development of intermodal airports is also considered as a key determinant of the emergence of air-rail partnership. Besides, the advent and growth of LCCs put significant threats to legacy airlines. LCCs increase the competitive pressure on legacy airlines, forcing some legacy airlines to decrease or even withdraw their services on particular routes.

4.2.2 Air-rail partnership cases and their features

It is also important to find a way to compare the various cases in order to understand what causes the wide-ranging differences of air-rail partnership levels. It is perfectly possible that one air-rail cooperation case shows some partnership features the other case lacks and also lacks some features the other case shows at the same time. Therefore, the first step we adopt is to summarize the existing air-rail cooperation cases and identify the features that are related to partnership levels. Then we'll count the number of such characteristics attached to each cooperation case so as to rank these existing cases. From the ranking, we'll try to draw some preliminary conclusions about the driving forces for a high partnership level air-rail cooperation case. Admittedly, we are essentially giving the same weight to every characteristic that we identify, i.e., treating these characteristics equally, which might not be accurate. For example, for a large number of passengers, time coordination might be more important than frequent flyer miles. We acknowledge that equal weighting for each feature is definitely not the best way to rank the partnership levels, but it is the easiest way. Serving as the first paper on this topic, we do not aim to present the most accurate methodology but to open up a new venue. We'll further discuss the potential follow-up directions in the conclusion section.

First, the relevant cases of the partnership between airlines and HSR were mapped, as shown in Table 4.1. Looking closer to each case (Table 4.1) with their main features (Table 4.2), the main characteristics are associated with the agreements in the air-rail partnership, and the agreements are different from each other. For example, code-sharing agreements enable each operator to allocate its own flight/train number to the train trip. In some extreme cases, the airline changes an "air leg" from the passengers' reservation to a rail leg at no extra charge if the flight is delayed or canceled (e.g., the partnership between VIA Rail and Air Canada). Passengers can transfer between these two different transport modes and complete the entire journey with a single ticket. Sometimes the joint ticket price is offered with special discounts. For example, in the case of the partnership between Shanghai Railway Bureau and China Eastern Airlines, the joint ticket price is about 50% less than the total price of buying a train and flight tickets separately. In some cases, the online reservation has made the whole booking process much easier with just one booking of the entire journey. There is also schedule coordination between flights and trains to allow connection opportunities and reduce transfer time and eventually, achieve the seamless intermodal travel. Shuttle services may be used to connect rail stations and airports so as to save transfer time when the rail station is not in the airport. It is also possible for passengers to earn miles in the frequent flyers program in the rail leg. The air-rail partnerships help increase the number of destinations within passengers' reach (e.g., the cooperation between VIA Rail and Air Transat). However, we can see from the table 4.2 that there are not much partnership cases involve baggage handling and booking flexibility.

As shown in the ranking results, the air-rail partnership is better developed in Europe. Deutsche Bahn is in a dominant place in the air-rail partnership in Europe. Their Rail&Fly product has implemented interlining agreements with more than 70 airlines, which enables airlines to sell rail tickets. Deutsche Bahn has an AIRail product with Lufthansa, which acts a joint venture with more main features than Rail&Fly. In this case, baggage can be checked from a check-in counter in Stuttgart or Cologne station directly to the final destination, and vice versa. AIRail began operation on the route between Stuttgart and Frankfurt Airport in 2001, and between Cologne and Frankfurt Airport in 2003. It is now the most advanced intermodal mode in Europe. In France, meanwhile, SNCF has a codeshare agreement with more than 10 airlines. However, the air-rail partnership remains novel outside Europe. This fact is also reflected in the ranking results where less main features can be found in countries outside Europe.

Table 4.1 Air-Rail cooperation cases

Case No.	Country	Rail Company	Airlines	Name
1	Canada	VIA Rail	Air Canada	
2			Air North	
3			Air Transat	
4			First Air	
5			Hainan Airlines	
6			Hawkair	
7			Royal Jordanian	
8	China	Chinese High-speed Rail	Tianjin-Binhai International Airport	
9			ShiJiazhuang Zhengding International Airport	
10			Zhengzhou Xinzheng International Airport	
11		Yuehai Railway	Hainan Airlines	
12		Shanghai Railway Bureau	China Eastern Airlines	
13			Spring Airlines	
14	Finland	Allegro	Finnair	
15	France	SNCF	Air France	Air&Rail
16			Air Austral, Air Caraïbes, Air France, Air Tahiti Nui, Corsair, Cathay Pacific, Etihad Airways, Malaysia Airlines, Oman Air, Qatar Airways, Srilanka Airlines, Vietnam Airlines	TGV AIR
17	Germany	Deustsche Bahn	Lufthansa	AIRail
18			More than 70 Airlines[12]	Rail&Fly

[12] The full list of airlines can be found at:
http://www.bahn.com/i/view/mdb/bahnintern/services/mobilitaet_service/rail_fly_airrail/mdb_88401_20120808_airlines_juli_2012_internetdarstellung.pdf

Case No.	Country	Rail company	Airlines	Name
19	Italy	Trenitalia	Aegean Airlines	
20	Netherlands, Belgium	Thalys	KLM	
21	Netherlands, France and Belgium	Thalys	American Airlines	
22			Brussels Airlines	
23			Jet Airways	
24	Portugal	Comboios de Portugal	TAP Portugal	
25	Spain	Renfe	Avianca	
26	Switzerland	Swiss Federal Railways (SBB)	Finnair	
27			Swiss International Air Lines	
28	Taiwan	Taiwan High- Speed Rail	China Airlines	
29			Eva Air	
30	United Kingdom	First Great Western, Heathrow Express	British Airways	
31		First Great Western, Heathrow Express	Singapore Airlines	Rail-Fly
32		Southwest Trains	Flybe	
33	United State	Amtrak	United Airlines	

Table 4.2 Lists of features

Case No.	Features	Number of Features	Partnership Level	Geographical Location	Airline Type		Rail Station
					Domestic/Foreign	Ownership	
1	Delay/cancellation assistance	1	Low	North America	Domestic	Public	
2	Online reservation	1	Low	North America	Domestic	Private	
3	Online reservation	1	Low	North America	Domestic	Private	
4	Online reservation	1	Low	North America	Domestic	Private	
5	Integrated ticketing	1	Low	North America	Foreign	Public	
6	Online reservation	1	Low	North America	Domestic	Private	
7	Code-sharing Online reservation Schedule coordination	3	Medium	North America	Foreign	Public	
8	Online reservation Special discounts	2	Low	Asia	Domestic	Public	
9	Online reservation Special discounts	2	Low	Asia	Domestic	Public	
10	Online reservation Special discounts	2	Low	Asia	Domestic	Public	
11	Code-sharing	1	Low	Asia	Domestic	Public	
12	Special discounts	1	Low	Asia	Domestic	Public	
13	Integrated ticketing Special discounts	2	Low	Asia	Domestic	Private	
14	Code-sharing Integrated ticketing	2	Low	Europe	Domestic	Public	
15	Code-sharing, Online reservation Delay/cancellation assistance Frequent flyer program	4	Medium	Europe	Domestic	Public	At airport

Case No.	Features	Number of Features	Partnership Level	Geographical Location	Airline Type		Rail Station
					Domestic/Foreign	Ownership	
16	Code-sharing Integrated ticketing Online reservation Special discounts Schedule coordination End to end services Delay/cancellation assistance Frequent flyer program	8	High	Europe	Domestic&Foreign	Public &Private	At airport
17	Integrated ticketing Online reservation Delay/cancellation assistance Schedule coordination Baggage handling End to end services Frequent flyer program	7	High	Europe	Domestic	Public	At airport
18	Online reservation	1	Low	Europe	Domestic&Foreign	Public& Private	At airport
19	Special discounts	1	Low	Europe	Foreign	Private	
20	Code-sharing	1	Low	Europe	Domestic	Public	At airport
21	Code-sharing, Online reservation Frequent flyer program	3	Medium	Europe	Foreign	Public	
22	Code-sharing, Integrated ticketing Online reservation Special discounts Schedule coordination Frequent flyer program	6	High	Europe	Domestic	Private	At airport

Case No.	Features	Number of Features	Partnership Level	Geographical Location	Airline Type		Rail Station
					Domestic/Foreign	Ownership	
23	Code-sharing, Integrated ticketing Online reservation Special discounts Schedule coordination Frequent flyer program	6	High	Europe	Foreign	Private	At airport
24	Online reservation Special discounts	2	Low	Europe	Domestic	Public	
25	Online reservation Delay/cancellation assistance	2	Low	Europe	Foreign	Private	
26	Code-sharing Integrated ticketing Frequent flyer program Baggage handling	4	Medium	Europe	Foreign	Public	
27	Code-sharing	1	Low	Europe	Domestic	Public	
28	Online reservation Special discounts	2	Low	Asia	Domestic	Public	
29	Online reservation Special discounts	2	Low	Asia	Domestic	Private	
30	Online reservation Delay/cancellation assistance Frequent flyer program	3	Medium	Europe	Domestic	Public	
31	Delay/cancellation assistance	1	Low	Europe	Foreign	Public	
32	Online reservation	1	Low	Europe	Domestic	Public	
33	Code-sharing, Online reservation Frequent flyer program	3	Medium	North America	Domestic	Private	

4.3 Econometric Model of Air-Rail Cooperation Cases

The determinants of air-rail partnership may include various factors. We assume that airline and HSR choose certain cooperation levels when the joint revenue or benefit outweighs the associated cost. In other words, airline/airport and HSR will not choose a particular level of cooperation if the implied joint revenue or benefit is lower than the cost to do so. The cost of cooperation should increase with the cooperation level. For HSR operator with public ownership, it may also consider to social welfare, thus the objective of air-HSR cooperation is to consider a weighted aggregate of joint revenue and social welfare. Let π^* be an air-rail cooperation case's latent revenue or weighted aggregate of revenue and social welfare, as follows:

$$\ln\pi_i^* = \ln x_i'\beta + \varepsilon_i \tag{1}$$

Where the subscript i stands for the pair of airline/airport and HSR, and the subscript j stands for the cooperation level. x_i' is the transpose of the vector of explanatory variable x_{ij} and ε_{ij} is a stochastic error term. Let D be the air-rail cooperation decision as shown in Eq. (2), with $D_i = 0$ as the cooperation level to be "Low", $D_i = 1$ as the cooperation level to be "Medium" and $D_i = 2$ as the cooperation level to be "High". Hence, the air-rail cooperation decision can be written as:

$$D_I = \begin{cases} 0, & when\ \pi_i^* < C_M \\ 1, & when\ C_M < \pi_i^* < C_H \\ 2, & when\ \pi_i^* > C_H \end{cases} \tag{2}$$

Where C_M is the cost to achieve "Medium Level" cooperation, and C_H is the cost to achieve the "High Level" cooperation.

The probability of cooperation decision for the "Low level" case can be specified as:

$$Prob(D_i = 0|x) = Prob(\pi_i^* < C_M) = Prob(\ln x_i'\beta + \varepsilon_i - \ln C_M < 0|x)$$

$$= Prob(\varepsilon_i < \ln C_M - \ln x_i'\beta) \quad (3)$$

Similarly, we can define the probability of cooperation decision for the "Medium" and "High level" cooperation.

$$Prob(D_i = 1|x) = Prob(C_M < \pi_i^* < C_H) = Prob(C_M < \ln x_i'\beta + \varepsilon_i < \ln C_H|x)$$

$$= Prob(\ln C_M - \ln x_i'\beta < \varepsilon_i < \ln C_H - \ln x_i'\beta) \quad (4)$$

$$Prob(D_i = 2|x) = Prob(\pi_i^* > C_M) = Prob(\ln x_i'\beta + \varepsilon_i - \ln C_H > 0|x)$$

$$= Prob(\varepsilon_i > \ln C_H - \ln x_i'\beta) \quad (5)$$

An ordered logistics regression can be adopted with a 'maximum likelihood' method under the assumption that ε is independently and identically distributed with the logit distribution. The estimation results would represent the cooperation decision process in general, instead of any particular cooperation case. Since air-rail cooperation is a newly emerged phenomenon, the sample size is quite small. Therefore, we should be very cautious in the interpretation of the results, and the results shall be reexamined when more air-rail cooperation cases provide services in the coming years.

4.4 Empirical Analysis: Data and Results

4.4.1 Data

We conduct our empirical analysis on the relationship between dependent variable (partnership level) and independent variable (geographical location, airline type, and rail station). We distinguish the air-rail partnership cases by their partnership levels. In this paper, we simply assume that the more features each case has, the higher the partnership level. Low level of partnership refers to the cases that have at most two features. In this level, the partnership is just like the traditional interlining agreements, where airlines only have the right to sell train tickets, and in most cases, cannot provide any further services. For medium partnership level, it has between 3 and 5 features and includes more dedicated services. High partnership level has more than 5 features. We can specify the latent function (1) as the following equation:

$$\ln\pi_i^* = \beta_0 + \beta_1 D_{Asia} + \beta_2 D_{NA} + \beta_3 D_{Airline} + \beta_4 \mathrm{D}_{Airport} + \varepsilon \qquad (6)$$

Where we consider the following independent variables:

D_{Asia} : Dummy variable that takes a value of one for those cooperation cases in Asia;

D_{NA} : Dummy variable that takes a value of one for those cooperation cases in North America

(Cooperation cases in Europe are being excluded from the model);

$D_{Airline}$: Dummy variable that takes of one for foreign airlines, and zero for domestic airlines;

$\mathrm{D}_{Airport}$: Dummy variable that takes a value of one for those cooperation cases having HSR station at airport.

Table 4.3 reports the descriptive statistics for the variables used in the empirical model.

Table 4.3 Descriptive statistics of variables

Dependent Variable			**Independent Variable**							
Partnership Level			Asia		North America		Airline Type		Airport	
High	Medium	Low	1	0	1	0	1	0	1	0
4	5	24	8	25	8	25	10	23	7	26

4.4.2 Regression Results

Table 4.4 shows the results of the regressions using ordinal logistics model. Our research focuses on what are the main variables that affect air-rail partnership levels. The results reveal that the location of the train station has the largest impact on the partnership level. In particular, if the train station is located within the airport, the air-rail cooperation is more likely to end up with a high partnership level. Indeed, the coefficient associated with the dummy variable for the location of rail station is negative and statistically significant at the 1% level. The odds of the rail station located within the airport being entered for a higher cooperation level are 0.015 the odds for the rail station not within the airport.

Table 4.4 Regression results

	Coefficient	Standard Error	T Value	P Value	Odds Ratios
Asia	-1.507	1.362	-1.106	0.269	0.222
North America	-0.129	1.050	-0.123	0.902	0.879
Airline Type	0.388	0.891	0.434	0.663	1.474
Airport	-4.218***	1.567	-2.692	0.007	0.015***

Notes: significance level. *p < 0.10. **p < 0.05. ***p < 0.01.

4.4.3 Fisher's exact test

We then apply the Fisher's exact test to analyze air-rail partnership level in a different way. This test is powerful when sample sizes are small. One main advantage of the Fisher's exact test is that the significance of the deviation from a null hypothesis can be calculated exactly; instead of depending on approximation that will become exact in the limit as the sample size grows to infinity. We run three separate tests to find out if there is an association between partnership level and three variables (i.e., airline type, rail station location, and geographical location), respectively. The results can be found in the following tables.

Table 4.5 Fisher's exact test for partnership level and airline type

	Low	Medium	High	Row total
Domestic	18	3	2	23
Foreign	5	3	2	10
Column total	23	6	4	33

H_0: There is no association between partnership level and airline type.

H_1: There is an association between partnership level and airline type.

According to the R, we get the p-value = 0.2478, which is large than 0.05, and hence we can accept the null hypothesis at the 5% significant level.

Table 4.6 Fisher's exact test for partnership level and rail station location

	Low	Medium	High	Row total
At airport	2	1	4	7
Not at airport	21	5	0	26
Column total	23	6	4	33

H_0: There is no association between partnership level and rail station location.

H_1: There is an association between partnership level and rail station location.

According to the R, we get the p-value = 0.0009541, which is less than 0.001, and hence we can reject the null hypothesis even at the 0.1% significant level. The relationship between partnership level and rail station location is statistically significant.

Table 4.7 Fisher's exact test for partnership level and geographical location

	Low	Medium	High	Row total
Asia	8	0	0	8
Europe	9	4	4	17
North America	6	2	0	8
Column total	23	6	4	33

H_0: There is no association between partnership level and geographical location.

H_1: There is an association between partnership level and geographical location.

According to the R, we get the p-value = 0.1412, which is large than 0.05, and hence we can accept the null hypothesis at the 5% significant level.

Overall, the results of fisher's exact test show that rail station location is the only variable that has an association with the different air-rail partnership levels, and it is significant even at 0.1% level.

4.4.4 Discussion

One of the variables (i.e., airline type) that we tested here is from the (Jiang et al., 2017). As the most closely related research to our study, they investigate two possible air-rail partnerships: a domestic partnership between a rail operator and a domestic airline, as well as an international partnership between a rail operator and a foreign airline. In most cases, foreign airlines seem to have lower partnership levels with rail operators compared to domestic airlines. Their findings show that international cooperation cases will have a higher partnership level than domestic cases when the pre-investment quality of the air-rail cooperation case is sufficiently high compared with the quality of the air-air connecting service regarding operating costs from transport operators and travel cost from passengers. However, the airline type variable is statistically insignificant in this chapter. We suppose that one possible reason is that air-rail cooperation is a complicated issue involving a wide range of variables that may have an impact on the partnership level. There are may be some potentially important determinants of partnership levels, but it is not feasible to include all of them in the regression model due to data limitation. Since most of the cooperation cases only emerged in the past few years, there are only 33 samples. The small sample size may also contribute to the insignificance of airline type variable. However, air-rail cooperation is rapidly developing. We would be able to see more cooperation cases in the near future. The regression results shall be revisited when larger sample size can be obtained with more cooperation cases.

On the other hand, the regression results seem to be consistent with the Fisher's exact test results. Both of them reveal that whether the rail station is located at airport is the main factor that has an effect on the air-rail partnership level. The consistency of the results serves as a robustness check of our study. When the role of rail is considered in terms of the future of the aviation industry, it is usually limited to the access to airport issue, but the potential for air-rail cooperation is overlooked. However, the operation of rail services at airports provides more opportunities for mode complementarity. With the integration of rail services with airlines and the substitution of airlines by rail, the real cooperation takes place.

It is critical for airports to allow for infrastructure integration in order to make the transfer between airport and rail station as easy as possible. For the cooperation cases, connection time between transport modes is critical for the success (Sun et al., 2017). In fact, poor air-rail connection conditions in some countries can be a barrier to the higher partnership level. It is highly demanding for those airports with rail stations due to the fact that they must generate enough passenger demand to make it attractive for rail operators to invest on and operate a link. In line with the previous studies examining the cooperation between rail and air transport, the empirical results reported here confirm that air-rail cooperation is well-developed in Europe than the other parts of the world. We suppose that this is mainly because most of the European cooperation cases have a rail station at airport. Some dominant airports in Europe manifest higher air-rail partnership levels where rail services have been regarded as additional spokes of airlines to expand airports' catchment areas and free up slots. For example, the best-practice in air-rail cooperation cases is at Frankfurt airport where a long-distance train station is at airport. AIRail provides intermodal services on the Frankfurt-Cologne route with 50 minutes of total travel time and a frequency of 16 daily links. Moreover, the position of an 'intermodal manager' has been created at Frankfurt airport to further support the air-rail cooperation, with the main responsibility of being a coordinator between rail operators and airlines. Our results indicate, therefore, that policy makers should pay more attention to airports' infrastructure development, particularly the location of rail station at airport. They need to consider how the creation of a new rail station at airport is going to change terrestrial access to the airport, and the following results on partnership level.

We then looked those cases that rail station is located at airport in detail and found that they relate to regulatory factors and government policy. Air-rail cooperation cases enjoy strong political support, especially in Europe, mainly due to the perceived contributions they are able to make to achieve environmental policy targets (Chiambaretto & Decker, 2012). In 1995, European Commission transport Green Paper (EC, 1995) first identified the importance to provide passengers integrated and intermodal services. Current European transport policy regards intermodality as a way of enhancing efficiency and sustainability and sets as a goal of the optimal use of the transport system. HSR has been promoted as the government key project and the integration of the Trans-European HSR network has also been very successful and still ongoing. As a result, European air passengers frequently use rail services to access the airport, while Asian airports still strongly depend on buses or cars as the main access mode for passengers. This situation provides competitive advantages for the European cooperation cases, which in turn improve the leading position of several European hub airports.

As discussed above, with the growing popularity of air-rail cooperation, more and more airline companies and rail operators are actively involved in the partnership. However, an intermodal integration is not an end in itself. More features, including schedule coordination and baggage handling, need to be embedded in the intermodal network. The success of a cooperation case depends on various factors, e.g., policy and regulation, regional characteristics and peculiarities, and current modal split, etc. In order to expand the penetration of air-rail cooperation case in more parts of the world, ambitious programs need to be implemented. The implementation of such programs requires cooperation among different parties, including airlines, airport authorities, railway operators, and policy makers. Furthermore, constraints like environmental issues, funding, and institutional barriers also need to be considered. The most important role lies in the quality of the value delivered to the customers. Our study has shown that the integration of rail station at airport into an intermodal system is a necessity for many airports worldwide.

4.5 Concluding Remarks

Intermodality between air and rail transport is gaining momentum around the world. However, operators of both airlines and rail will not have an incentive to cooperate unless the integration cost is sufficiently low (Xia & Zhang, 2016). Therefore, a better understanding of the driving forces behind air-rail cooperation needs to be investigated in order to best promote this new transport intermodal mode. This study looks into air-rail cooperation cases with different partnership levels which are applied to intermodal journeys where the rail trip serves as a leg of the journey in order to substitute short-haul air feeders and expand airport catchment areas instead of serving the purpose of offering access between city-center and nearby airports. This article contributes to the literature on air-rail cooperation and integration. Even though guidelines exist for cooperation cases in general, there does not seem to be one best solution for their success. Policy makers need to seek various approaches so as to best address specific concerns of both airports and rail operators. To promote air-rail cooperation, policy makers need to understand that different cases have their own optimal partnership levels. The partnership level of air-rail cooperation is characterized by different features, such as integrated ticketing, schedule coordination, and frequent flyer programs, etc. We attempt to find out the driving forces behind the different partnership levels, and our findings indicate that the location of the rail station has the largest impact, that is, a higher partnership level is more likely to exist when the rail station is located within the airport.

Some limitations exist due to the small sample size and simplifications of our regression model. First, equal weighting is given to each feature. Incorporating different weightings into the model would likely change some of the conclusions. Second, several variables are omitted from our model, such as the duration of each cooperation case and the network covered by each case. Although as the first attempt to investigate this issue, it would be interesting to enrich the model more and study the impacts of those omitted variables in future research. However, our preliminary results are still inspirational to a certain extent and have policy implications for policy makers.

Chapter 5 Conclusion

5.1 Summary

With the advent of HSR, the interactions between aviation and rail industry have become a critical issue in transport research area in recent years, including a wide range of topics and having significant impacts on the development of transport systems. In most cases, competition between air and rail has been the main stream in literature (Adler et al., 2014; Chen, 2017; Wang et al., 2017). Due to the increasing concerns of airport runway congestion and environmental issues, the intermodal complementarities of air and rail transport have now been adopted by many countries and already been regarded as a primary transport policy goal in Europe. Therefore, air-rail cooperation is an emerging research topic and has attracted more attention in recent years. However, there is still, up to now, very limited research studying the air-rail cooperation between aviation and rail transport. Additionally, most of research that focuses on the competition mode between air and rail transport tends to emphasize on FSC and ignore the LCC part. Given that background, three primary research questions have been studied in the thesis: the relationship between HSR and regional development, the impacts on air-rail interactions when LCCs instead of legacy airlines are involved, and the driving forces behind the different air-rail partnership levels. Recognizing the importance of these questions, this thesis attempts to apply both analytical and empirical methods to investigate the questions.

Chapter 2 offers a comprehensive framework for the discussion of the impacts of major government initiatives on the spatial transformation of transport and regional systems. Governments often play hugely significant, and sometimes decisive, roles in the evolution and development of transport systems. However, the impacts of government initiatives on the transformation of transport and regional systems are currently under-researched. This chapter attempts to address this deficiency by discussing a relevant case study of the Chinese HSR network. It includes a review of the Chinese HSR network development and discussions of its future development. We find that Chinese government has been actively involved in HSR project, providing substantial financial supports. This is the main reason why its HSR network has achieved outstanding success. Also, new projects may have less impact than some of their politically motivated promotions may lead one to expect. Governments need to be really careful of the approach of presenting of new initiatives because of many complex issues (e.g., cultural, economic, and political differences) involving in them.

In chapter 3, a macroeconomic comparison between LCC and HSR sectors in Japan and Western Europe has been conducted. The findings show that the Japanese LCC sector seems to be lagging behind its European counterparts while both regions have strong HSR systems but the Japanese case appearing more dominant. A few factors may play a role in this contrast. First, a larger geographical coverage and the more polycentric spatial pattern in Western Europe means that there are more viable markets for LCCs. Second, HSR predated LCC by a long period of time in

Japan, while they emerged almost at the same time in Western Europe. This might give an extra strategic advantage to HSR in Japan, since if HSR has established itself in a market, it is very hard for LCCs to compete; but if LCCs has a period of time to develop, they might have a chance to survive. Last and probably most importantly, both Japan and Europe has promoted HSR as the government key project, but the European government has a more liberal attitude towards its aviation sector compared with the Japanese government, which discourages the LCC sector in Japan.

Chapter 4 looks into air-rail cooperation cases with different partnership levels which are applied to intermodal journeys where the rail trip serves as a leg of the journey in order to substitute short-haul air feeders and expand airport catchment areas instead of serving the purpose of offering access between city-center and nearby airports. We first study the emergence of air-rail partnership and then summarize the existing air-rail cooperation cases around the world. We also investigate the potential driving forces behind different partnership levels in such intermodal cooperation with an econometric model. The results reveal that the location of the train station has the largest impact on the partnership level. In particular, if the train station is located within the airport, the air-rail cooperation is more likely to end up with a high partnership level. However, there does not seem to be one best solution for the success of air-rail cooperation. Policy makers need to seek various approaches so as to best address specific concerns of airports and rail operators.

5.2 Contribution

The thesis is intended to be a pioneer research on air-rail interactions and fill some of the research gaps in the existing literature. In addition to studying the three primary research questions and achieving the four main objectives, this thesis partially fills the research gap on the air-rail interactions. On the one hand, the thesis provides a better understanding of the competition and cooperation between air and rail transport. On the other hand, it also has substantial policy implications, which can be a valuable reference for governments and regulators.

First, by providing a case study on the development of the Chinese HSR network, it offers an interesting example explaining the impacts of the government initiatives on the transformation of transport and regional systems. However, government initiatives on transport and regional systems can be highly diversified regarding to physical locations, economic and social systems, institutional, and even cultural issues between various countries. Sometimes, if the initiatives are presented too aggressively, they may not get the desired results that they look for. Policy makers need to be very careful on the arts of presenting new and major initiatives. It is believed, therefore, that this thesis will contribute to the future regional studies in relevant topics.

Second, this thesis applies a comparative research analysis to compare the macroeconomic development status of both HSR and LCC in Japan and Western Europe. This is the first time a macroeconomic comparison is given to the development of HSR system and LCC sector. By doing so, it provides an innovative aspect for future research on the HSR-LCC relationship. The results also have practical implications for those countries that are currently building their HSR networks or planning to foster their LCC sectors.

Third, this thesis conducts an empirical study to examine what are the driving forces behind the different air-rail partnership levels. The results are informative. The thesis explores the rationale behind different partnerships and explains why a variety of different situations exist in reality. In particular, the location of rail station plays a critical role in different partnerships. That is to say, the air-rail cooperation is more likely to end up with a high partnership level when the rail station is located within the airport. Furthermore, it is the first attempt to summarize all the existing cooperation cases in the world, and hence, enriches the literature on air-rail cooperation and integration.

5.3 Limitation and Future Research

Several limitations still remain in this thesis. Given that the thesis only focuses on the development of Chinese HSR network, the results may not reflect the situation of HSR system in other countries. Despite such, it offers a solid theoretical foundation and practical reference for the implementation of other government initiatives in the future. Further research is necessary to draw the experiences from other parts of the world and compare them with the Chinese HSR case in order to discuss the similarities and differences between different cases and find out the potential reasons behind the situation. Also, the four predictions about future development of

Chinese HSR are ex-ante forecasts. Although ex-ante forecasts play an important role in evaluating transport systems, they might inaccurate sometimes. Therefore, further modeling and quantitative studies with real data need to be conducted to examine these predictions. On the other hand, from the discussion in chapter 2, the development of HSR services does have a significant impact on the balance of regional disparities (Garmendia et al., 2012). However, it is left largely unexplored that whether the uneven regional development will become larger or smaller. This might also be an interesting orientation for future research.

Due to the lack of data, only macroeconomic comparisons have been made between HSR and LCC in chapter 3. This might potentially cause analytical inaccuracy. Second, only logical inferences are applied to identify the reasons why the different development status of LCC and HSR exist in the different markets, but there are no statistical tests for these conjectures. Nevertheless, it is believed that chapter 3 serves as a meaningful first step in this research venue. When first-hand data is collected, more rigorous statistical analysis and more detailed case studies can be implemented. Finally, the competition between HSR and LCC should be reexamined in a few years. In fact, it is difficult to say whether LCCs will have more negative impacts on HSR or whether this competition will become marginal. We should keep in mind that characteristics of these two modes may also play a role in the competition. HSR network expansion may be hampered by huge construction costs (Sanchez-Borras et al., 2010). In contrast, LCCs are often able to obtain significant reductions in airport charges or subsidies whose legality remains disputable (Hunter, 2006).

For the air-rail cooperation part, the small sample size may influence the results of empirical study and cause the insignificant of some variables. This is mainly due to the fact that air-rail cooperation is an emerging phenomenon around the global, and many parts of the world have not adopted this new transport mode yet. Although we have tried to make the setting more realistic and complicated, some features are still omitted from analysis. The regression results shall be revisited when more related variables and larger sample size can be obtained with more cooperation cases offering services in the near future. Other than the ones discussed in chapter 4, there are still many interesting topics, which are currently under-researched. We have already known that in reality different partnership levels exist between the air-rail cooperation cases and roughly classified them into three categories. However, there are still some critical questions that are not discussed in the thesis. For example, is the cooperation level related to decision markers (i.e., airports, airlines, and rail operators)? What is the socially optimal intermodal partnership level? These questions are crucial in terms of having a better understanding of the air-rail cooperation cases and having important policy implications to governments and regulators.

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